

Learning to spell in second grade using the spelling checker*

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The spelling process of Dutch second-grade students using the word processor was studied in three different feedback conditions. In the no-feedback condition, they merely had to type words without being told whether the spelling was correct or not. In one of the feedback conditions they were only told whether the word was spelled correctly, whereas in the other feedback condition they were given suggestions when words were spelled incorrectly. Students learned about the spelling of words without receiving feedback. Providing feedback, however, improved spelling performance substantially more than no-feedback. The nature of the feedback affected spelling performance of native and non-native Dutch words differently. Native Dutch words benefited more from suggestions than non-native words, and both word types benefited equally when no suggestions were provided. The quality of the suggestions provided by the spelling checker was substantially better in case of native Dutch words. Thus, Dutch second graders are capable of making efficient use of the spelling checker only in case of native Dutch words.

1. Introduction

Implicit learning is the acquisition of knowledge without the intention to do so. An important characteristic of implicit knowledge is that people are generally incapable of expressing the structure that underlies the knowledge that has been acquired in an implicit-learning context (Berry, 1997; Reber, 1993). Domains in which implicit learning is apparent encompass knowledge about the physical and the social world, category learning, language learning (first and second), and reading and spelling (Reber, 1993). Native-language acquisition is a good example of implicit learning, because children learn their mother tongue to a large extent incidentally. Moreover, the majority of native speakers are perfectly capable of producing grammatically correct sentences in their mother tongue, while they are at

the same time unable to explain why a particular sentence is grammatically correct or not.

Explicit learning, on the other hand, is intentional and goals determine what will be learned. Also, people are usually able to express the rules or structure that underlie the acquired knowledge. Because most of what people learn appears incidental rather than intentional, there is common agreement among psychologists that models about human learning should incorporate the notion of explicit learning as well as implicit learning (Reber, 1993).

The discussion on implicit or natural learning as opposed to explicit instruction has a long history in the United States. Already in the beginning of the 20th century spelling experts argued that incidental learning was as effective as direct instruction. In the 1980's and 1990's when whole-language methods gained popularity, explicit spelling instruction was again criticised. Graham (2000:235–47), who studied the literature for empirical evidence to settle the debate, concluded that the available literature does not answer the question. English-speaking children in first grade who receive no explicit spelling instruction appear to do as well as children who are being taught explicitly. However, little is known about the effects beyond first grade.

In the Netherlands, the debate on explicit versus implicit teaching or whole-language versus phonics, never really gained momentum. In the vast majority of Dutch schools, teachers use direct instruction rather than natural learning, because they assume that explicit learning is more efficient than natural learning. The issue is important with respect to the educational practice. If the spelling of words is easily attained while students are involved in various writing activities, such as composition, then there is no need for explicit spelling-instruction methods. If, on the other hand, direct instruction in spelling appears to be more effective than natural learning, a compelling question arises: What is the most effective means to teach spelling explicitly.

1.1 Learning to spell implicitly

A limited number of experimental studies have been conducted to investigate whether orthographic knowledge can be acquired implicitly. Pacton, Perruchet, Fayol, and Cleeremans (2001:401–26) studied French-speaking students in Grades 1 to 6. They participated in a pseudoword-spelling task assessing the level of sensitivity to orthographic regularities; in this case, the likelihood of the doubling of particular consonants, the legal position of double consonants, and the fact that vowels in French are never doubled. The students showed an increasing, implicit awareness of the orthographic structure in the French language.

The work by Kemp and Bryant (2003:63–74) revealed that English-speaking primary grade students, without explicit instruction, become sensitive to the fact

that the spelling of plural *-s* is always an *s*, irrespective of the fact that some plurals have an [s] pronunciation as in *cats* and some a [z] pronunciation as in *dogs*. Steffler (2004:248–64) showed increasing awareness in primary-school children for the doubling rule with final *-ed* spelling in English words with a short vowel (e.g., *HOP* becomes *HOPPED*, whereas *HOPE* becomes *HOPED*). Finally, Treiman (1983) in her book on learning to spell showed that young beginning spellers had acquired implicit-spelling knowledge. In an attempt to spell the word *cake*, they produced the misspelling *KACK*, but never *CKAK*. Without being told, the students knew that the English, legal *CK* cluster cannot occur at the beginning of a word. In sum, these studies provide evidence for the occurrence of implicit learning in the acquisition of spelling knowledge.

Although the role of implicit learning in spelling is not negligible, studies in the Dutch language reveal a rather limited role. Bosman and her colleagues (Bosman & de Groot 1992:279–89; Bosman & van Leerdam 1993:28–54; Kieboom, Hasselman, Verhoeven, & Bosman 2005:250–58; van Leerdam, Bosman, & Van Orden 1998:307–20) compared various direct spelling-instruction methods with a condition in which they merely had to read a set of words, a means to induce implicit learning. In all cases, students' spelling knowledge increased significantly more when they studied the spelling of words in an explicit (or direct) teaching condition than in the implicit-reading condition. The overall conclusion from their work is that instruction methods that mimic the actual spelling process, that is, writing down the word from memory, providing immediate feedback, and correcting actual spelling errors, appear to be most efficient.

In the present study, we will address the issue of implicit learning of spelling in an experimental context in which Grade-2 students are writing words using the keyboard of a computer. They are asked to type spoken words presented to them, without the opportunity of checking their spellings. Spelling performance will be assessed before and after a number of training sessions. If their spelling knowledge increases after the writing training in which no explicit reference is made towards the spelling-acquisition goal, and regular classroom instruction during the intervention cannot explain the increase, we conclude that implicit learning has occurred.

1.2 Learning to spell explicitly

As said, the general conclusion from Dutch studies is that an instruction method that resembles the actual spelling process relatively closely appears to be most effective. Although, explicit learning, induced by direct-spelling instruction may be effective, it leaves various aspects concerning the actual principles of the instruction unanswered; one of them being feedback.

The importance of feedback in learning and instruction is hard to underestimate (for a meta-analysis see, Azevedo & Bernard 1995:111–27). Without providing feedback, particularly in the domain of academic learning, it is almost impossible to learn effectively let alone efficiently. This is certainly true for learning to spell. Students who are unaware of the spelling errors they made in their assignments will have great difficulty learning to spell properly. Ample research has shown that feedback on spelling should be provided immediately rather than delayed. Students whose spelling work is corrected hours or even days after it is completed improved their spelling performance to a lesser extent than students who received feedback on their spelling immediately after they had completed their work (Harward, Allred, & Sudweeks 1994:245–71; Kauffman, Hallahan, Haas, Brame, & Boren 1978:217–22; Kearney & Drabman 1993:52–56; Murphy, Hern, Williams, & McLaughlin 1990:378–86; Nulman & Gerber 1984:328–33). Moreover, immediate feedback may lead to even higher gains if students themselves rather than the teacher inspect and correct their spellings (e.g., Murphy et al. 1990:378–86; Vaughn, Schumm, & Gordon 1993:191–98). Inspecting the word one has just written and correcting it when necessary not only provides immediate feedback on the accuracy of spelling the word, but is also an important step in the development of self-monitoring skills (cf., Reid & Harris, 1993:29–40).

The type of feedback also affects the learning process. Its effectiveness appears to be highly dependent upon the content of what has to be learned and the proficiency of the student. In the literature, three kinds of feedback have been distinguished that are applicable to spelling, that is, ‘knowledge of results’, ‘informational feedback’, and ‘meta-cognitive feedback’ (Geis 1986:3–6; van der Linden 1998). For present purposes only the first two are important. In case of knowledge-of-results feedback, the speller is told *whether* the spelling is correct or incorrect. It has been argued that this kind of feedback provides students with relatively limited information regarding the underlying knowledge structure, and that only a small number of students with high-cognitive capabilities may be able to refer to these underlying knowledge structures with the help of knowledge-of-results feedback (van der Linden 1998). Informational feedback provides the learner with some information as to *what* is wrong. Informational feedback can have several different forms: Presenting the right answer, referring to a definition, repeating a specific part of the instruction, pointing out the rule that should be applied, providing a new textual explanation, a demonstration, or a combination of these forms. Informational feedback is particularly effective for students who have little pre-knowledge (van der Linden 1998).

In the present study, both types of feedback were investigated. Knowledge-of-results feedback was tested using the spelling checker of Microsoft’s word processor. The spelling checker indicated that something was wrong in the spelling

indicated by the standard twisting red line underneath the typed word, but it did not provide any clues as to what was wrong. Informational feedback was also tested using the spelling checker. In this case, the spelling checker not only indicated that an error had occurred, but also presented the student with a list of possible alternatives. This is a standard option of Microsoft Word's spelling checker.

1.3 Dutch orthography

Before turning to the experiment proper, some facts about Dutch orthography need to be explained. Linguistically, the Dutch language broadly comprises two types of words: Indigenous words and borrowings. Indigenous words are those words that already existed when the Germanic-language group, of which Dutch is a member, was still a unity. Borrowings enter(ed) the Dutch language from other languages. The Dutch etymologist van der Sijs (1996) distinguishes three types of borrowings: Semantic borrowings, translation borrowings, and loan words. Semantic borrowings occur when extant Dutch words (both indigenous words and borrowings) receive an additional meaning derived from another language. For example, the indigenous Dutch word *STEM* first meant *voice*, but received a second meaning through a semantic borrowing from French *voix*, meaning *vote*. Translation borrowings are foreign words translated into indigenous Dutch words. Usually, both meaning and composition of the foreign word are adopted. For example, the Dutch word *EZELSBRUG* (*mnemonic*, literally donkey bridge) came from the Latin word *pons asinorum*. Loan words take phonology and/or meaning from the language of origin; examples are *IMPERIUM* from Latin, *FINISH* from English, and *PIZZA* from Italian.

Loan words are the most common borrowings in the Dutch language and are often subdivided in naturalized words, strange words, and bastard words (from te Winkel, 1865). Naturalized words are morphologically and phonologically identical to indigenous words; the borrowing *KERK* (*church*) is an example of a naturalized word. It strongly resembles the indigenous word *WERK* (*work*), but is borrowed from the Greek word *kuriakon*. Strange words usually retain phonology, morphology, and spelling of the source language; examples are *THRILLER* and *COMPUTER* from English, *GRAMMATICA* (*grammar*) from Latin, and *BUREAU* (*desk*) and *DOUCHE* (*shower*) from French. Bastard words are loan words with spelling and phonology adapted to indigenous words, examples are *FITHEID* from *fitness*, *EMPIRISCH* from *empirical*, and *CITROEN* from the French word *citron* (*lemon*).

In conclusion, indigenous words and loan words constitute the two most important, etymological categories of Dutch words. Although it is tempting to conclude that a formal description of Dutch spelling should therefore be based on the etymological distinction, it is not the most useful option. There are two major

reasons. One, Dutch language users are largely unaware of the origin of words. Two, the phonology and spelling of a large number of loan words are identical to indigenous words. The Dutch linguist Nunn (1998; see also Bosman, de Graaff, & Gijssels, 2006:135–50) proposed to distinguish between two types of words for which two different sets of spelling rules can be developed. The distinction is based on formal criteria and the result was a set of native words and a set of non-native words. Nunn decided to reserve the terms native and non-native for the distinction between type of words on formal, linguistic criteria, as opposed to the terms indigenous and loan, a distinction based on the origin of words.

The important psycholinguistic difference between native and non-native words is that native words are spelled according to prototypical Dutch phoneme–grapheme relationships, whereas non-native words are composed of atypical or inconsistent Dutch phoneme–grapheme relationships. Bosman and Mekking (2005) applied Nunn’s criteria (1998) on the CELEX-database (Baayen, Piepenbrock, & van Rijn 1993) and established that about 15% of Dutch words are non-native. Interestingly, this figure is rather close to the percentage of loan words (i.e., 16%) reported by van der Sijs (1996, see page 66).

In the present study, the acquisition of the spelling of two types of words will be investigated. One is a group of non-native words with spellings that deviate from the typical Dutch phoneme–grapheme relationship, like *GEL* or *COMPUTER*, and the other is a group of native Dutch words with an ambiguous phoneme–grapheme relationship. An ambiguous phoneme–grapheme relationship refers to the fact that particular phonemes can be represented by more than one grapheme. However, only one of usually two graphemes is correct. An example in the English language is the phoneme [ie] which can be spelled with *EE* as in *DEEP*, *EA* as in *CHEAP*, *EY* as in *KEY*, *Y* as in *ENTRY*, and *IE* as in *CHIEF*.

1.4 The present study

The first question of this study is whether students in second grade will learn about the spelling of words without being informed whether their spellings are correct or not. If implicit learning takes place, an increase in spelling performance from pretest to posttest should occur in a no-feedback condition. The second question is whether explicit learning is more effective than implicit learning with respect to spelling. As said, not many students learn to spell without instruction, and because feedback provides the novice speller with explicit opportunities to learn about spelling, it is expected that the two feedback conditions will be more effective than the no-feedback condition. Because of the two different categories of words in Dutch orthography, an exploratory analysis was performed to test for differential effects on words with native spellings and words with non-native spellings.

The third question is whether explicit learning of the spelling of words in students from second grade is crucially dependent upon the type of feedback provided by the computer. Because students in the present study are novices with respect to spelling, it is expected that students who participate in the spelling-checker-with suggestions will improve their spelling performance more than students who take part in the condition in which the spelling checker does not provide suggestions. Moreover, we expect that in the condition in which no spelling suggestions are offered, it will be more difficult to learn the spelling of non-native words than of native words. In case of a misspelling in native words, it is highly likely that they misspell the ambiguous grapheme. Because students in Grade 2 are aware of this spelling difficulty, we expect them to hypothesize with relatively great confidence and accuracy spelling errors in native words. In the spelling-checker-with suggestions, both types of words may profit from the feedback that will be provided.

The fourth and final question concerns the quality of the suggestions that are provided in the spelling-checker-with-suggestions condition. To assess differential effects of native and non-native words, the errors on the pre- and posttest will be subjected to the spelling checker, and the number of suggestions and the place of the correct suggestions in the list of suggestions will be determined. One additional issue that is also relevant for the educational practice is whether spelling performance of words practiced in a sentence is more effective than words practiced in isolation. This question was raised, because there are indications that a semantically meaningful context aids the learning process.

2. Method

2.1 Participants

In this experiment, 68 Grade-2 students (37 boys and 31 girls) with a mean age of 8.0 years (ranging from 6.7 to 10.6 years, $SD=0.5$) participated. Students were recruited from two different regular primary schools located in the south of the Netherlands, and their socio-economic backgrounds were low and middle class. The participants were assigned to one of three experimental conditions: A non-feedback condition ($n=23$), a spelling-checker-without-suggestion condition ($n=23$), and a spelling-checker-with-suggestions condition ($n=22$). The groups were matched based on the scores of a spelling test (see materials section) that was used as pretest, $F < 1$.

2.2 Materials

Sixty words were selected from the target list of Schaerlaekens, Kohnstamm, and Lejaegere (1999). The target list is a valid indicator of the age of acquisition of children's passive vocabulary. All words are generally known by children entering first grade. Thirty words were native Dutch words with an ambiguous phoneme-grapheme relationship. The ambiguous phoneme-grapheme relationships used in the current experiment were the phonemes [ɛi] corresponding with the graphemes EI or IJ, and the phoneme [au] corresponding with the graphemes OU, OUW, and AUW. The remaining thirty words were non-native Dutch words and contained atypical or inconsistent phoneme-grapheme relationships; examples are TEAM, SCOOTER, HORLOGE, and PIZZA. The language of origin of the majority of the non-native words was English or French. The Appendix lists the stimuli used in the experiment. In both categories 12 words (the worst spelled in the pretest) were selected for training, resulting in a set of 24 training words. The remaining 36 words (18 native and 18 non-native) were control words and tested again in the posttest.¹

The spelling-training materials consisted of four different lists that each contained all 24 words. In each list, half of the materials were native and the other half were non-native words. Moreover, half of the native words and half of the non-native words appeared in isolation (henceforth referred to as word context) and the remaining two sets of words occurred in a sentence context. Half of the participants received a training word in the word-context condition and the other half in the sentence-context condition, with each word occurring equally often in either context condition. To prevent the emergence of additional spelling problems, relatively simple context sentences were constructed.

2.3 Procedure

For all three experimental conditions, a dictation program was developed that automatically dictated words and sentences upon request. The students used Microsoft Word 2000, equipped with the Dutch-spelling-checker module, to type in their responses. The training was self-paced, participants used the dictation program to provide them with the oral presentation of the stimulus.

The first training condition constituted the no-feedback condition. Participants in this condition were simply asked to spell the words and sentences and after they had finished typing, they continued with the next word or sentence. They received no feedback with respect to the correctness of their response.

The second training condition constituted the spelling-checker condition. This training condition was identical to the first except that participants received

feedback on their spelling by means of Microsoft Word's spelling checker. The spelling checker indicated a spelling error by showing a wavy red line underneath the mistake. Participants were asked to try to correct the error, and they were told that they would know that the word was correct, because the red line would disappear. In this condition, no possible alternative spellings were presented to the participants; they had to correct the errors without any help. Note that when a word was presented in a sentence context Microsoft Word also gave feedback on the spelling of the other words in the sentence apart from the training word.

The third training condition constituted the spelling-checker-with-suggestions condition. This training condition was identical to the second except that in this condition participants were also given the possibility to view and select one of the spelling suggestions that Microsoft Word provides when it determines that a word is spelled incorrectly. Note that Microsoft Word, like any other spelling checker, cannot always provide the correct spelling suggestion particularly when a spelling deviates too much from the intended word (see also, MacArthur, Graham, Haynes, & DeLaPaz 1996:344–354).

Each participant received half of the training words in the context of a sentence and the other half in isolation. The entire set of 24 training words was divided in two lists of 12 words each. Over a period of 6 weeks, every participant practised the training words three times. One week after the last session, the participants received the posttest. The posttest, which was identical to the pretest, required participants to spell both the training (24) and control words (36) again.

3. Results

The first analysis concerned the occurrence of implicit learning by comparing the relative gain in spelling knowledge of training and control words on the posttest of students who did not receive feedback. Note that overall performance on control words is expected to be better than on training words, because training words were words that students spelled worst, whereas control words were words that were generally spelled better. The second analysis was a comparison between the two feedback conditions (spelling checker without and spelling checker with suggestions) and the no-feedback condition. The third analysis concerned the effectiveness of the nature of feedback: Is the spelling checker with suggestions more effective than the spelling checker without suggestions? The fourth and final analysis pertained to the quality of the suggestions provided by the spelling-checker-with-suggestions. Analyses were conducted on both subject (F_s) and item means (F_i).²

3.1 Learning without feedback

To test whether implicit learning had occurred, a 2 (word: control vs. training) \times 2 (test: pretest vs. posttest) analysis of variance was performed on the percentages of correctly spelled words of students in the no-feedback condition. Means are listed in Table 1. With respect to the subject analysis both the word and the test variable were treated as within-subjects' variables, whereas in the item analysis, the word variable was treated as a between-subjects' variable and test as a within-subjects' variable.

Table 1. Mean Percentages of Correctly Spelled Words in the No-Feedback Condition.

Test	Pretest	Posttest	Difference
Control words			
Mean	47.1	50.6	3.5
SD	23.1	25.7	15.2
Training words			
Mean	20.8	29.4	8.5
SD	16.2	20.1	10.2

The main effect of word was significant in both subject and item analyses, $F_s(1, 22) = 172.13$, $p < .0001$, $\eta^2 = .89$; $F_i(1, 58) = 11.06$, $p = .002$, $\eta^2 = .16$. As expected, performance on control words was significantly better than on training words. The main effect of test was also significant in both analyses, $F_s(1, 22) = 6.59$, $p = .02$, $\eta^2 = .23$; $F_i(1, 58) = 21.45$, $p < .0001$, $\eta^2 = .27$. Performance after the training was better than prior to the training. The two main effects need to be qualified as a result of a marginally significant interaction effect between them in both the subject and the item analyses, $F_s(1, 22) = 3.54$, $p = .07$, $\eta^2 = .14$; $F_i(1, 58) = 3.32$, $p = .07$, $\eta^2 = .05$. Separate t tests on performance differences between pre- and posttest on control words and on training words were conducted to investigate the source of this interaction. The t value in the subject analysis of the control words was not significant, but in the item analysis it was; $t_s(22) = -1.11$, $p = .28$; $t_i(35) = -2.16$, $p = .04$. The same analysis on the training words revealed a significant difference in both subject and item analyses, $t_s(22) = -4.02$, $p < .001$; $t_i(23) = -5.65$, $p = .0001$. This result suggests that spelling knowledge of training words had increased more so than that of control words during the training period.

3.2 Feedback vs. no feedback

To test whether explicit learning had stronger effects than implicit learning, a comparison was made between the no-feedback condition and the two conditions in which feedback was provided. The variable word type was added to test for

differential effects. A 2 (feedback condition: no vs. yes) \times 2 (word type: native s vs. non-native) analysis of variance was performed on the percentage improvement of correctly spelled training words on the posttest (difference of posttest and pretest scores). Means are listed in Table 2. Note that the scores of the no-feedback condition in this table were a further breakdown of the findings presented in the second row of Table 1 representing the scores of the training words on pre- and posttest. In the subject analysis, feedback condition was a between-subjects' variable and word type a within-subjects' variable, whereas in the item analysis feedback condition was a within-subjects' variable and word type a between-subjects' variable.

Table 2. Mean Percentages of Correctly Spelled Training Words in the No-Feedback and Feedback Conditions.

Test	No Feedback		Feedback	
	Pre	Post	Pre	Post
Native words				
Mean	35.9	46.7	38.5	57.0
SD	22.7	28.0	20.7	22.0
Non-native words				
Mean	5.8	12.0	3.9	15.6
SD	14.3	20.2	8.3	19.8

The main effect of feedback was significant, $F_s(1, 66) = 5.20, p = .03, \eta^2 = .07$; $F_i(1, 22) = 10.27, p = .004, \eta^2 = .32$. Students who received feedback improved their spelling more than children who did not receive any feedback. The main effect of word type was also significant, $F_s(1, 66) = 5.64, p = .02, \eta^2 = .08$; $F_i(1, 22) = 5.77, p = .03, \eta^2 = .21$. Improvement of spelling performance on native words was higher than that on non-native words. The interaction between word type and feedback was not significant, $F_s < 1$; $F_i < 1$.

3.3 Feedback with and without suggestions

To examine the effect of the two different feedback conditions, a 2 (nature of feedback: without suggestions vs. with suggestions) \times 2 (word type: native s vs. non-native) analysis of variance was performed on the percentage improvement of correctly spelled training words on the posttest (difference of posttest and pretest scores). Means are listed in Table 3. Note that the mean scores presented in Table 3 represent a further breakdown of the scores represented in the two feedback columns of Table 2. In the subject analysis, nature of feedback was a between-subjects' variable and word type a within-subjects' variable, whereas in the item analysis nature of feedback was a within-subjects' variable and word type a between-subjects' variable.

Table 3. Mean Percentages of Correctly Spelled Training Words in Both Spelling-checker Conditions.

Test	Without suggestions		With suggestions	
	Pre	Post	Pre	Post
Native words				
Mean	43.1	58.3	33.7	55.7
SD	19.9	25.1	20.8	18.6
Non-native words				
Mean	3.3	18.1	4.6	12.9
SD	6.5	19.2	9.9	20.4

The main effect of feedback condition was not significant, $F_s < 1$; $F_i < 1$. The main effect of word type was, $F_s(1, 43) = 6.47$, $p = .02$, $\eta^2 = .13$; $F_i(1, 22) = 4.22$, $p = .05$, $\eta^2 = .16$. Performance on native words improved more than performance on non-native words. The interaction effect between nature of feedback and word type was also significant, $F_s(1, 43) = 6.07$, $p < .02$, $\eta^2 = .12$; $F_i(1, 22) = 4.16$, $p = .05$, $\eta^2 = .16$.

To investigate the source of this interaction simple t tests were conducted. In the spelling-checker condition without suggestions, there was no significant difference between the improvement of native and non-native words $t_s(22) = .14$, $p = .45$; $t_i(22) = .07$, $p = .47$, whereas in the spelling-checker condition with suggestions spelling knowledge of native words had improved more than of non-native words $t_s(21) = 2.86$, $p < .0001$; $t_i(22) = 3.08$, $p < .0001$. Thus, the spelling checker without suggestions was equally beneficial in learning the spelling of the two types of words. The feedback condition in which suggestions were provided revealed more improvement on the spelling of native words than of non-native words.

Testing the difference in improvement for native words in the spelling-checker condition without versus with suggestions showed a marginally significant difference in the subject analysis and no difference in the item analysis, $t_s(43) = -1.45$, $p = .08$; $t_i(11) = -1.26$, $p = .12$. This suggests that providing no suggestions is almost as beneficial as providing suggestions in learning the spelling of native words. The same analyses on the improvement of spelling knowledge of non-native words in the two feedback conditions revealed a marginally significant difference in the subject analysis and a significant difference in the item analysis, $t_s(43) = 1.53$, $p = .07$; $t_i(11) = 1.75$, $p = .05$. This finding suggests that the spelling-checker-without-suggestions is more beneficial for learning the spelling of non-native words than the spelling-checker-with-suggestions.

Based on the previous findings, we conducted an additional item analysis to investigate whether the quality of the misspellings of the two types of words differed. Quality of misspelling was defined as the extent to which a misspelling was phonologically correct. For example, *Deap* is a phonologically correct

misspelling of DEEP, whereas *Delp* would be phonologically incorrect. From each misspelling on the pre- and posttest it was assessed whether it was phonologically correct or not. A 2 (word type: native vs. non-native) \times 2 (nature of feedback: without suggestions vs. with suggestions) \times 2 (test: pretest vs. posttest) analysis of variance was performed on the items' percentages of phonologically correct misspelled training words. Mean are listed in Table 4. Word type was treated as a between-subjects' variable and nature of feedback as well as test were within-subjects' variables.

Table 4. Mean Percentages of Phonologically Correct Misspellings of Training Words in Both Spelling-Checker Conditions.

Test	Without suggestions		With suggestions	
	Pre	Post	Pre	Post
Native words				
Mean	66.0	71.1	75.9	80.1
SD	22.9	24.6	22.9	26.1
Non-native words				
Mean	36.1	42.8	38.1	44.3
SD	27.1	21.0	30.6	28.0

Just two effects reached significant levels. The main effect of word type indicated that about twice as many spelling attempts of native words as opposed to non-native words were spelled phonologically correct (73% and 40%, respectively), $F_i(1, 22) = 12.36, p = .002, \eta^2 = .36$. The main effect of this test suggested that students committed more phonologically correct misspellings on the posttest than on the pretest (60% and 54%, respectively), $F_i(1, 22) = 4.74, p = .04, \eta^2 = .18$.

3.4 Quantity and quality of the spelling suggestions

To investigate the difference in spelling improvement of native and non-native words in the spelling-checker-with-suggestions condition, two analyses were conducted. First, we investigated the number of spelling suggestions provided by the spelling checker when the students misspelled words. Because there were no training records, the misspellings of the pre- and posttest were used to assess this measure. A 2 (word type: native vs. non-native) \times 2 (test: pretest vs. posttest) analysis of variance was performed on the number of suggestions to incorrect spellings based on pre- and posttest performance. Word type was treated as a between-subjects' variable and test as a within-subjects' variable. The main effect of word type appeared to be significant, $F_i(1, 323) = 45.02, p < .0001, \eta^2 = .12$. The mean number of suggestions for native-word misspellings ($M = 2.43, SD = 1.76$) was lower than for non-native misspellings ($M = 3.72, SD = 1.53$) in both pre- and posttest. Neither

Table 5a. Frequency Distributions in Percentages and Absolute Numbers of the Position of the Correct Spelling in the List of Suggestions based on Pretest Misspellings.

	1	2	3	considered correct	no suggestions provided
Native	67.4 <i>n</i> = 118	2.3 <i>n</i> = 4	7.4 <i>n</i> = 13	15.4 <i>n</i> = 27	7.4 <i>n</i> = 13
Non-native	17.6 <i>n</i> = 44	10.0 <i>n</i> = 25	6.8 <i>n</i> = 17*	8.8 <i>n</i> = 22	56.8 <i>n</i> = 142

* In two cases, the correct suggestion was fourth rather than third in the list of suggestions

Table 5b. Frequency Distributions in Percentages and Absolute Numbers of the Position of the Correct Spelling in the List of Suggestions based on Posttest Misspellings.

	1	2	3	considered correct	no suggestions provided
Native	68.4 <i>n</i> = 80	2.6 <i>n</i> = 3	6.0 <i>n</i> = 7	17.1 <i>n</i> = 20	6.0 <i>n</i> = 7
Non-native	17.4 <i>n</i> = 40	7.0 <i>n</i> = 16	5.2 <i>n</i> = 12*	13.5 <i>n</i> = 31	57.0 <i>n</i> = 131

* In one case, the correct suggestion was fifth rather than third in the list of suggestions.

the main effect of test ($F_i(1, 323) = 1.42, p = .23, \eta^2 = .004$) nor the interaction between test and word type reached significant levels $F_i < 1$).

Second, the quality of the suggestions was investigated by assessing the position of the correct spelling in the list of suggestions. The frequency distributions are listed in Tables 5a and 5b, and were subjected to Chi-square analyses. Both Chi-square tests revealed a significant relationship between the position of the correct suggestion and type of word; Pretest: $\chi^2(4) = 148.81, p < .001$; Posttest: $\chi^2(4) = 112.47, p < .001$. More correct spellings in the first position were suggested for native than for non-native misspellings. Moreover, in 57% of the cases, with respect to both pre- and posttest misspellings, no suggestions at all were provided for the non-native words, whereas for native words this occurred in 7.4% of the pretest and 6% of the posttest misspellings.

4. Discussion

The focus of this study pertained to the learning-to-spell process of Dutch students from Grade 2 using a spelling checker. The following four issues were investigated: The occurrence of implicit learning, the relative effectiveness of implicit versus explicit acquisition of spelling knowledge, the nature of explicit feedback on the improvement of spelling performance, and the quality of the suggestions provided by the spelling checker.

The first question was whether students would learn about the spelling of words implicitly. Stated differently, will they acquire spelling knowledge without being provided with feedback on the accuracy of their spelling? This appears to be the case. Spelling performance of words that were trained without any kind of feedback during training had increased significantly as a result of the typing training, whereas spelling performance on control words had not. We believe that this phenomenon is the result of implicit learning. An alternative interpretation is that students somehow learned some of the spellings during regular school hours. However, if students acquired spelling knowledge of the experimental materials during spelling lessons, the question remains why they did not learn as much about the spelling of the control words. It is possible that the typing training without feedback induced the emergence of a spelling consciousness (Lull in Tidyman 1924:349–50). Spelling consciousness is an instantiation of meta-cognition (Block & Peskowitz 1990:151–64), which could be defined as being aware of the state of one's knowledge (i.e., spelling knowledge). Studies in the Dutch language revealed that spelling awareness can be induced quite easily in students with and without learning difficulties (Willemen, Bosman, & van Hell 2000:173–82, 2002:22–25). Perhaps, the students who were confronted with unfamiliar spellings in the typing training became aware of the state of their spelling knowledge. While they were typing each of the 24 words three times during a period of six weeks, they probably realized that they were unfamiliar with the spelling of quite a number of the words. If at some point during the training period, they came across some of the words unintentionally, they might have learned about the spelling. Although the chance that they saw some of the control words unintentionally is equally large, it is less likely that would learn about the spelling, because awareness of the spelling of the control words was limited to a pretest occurrence only.

The second question concerned the issue of the relative effectiveness of implicit learning. After the training, spelling performance in the feedback conditions had increased significantly more than spelling performance in the no-feedback condition. This shows that explicit learning is indeed more effective than implicit learning. Thus, the answer to Graham's (2000:235–47) question whether natural learning should replace spelling instruction is a definite no. Dutch students in second grade clearly learn more when they receive feedback on their attempts to spell words.

The third question was whether the nature of feedback had differential effects on the acquisition of spelling knowledge. The hypothesis was that the spelling-checker-with-suggestions condition would be more effective than the spelling-checker-without condition. This hypothesis was not confirmed, because the overall difference between the two feedback conditions was not significant. The expectation concerning the differential effect of word type was not confirmed either.

In the spelling-checker-without-suggestions condition, students were expected to improve their knowledge to a larger extent on native words than on non-native words, and equally well in the spelling-checker-with suggestions condition. The opposite pattern emerged. Students who took part in spelling-checker-without-suggestions condition did equally well on both types of words, and students who participated in the spelling-checker-with-suggestions condition did much better on native than on non-native words; performance was almost three times as good. Thus, our assumption that Grade-2 students would be capable of hypothesizing about the spelling error in native words was not corroborated, only when suggestions were provided were they able to profit from the information that was offered by the spelling checker.

The fourth question pertained to the quantity and quality of the spelling suggestions offered. Not only was the number of alternative options for the misspellings of native words smaller than for non-native words, the correct suggestion also appeared more often in the first position when it concerned native misspellings. Moreover, in more than half of the cases the spelling checker was unable to provide even one single suggestion for a non-native misspelling. These findings explain why spelling performance of non-native words increased only marginally, and those of native words more substantially.

Although the spelling checker may be of help, our study also showed clear limitations, a finding corroborated by MacArthur (1996:344–54, 1999:169–92). He also analysed the workings of the spelling checker with the suggestions option made available and came to similar conclusions: a) they do not flag misspelled words that are actually words, b) they flag an error when it is a proper noun, c) they cannot provide a suggestion in case the misspelling deviates too strongly from the intended word, and d) the student may be unable to choose the correct suggestion. Moreover, the effectiveness strongly depends on students' academic level. The speller needs a certain amount of spelling knowledge to be able to benefit from the spelling checker (MacArthur 1999:169–92; Weekers, van Huygevoort, Bosman & Verhoeven, 2003: 28–36). Adult students with spelling disabilities, for example, appear to be able to use the spelling checker effectively (McNaughton, Hughes, & Clark 1997:643–51).

To conclude this study, we will discuss a number of implications for the educational practice. One, teachers do not need to be apprehensive about students writing words they might not yet know how to spell; even without being informed about the correctness of the spelling students appear to learn about the orthography. This effect is not limited to Grade-2 students. Spelling performance of Dutch students with spelling disabilities also benefited from writing assignments (Bosman, Schep-Ottevanger, & van Bon 1997:303–12). This is particularly relevant for students with learning disabilities, because they need to practise even

more than students without learning disabilities. Two, although implicit or natural learning does occur, teachers should know that explicit or direct instruction concerning spelling is warranted, because of its relative greater beneficial effects. Three, the spelling checker cannot (yet?) replace the Grade-2 teacher. For native Dutch words (i.e., words that obey typical phoneme–grapheme relationships), the spelling checker may provide adequate suggestion. However, with respect to non-native Dutch words (i.e., words with unpredictable spelling patterns), the spelling checker appears to be unable to provide adequate suggestions for students at second-grade level, due to the fact that their attempts deviate too strongly from the intended word. Only more sophisticated spelling-check software might perhaps solve this problem.

Notes

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1. In an attempt to assess the familiarity of the stimuli, the written and spoken frequencies of the stimuli (based on the adult written CELEX corpus Baayen, Piepenbrock, and Gulikers (1995) and the spoken corpus of Oostdijk (2000) were subjected to an ANOVA. No significant effects of word type (native vs. non-native) or condition (training vs. control) emerged on either of the dependent variables.
2. Initially, we conducted analyses that contained the variable context in which the training words were practised (in isolation or a sentence context). Because in none of the analyses, a significant main or interaction effects of the variable context occurred, we decided to drop this variable from the analysis.

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Appendix. Stimuli used in the Experiment

Training words	
Native	Non-native
allebei [both]	clown
dweil [floor cloth]	curry
eerlijk [honest]	douche [shower]
goudvis [gold fish]	jus [gravy]
heide [heather]	kangoeroe
hijskraan [crane]	ketchup
kauwen [to chew]	rugby
kleien [working clay]	scooter
kou [cold]	shirt
tapijt [carpet]*	station
vrolijk [merry]	ticket
wenkbrauw [(eye)brow]	training

Control words	
Native	Non-native
auto (car)*	blouse [shirt]
bijna (almost)	camera
drijven (to float)	camping
eieren (eggs)	chips
einde (end)	computer
flauw (bland)	flat
kiespijn (tooth ache)	frites [fries]
ontbijt (breakfast)	gel
onthouden (remember)	horloge [watch]
opvouwen (to fold)	lunch
paasei (Easter egg)	mixer
reizen (to travel)	pizza

schouder (shoulder)	race
springtouw	rails
veilig (safe)	route
vouwen (folds)	tank
zijkant (edge)	taxi
zout (salt)	team

* These words are not indigenous, but obey typical phoneme–grapheme relationships, and are as such native Dutch words.

