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THE ECOLOGY OF SPELLING INSTRUCTION: EFFECTIVE TRAINING IN FIRST GRADE

Since Huey (1908), reading and reading pedagogy have been popular topics among psycholinguists and educational researchers. Spelling and learning to spell, however, never reached the popularity of reading research. Yet, in most alphabetic languages spelling is more difficult than reading. Therefore, increased attention to beginning spelling is warranted. Our objectives with this chapter are both practical and theoretical. Our practical goal is to review what contributes to effective spelling instruction. Theoretically, we present a perspective on reading and spelling that helps us understand the basis of effective spelling-instruction. We also describe an empirical study that illustrates different outcomes of several instruction methods. After that, we discuss why some instruction methods are more successful than others and discuss some educational implications. This final section also broadly describes a theoretical framework within which to understand spelling and reading performance.

Reading and spelling are closely related, as suggested by moderate to high correlation's between scores on reading and spelling tests (see Frith, 1980; Mommers, 1987). However, reading and spelling are not each other's inverse (Frith, 1979; Read, 1981; Treiman, 1993). An asymmetry develops as children learn to read and spell. Not only is learning to spell more difficult than learning to read, spelling problems are also more persistent than reading problems (for a review see Bosman & Van Orden, 1997; Mushinski Fulk, & Stormont-Spurgin, 1995). Results from experimental studies show that merely reading words does not contribute greatly to spelling ability (Bosman & De Groot, 1992; Bosman & Van Leerdam, 1993).

If reading is not very effective for learning about words' spellings, how should spelling be taught? Various methods have been used to investigate this question. Next, we review four aspects of spelling instruction that have shown to contribute to enhanced spelling performance.

Kinematic aspect. A common and fairly straightforward method to teach spelling is having children copy words into a notebook. The effectiveness of this procedure has been studied experimentally. Results indicate that copying is a great deal more effective than reading (Bosman & De Groot, 1992; Bosman & Van Leerdam, 1993; Van Doorn-van Eijsden, 1984). One reason why children learn the spelling of words more effectively through copying may be because

P. Reitsma, & L. Verhoeven (Eds.), Problems and Interventions in Literacy Development, 307—320.

the actual kinematics of writing inculcates precise mnemonic constraints for writing movements of correct spellings.

To our knowledge, only one study has failed to find enhanced spelling performance after a copying training. Sears and Johnson (1986) tested a group of children from grades four to six, but did not find superior spelling performance in a copying condition as compared to a condition that involved visualizing the word and using the computer keyboard. Yet, it must be noted that in the condition using the computer keyboard, a correct response was followed by the request to spell the word by heart. Spelling from memory is itself an effective aspect of instruction, which may mask the effect of copying. As indicated by the studies above, when spelling from memory is not part of the training, the advantage for copying emerges.

For example, Cunningham and Stanovich (1990) assigned children from first grade to three different kinds of spelling training. In all three conditions, words printed on cards were presented to the child. After the experimenter named the word the child repeated it, and then reproduced the word either with a pencil on paper, or using letter tiles, or using a computer keyboard. The word remained visible throughout the training procedure. Spelling performance was assessed through a writing-to-dictation test. Children in the copying condition performed better than those in the letter-tile condition or in the computer condition. Thus, the precise motor activity of writing appears to benefit learning to spell.

From memory. People usually produce the spelling of words from memory when they write. Thus, training in which the spelling of words are produced from memory may differ in its effect from training in which spellings remain visible (see above, Sears & Johnson, 1986). Roberts and Ehri (1983) had second grade children rehearse the spelling of pseudowords, which they had seen several times before. One group of children were instructed to make visual images of the spellings of these pseudowords, followed by letter-analysis tasks requiring the use of those images. Another group performed the same letter-analysis tasks without the imaging instructions, but with the correct spellings in view. Subsequent spelling tests revealed that visualizing from memory led to superior spelling performance (see also Bosman & De Groot, 1992; Bosman & Van Leerdam, 1993; but see Van Daal & Van der Leij, 1992).

Immediate feedback. The importance of immediate feedback has been shown by Harward, Allred, and Sudweeks (1994). Spelling performance of fourth graders who received immediate visual feedback on the spellings they produced was better than that of children who received delayed visual feedback (Gettinger, 1993; but see Ormrod, 1986, in a study with college students).

Visual feedback that included imitation of children's spelling errors followed by immediate presentation of the correct spelling improved spelling performance of two mildly retarded children and one 12-year old with learning disabilities. Moreover, the contrast provided by error imitation benefited subsequent spelling performance more than just showing the correct spelling (Kauffman, Hallahan, Haas, Brame, & Boren, 1978; Gerber, 1984).

The effectiveness of on-line visual support was also investigated by Farnham-Diggory and Simon (1975). Third graders who learned the spelling of words by consecutive visual presentation of each letter of the word performed better on a spelling test than children who learned the words by consecutive oral presentation of each letter. Conversely, saying each letter while writing the word down appeared to be an effective way to improve spelling performance in children with learning disabilities (Kearney & Drabman, 1993; Bradley, 1981; but see Cunningham & Stanovich, 1990).

Whole word. Learning the spelling of a word is often a matter of learning to remember an ambiguous phoneme-to-grapheme relation. For example, in spelling the word Feel the phoneme [i:] presents the greatest difficulty. The letters F and L are relatively unambiguous, but for the vowel [i:], the phoneme can be spelled two different ways, either with EA as in DEAL, or with EE as in PEEL.

Bosman and De Groot (1992) tested a spelling training (i.e., problem naming) that involved practicing the ambiguous part of the word exclusively. Words were presented on a piece of paper with the ambiguous part, the target problem, underlined. The children who practiced the words in this condition were instructed to explicate the ambiguity in each word. Although this method was more effective than learning the spelling through reading, it was less effective than a condition in which the whole word was practiced, i.e., oral spelling. In this condition, children were instructed to read the word aloud and then spell it orally from memory. The superiority of the oral-spelling condition, requiring reconstruction of the whole word, was clear both in a test assessing the correctness of the entire word, as well as one in which target errors (i.e., ambiguous part) were assessed. Note, however, that oral-spelling also required that children practiced the spelling from memory, which was not the case in the problem-naming training.

Summary. This brief review of the literature on spelling-instruction methods provides insights concerning the effectiveness of spelling training. Reconstructing the spelling from memory appears more beneficial than having the spelling of the word available. Practicing the entire word may be more helpful than exclusively focusing on the ambiguous phoneme-grapheme part of the word. Both immediate feedback and the involvement of the kinematic modality may provide additional learning benefits.

In the study that follows, we illustrate the previous points by contrasting four different spelling-instruction methods comprising some or all four aspects. Young Dutch-speaking children learned the spellings of words by means of copying, grapheme selection, oral spelling, or visual dictation. We used reading, effectively, an implicit spelling training, as a baseline condition to assess four explicit spelling-instruction methods. The copying condition involves the motor aspect, it requires reconstructing the entire word, but not from memory. Visual feedback is provided to some extent in the form of a child's own hand-written spelling. Grapheme-selection training focuses on the ambiguous phoneme-grapheme relation in a word. It does not require the reconstruction of the entire word, but the ambiguous part is practiced from memory. Visual feedback and some motor movement is involved in the training. Oral spelling training does not involve handwriting, nor is visual feedback provided, but the spelling of the whole word must be reconstructed from memory. Finally, the visual-dictation training involves all four aspects, children must write whole words from memory. It is expected that the visual-dictation training that combines the four beneficial aspects will be the most successful spelling training. Another aspect we will investigate is the differential effectiveness of instruction methods for more advanced spellers and less advanced spellers.

METHOD

Participants

Seventy children, five groups of 14 children each, from regular primary schools participated in the experiment. All children attended first grade. Their mean age was 88 months at the time the experiment was conducted. The experiment took place in June, ten months after formal reading and spelling instruction had started.

All children were instructed according to the reading curriculum *Veilig Leren Lezen* (Caesar, 1979). The emphasis in this method is on phonics. Initially, only regular words are used. After four months of instruction, children are familiar with the main grapheme-phoneme relations. Assessment of reading and spelling levels is straightforward and reliable because the curriculum imposes a strict day-by-day and week-by-week program.

About one week prior to the experiment, we assessed spelling and reading levels of all children (see Table 1). Spelling level was estimated with a word-dictation test developed by the second author. The test consists of 20 words, and their orthographic complexity resembles those of the words from the curriculum. The score on the spelling test is the number of correctly spelled words in a dictation task. Each of the five groups of children was composed of seven more advanced spellers and seven less advanced spellers. The mean spelling scores of the five groups did not differ significantly from each other ($p > .30$), but the more advanced spellers scored higher on the spelling test than the less advanced spellers.

TABLE 1
Gender ratio, mean age (in months), mean word-reading level and mean spelling levels of children who participated in the study

				Spelling[b]		
Spelling Training	Girl/Boy	Age	Reading[a]	More advanced	Less advanced	N
reading	9/5	87	38.6 (16.7)	19.1 (0.4)	16.6 (2.1)	14
copying	6/8	89	39.9 (15.2)	19.1 (0.4)	15.9 (2.0)	14
grapheme selection	7/7	89	38.7 (10.6)	19.3 (0.5)	17.3 (0.8)	14
oral spelling	5/9	89	43.4 (13.2)	19.3 (0.5)	17.0 (1.0)	14
visual dictation	6/8	88	46.9 (14.1)	19.3 (0.5)	17.1 (0.9)	14
total	33/37	88	41.5 (14.1)	19.2 (0.4)	16.8 (1.5)	70

Note. [a] Maximum score is 100. [b] Maximum score is 20. Standard deviations in parentheses.

Reading level was assessed by means of a standardized test for reading-decoding. This test consists of a list of unrelated words. The score on the test is the number of words read correctly in one minute. The reading test scores of the five participant groups did not differ significantly from each other ($F < 1$).

Materials

Twelve words with at least one grapheme likely to be a spelling problem constituted the set of training words. All words were semantically familiar (see Krom, 1990), but orthographically unfamiliar to the children. All words were multi-syllabic, and their mean length in letters was 6.7 ($SD = 1.37$), with the shortest word having five letters and the longest nine. One grapheme in each word was assigned the target spelling problem. The target spelling problems are known to be causing difficulties for the beginning speller. Appendix A lists the words and their target spelling problems.

Procedure

The experiment consisted of a training and a test session. During individual training the children practiced spelling of the 12 training words three times each, making a total of 36 trials. A child practiced the training words according to one of four explicit spelling-instruction methods (copying, grapheme selection, oral spelling, and visual dictation) or practiced the words through reading. We describe each method, in turn, next.

Reading: children in this condition simply read the training words aloud. Each reading error was pointed out by the experimenter, and the child was asked to read the word again.

Copying: children assigned to this condition copied a printed list of the training words into a notebook. The experimenter encouraged the children to consult the list of target words throughout the training.

Grapheme selection: in this condition, children focused on the target spelling problem in each training word. The child was asked to read the word first. Subsequently, the experimenter covered the word, and presented one of the graphemes that occurred in the word and a possible (incorrect) alternative grapheme. The child circled the correct grapheme. Finally, the word was shown without the target grapheme, and the child filled in the missing grapheme.

Oral spelling: children in this condition read the training word from a list, and subsequently named each letter of the word without consulting its written form. Generally, children at this age use letter sounds to name the letters that constitute the word. In cases where letter-sound naming led to ambiguity concerning the letter, the experimenter asked the child for clarification.

Visual dictation: children in this condition were presented with each training word separately. The word was presented on a card for about 4 seconds. The children were encouraged to observe the word carefully. After the card was removed, the children wrote the word into a notebook.

The test session took place shortly after the training session was completed. Spelling knowledge of all target words was assessed individually in a writing-to-dictation task.

RESULTS

Training results. During the training, the experimenter kept note of the spelling errors made by the children, and the time it took each child to complete the training. Table 2 presents the mean number of spelling errors during training and the mean time-on-task.

A 5 (spelling training: reading vs. copying vs. grapheme selection vs. oral spelling vs. visual dictation) by 2 (spelling level: more advanced vs. less advanced) ANOVA on the mean number of spelling errors during training revealed significant main effects and a non-significant interaction effect. A significant difference in number of errors among spelling training conditions was apparent, $F(4, 60) = 2.83$, $p < .05$. The mean number of errors made by the children in the visual-dictation condition was significantly higher than those in the copying condition (Newman-Keuls, $p < .05$). None of the other conditions differed significantly from each other. More advanced spellers made fewer errors ($M = 5.5$; $SD = 4.3$) than less advanced spellers ($M = 8.0$; $SD = 5.6$), $F(1, 60) = 5.21$, $p < .05$. The maximum number of errors possible is 36.

TABLE 2
Mean number of spelling errors during training and the time it took the children to complete the training

Training results	Reading	Copying	Grapheme selection	Oral spelling	Visual dictation
Mean error rate [a]	5.3 (5.4)	4.1 (4.0)	6.9 (3.9)	8.4 (6.5)	9.1 (4.3)
Time on task [b]	3.1 (2.1)	18.2 (4.4)	13.5 (4.5)	12.4 (4.4)	23.5 (3.1)

Note. [a] Maximum is 36. [b] In minutes and seconds. Standard deviations in parentheses.

The same analysis of variance on the mean time-on-task variable also yielded significant main effects and a non-significant interaction effect. The children in the visual-dictation took longest to complete the training, followed by those in the copying condition. The children in the oral-spelling and the grapheme-selection training required statistically similar amounts of time, but needed more time than the children who participated in the reading condition, $F(4, 60) = 59.35$, $p < .001$. All differences of the time-on task variable, except the one between oral-spelling and grapheme-selection, were significant (Newman-Keuls, $p < .01$). Finally, the more advanced spellers ($M = 13.0$; $SD = 7.5$) took less time to complete the training than the less advanced spellers ($M = 15.44$; $SD = 7.5$), $F(1, 60) = 9.50$, $p < .01$.

Thus, both the results of the analysis on the number of spelling errors made during the training, and the results of the time-on-task variable indicate that the spelling training appeared somewhat easier for the more advanced than for the less advanced spellers. The results also indicate that there was no speed-accuracy trade-off between time-on-task and the number of errors made during training. After all, those children who took part in the visual-dictation condition needed more time to complete the training than any of the children in the other conditions, and they also had more trouble getting the spelling correct during the training. Keeping the spelling mentally available, as is required in the visual-dictation training, does not seem an easy task.

Test results. Two analyses of variance were conducted on the data of the dictation test: A 5 (spelling training: reading vs. copying vs. grapheme selection vs. oral spelling vs. visual dictation) by 2 (spelling level: more advanced vs. less advanced) ANOVA on the mean proportion of target errors, and the same analysis on the mean proportion of wrongly spelled words. Figure 1 presents the mean proportions of target errors of the more and less advanced spellers in all five spelling-training conditions.

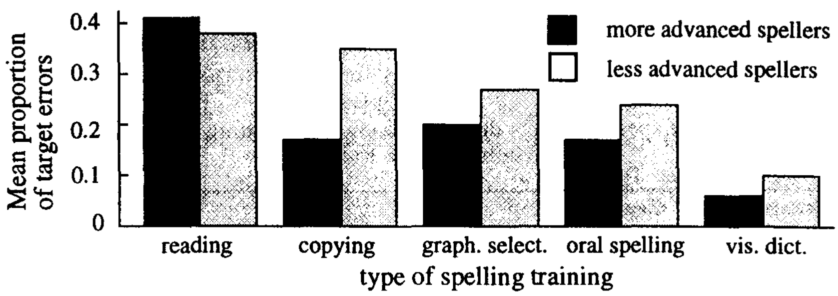

Fig. 1. Mean proportion of target errors on the dictation test for all five experimental groups. Standard deviations are presented in the text.

The analysis on the mean proportion of target errors yielded a significant main effect of spelling training, $F(4, 60) = 7.19$, $p < .001$, by subjects, and $F(4, 44) = 8.00$, $p < .001$, by items. Children in the visual-dictation condition ($M = .08$; $SD = .08$) made significantly fewer errors than the children in the remaining groups (Newman-Keuls, $p < .05$), and the children in the reading condition ($M = .40$; $SD = .12$) made significantly more errors than those in the other groups (Newman-Keuls, $p < .05$). The differences between the copying ($M = .26$; $SD = .22$), grapheme selection ($M = .24$; $SD = .18$) and oral-spelling ($M = .21$; $SD = .16$) conditions did not reach significant levels.

The main effect of spelling level was marginally significant, $F(1, 60) = 3.10$, $p = .08$, by subjects, and $F(1, 11) = 4.48$, $p = .06$, by items. More advanced spellers ($M = .20$; $SD = .18$) made fewer errors on the dictation test than the less advanced spellers ($M = .27$; $SD = .19$). However, the marginally significant interaction effect between spelling level and instruction level qualifies this result ($F < 1$, by subjects, and $F(4, 44) = 2.33$, $p = .07$, by items). Simple effects indicate that in the copying condition more advanced spellers benefited disproportionately as compared to less advanced spellers, $F(1, 11) = 5.10$, $p < .05$.

The same analysis on the mean proportion of wrongly spelled words revealed a similar pattern. The children in the visual-dictation condition made fewer errors than those in any of the other conditions, whereas children in the reading condition made more errors than children in the other conditions, $F(4, 60) = 6.89$, $p < .001$, by subjects, and $F(4, 44) = 19.43$, $p < .001$, by items. More advanced spellers ($M = .39$; $SD = .25$) made fewer errors on the dictation test than the less advanced spellers (M = .57; SD = .31), $F(1, 60) = 9.24$, $p < .01$, by subjects, and $F(1, 11) = 25.28$, $p < .001$, by items. Again, the interaction effect qualifies this result, $F(4, 44) = 7.12$, $p < .001$, by items, and $p > .25$ by subjects. In both the copying condition $F(1, 11) = 34.71$, $p < .001$ and the oral-spelling condition $F(1, 11) = 4.71$, $p < .05$ more advanced spellers benefited more than the less advanced spellers, whereas in the other conditions no significant differences emerged between the two groups.

Thus, both more advanced and less advanced spellers in the visual-dictation condition benefited most from the training. They outperformed their peers in all other conditions. The results suggest that more advanced spellers benefit more and from a greater variety of instruction methods than less advanced spellers. Less advanced spellers in the copying and in the oral-spelling condition did not benefit to the same extent as the more advanced spellers. Bosman and De Groot (1992) also found that less advanced readers/spellers in a copying condition were less effected by training than the more advanced children. Our finding that reading is not a very effective way to learn the spelling of words is supported by the results of earlier studies (Bosman & De Groot, 1992; Van Doorn-van Eijsden, 1984).

One explanation of why visual dictation is so successful might be that the children spent more time doing the training. However, this is not supported by the results of a correlational analysis. For most conditions, the longer children took to complete the training, the more errors they made in the dictation test. The values for the correlations between the time-on-task variable and the number of target errors was positive in all five conditions, reading: $r = .17$; copying: $r = .77$; grapheme selection: $r = .53$; oral spelling: $r = .74$, except the visual-dictation condition in which it was $r = -.04$ (significance is reached when $r < -.43$, or $r > .43$).

DISCUSSION

The results of our experiment corroborates the superiority of the visual-dictation training. This is not surprising. After all, visual-dictation includes all of the beneficial key aspects that we reviewed in the introduction, that is, practicing the whole word from memory, with immediate feedback and kinematics supporting the learning process. In this final section, we discuss the broad theoretical implications of these four aspects of spelling training. The point we want to emphasize is that instruction must include ecologically informative relations. Stated differently, we believe that training methods best reflecting the natural demands of spelling lead to the best subsequent spelling performance.

Most contemporary accounts of reading and spelling are information-processing-type theories, the most successful being Coltheart's Dual-route theory (1978). Spelling and reading are assumed to have a common basis in orthographic representations (e.g., Brown & Ellis, 1994; Hanley & McDonnell, 1997; Rapp, Benzing, & Caramazza, 1997). In such accounts, "inputs" (stimulus forms, e.g., spoken and written words) and "outputs" (the language functions they serve) have arbitrary relationships to the mental representations and processes that are proposed. Mental representations are symbols representing an abstraction of a stimulus or response, and are independent of the environment that initiate their activation. Consequently, with respect to our topic, any training method that "activates" orthographic representations should be as good as any other. However, the results of our study indicate that training methods do differ in their effectiveness. Conventional accounts thus require ad hoc ways of accounting for the demonstrated differences. Such ad hoc theorizing could be made very plausible, and our point is not to discredit these models with the present data. Rather, we wish to motivate an alternative framework in which the effects obtained in our study are more naturally expected.

The theoretical perspective we present is rooted in dynamic systems theory, which provides an alternative metaphor for cognitive systems (e.g., Thelen & Smith, 1994; Van Orden, Bosman, Goldinger & Farrar, 1997; Van Orden & Goldinger, 1994). Van Orden and colleagues framed reading and spelling in terms of a recurrent network. Recurrent networks are connectionist models in which activation flows from input to output and back again, creating feedback loops. The assumed dynamics approximate those of the interactive-activation model of McClelland and Rumelhart (1981). Behavior is modeled in self-organizing patterns of activation, but activation in any part of the network is always reflected throughout the network. Bi-directional flow of activation binds activation at each part to activation at every other part. Consequently, input (stimulus) and output (perceiver) become an irreducible whole, and the patterns of interrelation between input and output become the essential basis of theorizing. In contrast to information-processing theories, there is a meaningful or non-arbitrary relationship between the environment or the input (here, printed words) and the perceiver or the output (here, language functions of printed words). Accordingly, the behavior of a system (it being a network or cognizant organism) is determined by the history of the bi-directional correlations between a stimulus forms and their functions.

At this point, we need not concern ourselves with the details of the proposed network (cf. Bosman & Van Orden, 1997; Van Orden &

Goldinger, 1994; Van Orden, Pennington, & Stone, 1990). Three properties of the framework that we adhere to are relevant for our discussion here, namely, all parts of the network are interdependent, the type of input affects the output, and the history of the input-output relations is crucial for predicting future performance. Assuming that input and output have meaningful relationships explains why a spelling training that mimics natural spelling will be more beneficial than one that mimics natural spelling to a lesser degree. Natural spelling usually involves both writing whole words and writing them for memory. These aspects are combined in the visual-dictation training.

The benefits of training whole-word spellings also agrees with the claimed interdependency of input and output. For example, all letters and all phonemes of a word are intertwined through recurrent feedback. Each letter and each phoneme of a word contribute to the production of each letter in spelling (and to the production of each phoneme in reading). Training of just the ambiguous phoneme-grapheme relation (as in the grapheme-selection training) disregards an essential property of our account.

Immediate feedback is not usually provided during natural spelling. It makes a natural sense that it would be an important aspect of spelling training, however. For example, any account that includes associative learning, as is the case in a recurrent network, would work best when correct spellings are appropriately available to be associated. After all, it is important to prevent erroneous spellings to consolidate.

To conclude, the way we understand differential effects of various spelling-instruction methods comes less from the details of models than from the larger assumptions of the modeling framework. As we argued above, it matters that instruction includes ecologically informative relations. Once a child is viewed as a person situated in an environment (rather than as an information processing device) we expect factors like the kinematic modality to be important. The ecology of spelling is the production of written words to function properly in written language (e.g., to usefully reflect phonology and meaning). The ecology is relatively well represented in training that includes production of words from memory, actual writing of words, and immediate feedback so that errors are not perpetuated. This is precisely the collective message of studies reviewed here, and it is illustrated as well in the outcome of our study.

Finally, we wish to note a further entailment of our claims. In our study we found a differential effect of spelling level on the effectiveness of spelling training; the less advanced spellers hardly benefited from the copying training, whereas the more advanced spellers did.

Thus, there is unlikely to be one solution to teaching spelling across languages and cultures. Not only do languages have different functional relations with their printed forms, but cultures have different relations to literacy, both in perceived importance and material support. Thus, the ecology of natural spelling may change in a language that is not more ambiguous from phonology to spelling (e.g., Hebrew; Berent, Frost, & Perfetti, 1997) or in a culture in which literacy must be taught without notebooks (see Verhoeven, 1994). A focus on organism-environment relations may escape the attractive simplicity of one-size-fits-all educational programs. To be most effective, instructional methods must evolve to fit the ecology of literate cultures and the functional relations of print to language.

NOTE

We are greatly indebted to all teachers and children from primary schools in Alkmaar, The Netherlands: In den Bongerd, De Meerpaal, De Middelburg, De Rank, Tesselschade, and De Vogelboom. Thanks to Charles Perfetti who helped us thinking up a name for the training method 'grapheme selection'. The research reported here was carried out while the second author was appointed at the Department of Psychology of the University of Amsterdam. Preparation of this article was partly supported by an Independent Scientist Award (1 K02 NS01905-01) of the National Institute of Neurological Disorders and Stroke awarded to Guy C. Van Orden.

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APPENDIX A

Stimuli used in this experiment with English translations in parentheses and means of the target errors per item; Target spelling problem is italicized.

Stimulus	Reading	Copying	Graph.Select	Oral Sp	Vis.Dict.
Pal*ei*s (palace)	.50	.21	.36	.36	.00
St*ou*terd (naughty boy/girl)	.21	.29	.14	.29	.07
Ka*ch*el (stove/heater)	.79	.43	.57	.14	.14
Ron*d*je (round/lap)	.57	.43	.29	.21	.07
*V*uilnis (garbage)	.07	.00	.00	.00	.00
Mo*dd*er (mud/dirt)	.64	.36	.50	.29	.21
Schilder*ij* (painting)	.07	.14	.00	.07	.14
Mi*au*wen (miaow)	.64	.43	.36	.29	.00
Na*g*el (nail)	.07	.00	.00	.14	.14
Bloo*t* (nude)	.14	.14	.14	.00	.00
Panto*ff*el (slipper/house shoe)	.86	.29	.36	.43	.00
He*n*gel (fishing rod)	.14	.36	.14	.21	.14