

## The Effect of Morphological Training on Word Reading and Spelling of Iranian Dyslexic Children

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**Abstract:** There is little direct verification of a causal relation between dyslexic children's morphological knowledge and the progress that they make in reading. Here we report the results of two intervention studies which say learning to read depends on dyslexics being aware of morphology as well as of phonology. In the first study some children were taught about morphologically-based spelling rules and others about phonological rules. The morphological training had beneficial and non-specific effects on word reading that were similar to those obtained with phonological training. In spelling, morphological training had specific effects on the learning of morphological spelling rules. The second intervention study was with dyslexic children who had fallen behind in reading, some of whom were taught about morphology and spelling rules and others about phonological rules. Our intervention did not improve these children's reading, but we found evidence of specific effects on children's learning of morphological spelling rules.

**Key words:** Morphology • Phonology • Intervention • *Dyslexia*

### INTRODUCTION

It is now widely recognized that morphological awareness plays a role both in learning to spell and to read in Farsi as well as in other languages [1-4]. Longitudinal studies, help us understand whether morphological awareness is a predictor or a consequence of learning to read and spell with morphemes [2, 5]. However, the evidence provided by longitudinal research should be complemented by intervention studies in the test of causal hypotheses [6]. If we succeed in improving dyslexic children reading and spelling through morphological training studies, the evidence in favor of a causal connection between morphological awareness on the one hand and reading and spelling on the other, will be considerably stronger.

Here we elaborate on two intervention studies that analyzed the effect of instruction aimed to improve children's morphological awareness on word reading and spelling. In the first section we demonstrate why morphology plays a role in reading and spelling Farsi and create the underlying principle for the assessment of specific morphological processes in reading and spelling. Section two reports an intervention study with pupils aged seven to ten years in different places across Iran. Section three reports a second intervention study that

assessed the effect of teaching morphological awareness on dyslexic children. The last section summarizes the results and discusses their theoretical and practical implications.

### The Importance of Morphology in Spelling and Word

**Reading:** Morphology is represented in Farsi spelling both in the protection of stems across words and in the fixed spelling of affixes. The importance of the conservation of stems is easier to understand when the stem's pronunciation changes across words but the spelling remains constant. In this case, spelling can flout regular grapheme phoneme correspondences in one of the words. In 'dastband', which in English means bracelet, for example, the letter T is omitted through phonological processes and in speech it is pronounced as "dasband"; the T is remained here because the stem from the base form "dast" is preserved in the derived form.

The fixed form of affixes is also a powerful source of information for correct spelling in Farsi. The use of the "mi" for present progressive verbs and "n" for negatives are significant examples. The sound of some verbs varies across situation (e.g., "mibarad" is written like "mibord", which in English means: "carry something by somebody" both of which have different pronunciation,) but the spelling is constant because it is based on a suffix. In

contrast, the "/a:/" vowel as the middle of “khaar” and “khavaar” sound the same but we use different spellings. These examples show how it is possible to assess specifically the use of morphology in spelling by choosing examples where the spelling cannot be determined simply from phonology.

Identifying morphemes in long words can be a useful word attack strategy: words like ‘zibatarein’ (the most beautiful) and ‘hayajan angiz’ (exciting) might be more easily identified if the reader is able to break them up into stem and affixes. Dual route models of the type proposed by Caramazza and Taft assume that lexical access involves the analysis of the morphemic structure of written words as well as direct access to one morpheme written words. Such models also attribute a role to phonological units in reading and spelling. They provide an alternative hypothesis to single route models because they propose that it is possible to improve children’s word reading and spelling either through phonological training or through morphological training – there are two different, though not completely independent, routes to improving word reading and spelling [7, 8]. This is the type of theory that we used in the design of our research.

**Study 1: The Effect of Teaching Morphological Analysis on Word Reading and Spelling:** Previous research strongly suggests that it is important that children make sufficient progress in reading and spelling before they can use morphological strategies efficiently [4]. Thus the intervention study that we report here involved children who were beyond the initial stages of learning to read. Because Iranian children start reading instruction at about 6 or 7 years, we decided to work with children in their second and third year of instruction, when they were in the age range 8 to 9 years.

The study involved training both phonology and morphology. There were two reasons for working with both types of training. First, our theoretical framework was a dual-route model, in which there is both a phonological route and a lexical route to reading. It is known that phonological training at earlier ages has a positive effect on children’s reading and spelling [6, 9] but much less is known about the effectiveness of phonological training at later ages. So it was important to include phonological training in the study in order to show that interventions can still be effective at a later stage. Second, a comparison between phonological and morphological teaching should provide evidence to help us to tease out general and specific effects of intervention.

According to our analysis, both morphological and phonological intervention should have beneficial effects on reading and spelling in general but there is also the possibility of specific effects. In spelling, morphological intervention should increase children’s knowledge of morphologically-based rules such as the conservation of stems across words and the fixed form of affixes without affecting their learning of phonological rules.

In reading, the two types of intervention may have positive effects that are to some extent difficult to distinguish, because both phonology and morphology play a role in parsing words during the word recognition process. However, specific effects of morphological intervention in reading can also be hypothesized in the case of morpheme boundaries that break a common digraph. A second specific effect of morphology on word reading can be hypothesized with respect to the conditional rule for the pronunciation of “n” in negative words, as an instance. If “n” is part of the word, its pronunciation differs from the time when it is a prefix. We note, though, that there are relatively few such instances and there is to date no strong evidence that children or adults use, or know anything about, these conditional morphological rules in word recognition tasks. Research on phonological intervention has shown quite clearly that it is much more successful when the children are taught about phonological distinctions and their relation to written spellings, than when they are taught about the phonological distinctions alone [6, 10, 11]. The implication of this result is that one should routinely compare the difference between two kinds of intervention: those that aim only to increase explicit linguistic knowledge and those whose purpose is to teach children linguistic knowledge and also to tell them about the connection of this knowledge to written language.

These are the reasons why we planned and carried out a large-scale intervention study on the effects of instruction in phonological and morphological knowledge. We predicted that the phonological and the morphological training would have both general effects on word reading and spelling, which could be assessed by standardized tests, but that morphological awareness would also have specific effects, which could be demonstrated in assessments involving the rules that we discussed in the preceding section (for a detailed description, see Learning morphological and phonological spelling rules [12]).

## MATERIAL AND METHODS

**Participants:** Children from four schools from four provinces in Iran (N=380) were employed for the study. The children's mean age was 7 years and 8 months. The schools were randomly assigned either to the intervention or to the control group after we attempted to match the schools by socio-economic intake. The experimental groups included 198 children and the control group included 182 children, with approximately the same number of boys and girls. There was a loss of 18 participants (4.7%) between pre- and post-test, five from the experimental groups and thirteen from the control group. In each of the schools that provided participants in the experimental groups, one Year 2 and one Year 3 class participated in the study. In each class, the children were randomly assigned to one of the four intervention groups following the class roster, with the restriction that at least two children of the same sex should be present in the group. The project included 32 sets of children, 4 sets in Year 2 and in Year 3 in each of the four schools. The sets varied in number as a function of class size.

**Design:** There were four intervention groups, two that received morphological and two that received phonological training. Each of these forms of training was either offered in oral mode only or in association with writing. The groups will be referred to as Morphological Training Along (MTA), Morphological Training with Writing (MTWW), Phonological Training Alone (PTA) and Phonological Training with Writing (PTWW). Training was implemented during regular school hours. There was also an unseen control group.

### Procedure

**Pre-test and Post-test Assessment:** The Pre-test assessments were administered in the autumn and at the beginning of the Spring term before the intervention (which was carried out in the Spring term and the Summer term). The Post-test assessment tests were administered at the end of the summer term. The Pre- and Post- test assessments consisted both of reading and spelling measures, where we predicted specific intervention effects and of a mathematical reasoning test, where we expected no intervention effects. The insertion of a mathematics task served as a check that the intervention effects were due to the intervention itself rather than to the children receiving more attention from the experimenters during the project. If there are valid intervention effects, there should

be gains only in the literacy measures. A shortened version of the WISCIII (Wechsler Intelligence Scale for Children, 3rd. ed. (WISC-III, 1991) was administered at Pre-test to be used as a co-variate in the analyses of treatment effects. The reading and spelling measures included in the Pre-test investigated children's use of conditional morphological rules and conditional phonological rules. At Post-test we repeated the Pre-test measures and we also used two standardized assessments of reading and spelling, which were the final exams of schools including both reading and spelling.

**Assessment of Reading:** The reading assessment in the Pre-test and Post-test included words and pseudo-words that involved conditional phonological or morphological rules. We used these stimuli to compute three scores. The first one was a total word reading score, obtained by adding the number of correct responses for each word.

We also computed a specific score for reading words with phonological rules and a specific score for reading words with morphological rules. Due to limitations of space, only the results of the assessment of word with morphological rules are considered in Study 1. The real words and pseudo-words that involved *morphological rules* included examples where there was a need to identify morphemes to obtain the correct pronunciation.

**Assessment of Spelling:** The spelling assessment in the Pre-test and Post-test was also designed to include words and pseudo-words that involve conditional phonological and morphological rules. Similarly to the reading assessment, the spelling assessment provided an overall score, where a point was given for each word spelled correctly. The specific score for the use of *morphological rules* in word spelling was based on the correct spelling of derivational suffixes. Pseudo-words were included in the assessment to provide information about children's conservation of the stem when there is a phonological change due to the addition of a suffix. The method for the spelling of pseudo-words was to provide the children with a written sentence, where a word was missing; the child was told what the word was and asked to spell it. The morpheme to be used in the pseudo-word was provided in the written portion of the sentence. The scoring for this pseudo-word assessment was a pass if the child reproduced the stem exactly in the pseudo-word and a fail if the stem was not reproduced in the pseudo-word. Thus word spelling produced information on the correct use of suffixes and pseudo-word spelling produced information on conservation of the stem across related stimuli.

**Assessment of Mathematics:** The mathematics assessment is a group-administered test with instructions given orally in order to diminish the effects of reading on the children's score. The children work on booklets that contain pictures with the basic numerical information needed to solve the problem in order to decrease the effects of memory on performance [12].

**The Intervention:** We taught children in small groups in 14 weekly intervention sessions. All the sessions consisted of games, the aim of which was to promote explicit understanding either of morphological rules or of phonological rules.

The procedures were purely oral for children in the Morphological Training Alone and Phonological Training Alone groups. In contrast, the children in the Morphological Training With Writing and the Phonological Training With Writing groups were taught how to instantiate the rule at the centre of the activity in writing.

The activities in the games involved the cognitive operations of classification, segmenting, blending and analogy. These operations can be used easily in teaching children about morphology and phonology; thus we were able to make the task demands of the morphological and phonological training equivalent. For example, in the games that involved classification, the children in the phonological groups classified words in terms of similarity of phonemes, whereas the children in the morphological groups classified words into grammatical categories. Similarly, analogies were used with both types of training: whereas the children in the phonological groups made phonological transformations to words that were analogous to those made by the researcher, the children in the morphological groups produced morphological analogies. Blending activities were also used in the games. In the phonological group the children had to blend onsets with rimes that contained either long or short vowels and assess whether they had formed a word. In the morphological groups, the children had to use stems and affixes to form a word.

All games were specifically designed for this project. Each session lasted for approximately half an hour. Because different sets of children progressed at varying speeds, the amount of time spent with each set of children varied, but the quantity of material covered was held constant across groups receiving the same treatment.

## RESULTS

Our purpose was to see if our interventions affected the children's general progress in reading and spelling and to analyze whether the intervention effects were specific to the training that the children had received.

In spite of our attempt to distribute children of similar socio-economic backgrounds to the intervention and control group and in spite of the random assignment of children within each class to one of the four intervention groups, the groups differed significantly at Pre-test on several measures. The means and standard errors for the different overall Pre-test measures of reading and spelling and also the IQ scores are included in Table 1, which also reports the existence of significant group differences at Pre-test in several one-way analyses of variance.

Because of this roughness in the Pre-test scores of the five groups, we assessed the intervention effects by means of one-way analyses of co-variance in each of which the dependent variable was one of the post-intervention scores and the co-variables were the equivalent pre-intervention score as well as IQ and age. In the case of the standardized tests, which were only given at the time of the post-test, we used the overall score in our reading assessment at pre-test as a co-variate. This Pre-test score correlated highly with the standardized reading scores and with the standardized spelling score (both correlations were above .8). Table 2 presents the adjusted mean post-test scores for the standardized spelling and reading tests. Table 2 shows that the children in all four intervention groups did better than those in the control group in the standardized reading and spelling tests. The group effect was significant in the analysis of the *standardized reading scores* ( $F(4,402)=6.36; p<.001$ ).

Table 1: Means (adjusted for age at testing) and standard errors (in brackets) for the children's WISC IQ and the assessments of reading and spelling words with hierarchical rules

Intervention Group	WISC IQ	Word Reading	Word Spelling
Phonology Alone	93.65 (2.44)	21.12 (1.72)	8.41 (1.14)
Phonology with Writing	97.11 (2.49)	23.21 (1.74)	9.81 (1.16)
Morphology Alone	98.03 (2.44)	26.45 (1.72)	11.21 (1.14)
Morphology with Writing	96.48 (2.44)	26.13 (1.72)	11.19 (1.12)
Control	104.66 (1.58)	31.16 (0.79)	13.02 (0.76)

A significant main effect of group was observed in all analyses

Table 2: Adjusted means for the Standardized Score in the Spelling and Reading Tests and standard error (standard error in brackets) by group

Intervention Group	Spelling Test	Reading Test
Phonology Alone	113.43 (1.41)	122.47 (1.40)
Phonology with Writing	115.38 (1.47)	121.45 (1.48)
Morphology Alone	113.17 (1.41)	119.23 (1.42)
Morphology with Writing	115.26 (1.41)	120.17 (1.40)
Control	111.25 (0.75)	114.36 (0.71)

Table 3: Adjusted Mean Scores in the Assessments of Spelling Derivational Suffixes and Spelling Stems in Pseudo-words and Standard Error by Group

Intervention Group	Derivational Suffixes(Maximum Score=9)		Stems in Pseudo-words (Maximum Score=10)	
	Pre-test	Post-test	Pre-test	Post-test
Phonology Alone	1.82 (0.37)	4.34 (0.34)	3.71 (0.35)	4.45 (0.31)
Phonology with Writing	2.43 (0.36)	4.82 (0.31)	4.08 (0.37)	4.81 (0.33)
Morphology Alone	2.72 (0.33)	4.02 (0.29)	3.70 (0.35)	5.31 (0.30)
Morphology with Writing	2.81 (0.36)	5.67 (0.29)	4.18 (0.33)	5.12 (0.27)
Control	3.01 (0.19)	4.27 (0.16)	4.21 (0.19)	4.75 (0.16)

Post-hoc least significant pair-wise comparisons established that all four intervention groups significantly outperformed the Control group ( $p < .01$ ). Thus we conclude that both phonological and morphological interventions have a beneficial effect on children's word reading progress. Because the measure used here was a standardized test, not designed to identify the specific effects of either phonological or morphological training, these results provide strong support for the dual route models that we presented in the introduction.

The group difference was not significant in the analysis of the *standardized spelling scores* ( $F(4,395) = 1.61$ ;  $p = .136$ ). In post-hoc least significant pair-wise comparisons the Phonology with Writing and the Morphology with Writing groups showed a significant superiority over the Control group ( $p = .051$  and  $p = .05$ , respectively). The overall negative result suggests that it is not sufficient to increase children's linguistic awareness in order to improve their spelling; the training must involve the co-ordination of linguistic awareness with writing. This finding is in line with previous research that produced stronger training effects when linguistic awareness and writing were presented together.

#### Analysis of Specific Effects of Morphological Training:

Due to space limitations and the novelty of results regarding morphological interventions, the analysis of specific effects concentrates on this type of training. Table 3 presents the means for the *spelling* of words and pseudo-words where morphology played a part. The Post-test scores for our specific measures of the use of morphology in spelling showed definite signs of the effects of intervention. There was a significant group difference in the number of correct spellings for

derivational morphemes ( $F(4,391) = 4.69$ ;  $p < .001$ ); post-hoc least significant pair-wise comparisons established that the Morphology with Writing group significantly outperformed the Control group ( $p < .001$ ) and that there were no other specific group differences for this measure. There was no significant overall group difference in the analysis of the score for preservation of the stem spelling in pseudo-words ( $F(4,399) = 1.98$ ;  $p = .106$ ). However, post-hoc least significant pair-wise comparisons established that the Morphology Training Alone group significantly outperformed the Control group ( $p < .04$ ) in this measure. Thus the effects on children's use of morphological spelling rules were specific: only the morphological groups benefited from the intervention.

There were no effects of our interventions on the use of morphological rules in *reading*: neither the phonological nor the morphological intervention groups performed significantly differently from the control group.

We found no effects of the intervention on the measure of mathematical reasoning. This indicates that the observed effects of the intervention on reading and spelling cannot be attributed to a halo effect due to the children in the intervention groups receiving more attention from the experimenters.

#### DISCUSSION AND CONCLUSIONS

This study established for the first time, especially in the context of Iran and on Farsi language, that morphological training has beneficial effects on word reading that are similar to those obtained with phonological training. Only general effects on word reading were observed; there was no evidence of specific effects. A different picture emerged with respect to effects

of morphological training on word spelling: whereas there were no general effects documented in a standardized test, specific effects were established in word spelling where spelling represents morphology. These results support dual models that include the notion of morpheme representation in the lexical route.

The educational implications of evidence supporting a dual route model are clear: both phonological and morphological instruction can benefit word reading and spelling and should be contemplated in the curriculum. It should be borne in mind that the interventions carried out in this study offered each of these trainings to different children. The effects of training the same group of children both on phonological and on morphological rules might be considerably stronger but there is no relevant evidence so far. Because of the effectiveness of the morphological instruction on word reading, we decided to design a second intervention study, where we would offer morphological teaching to children who have fallen behind in reading by age 9. It is well documented that dyslexic children have phonological difficulties in comparison with normal readers of the same reading age but this is not the case with morphological awareness [13]. The study is reported in the section that follows.

**Study 2:** The Effect of Morphological and Phonological Interventions on Dyslexic Children' Word Reading and Spelling Progress

## **Study 2**

**Introduction:** Dyslexia is a learning disability that makes itself manifest primarily as a difficulty with the visual notation of speech or written language, particularly with reading the various man-made writing systems. It is separate and distinct from reading difficulties resulting from other causes, such as a non-neurological deficiency with vision or hearing, or from poor or inadequate reading instruction [14]. There are many definitions of dyslexia but no consensus. Some definitions are purely descriptive, while others embody causal theories. It appears that 'dyslexia' is not one thing but many, in so far as it serves as a conceptual clearing-house for a number of reading skills deficits and difficulties, with a number of causes (National Research and Development Centre for Adult Literacy and Numeracy).

Formal diagnosis of dyslexia is made by a qualified professional, such as a neurologist or an educational psychologist. Evaluation generally includes testing of reading ability together with measures of underlying skills such as tests of rapid naming to evaluate short term

memory and sequencing skills and non-word reading to evaluate phonological coding skills. Evaluation will usually also include an IQ test to establish a profile of learning strengths and weaknesses. While such "discrepancy" tests between full scale IQ and reading level have, on their own, been shown to be flawed, the tests often include interdisciplinary testing to exclude other possible causes for reading difficulties, such as a more generalized cognitive impairment or physical causes such as problems with vision or hearing [15].

Dyslexia has many underlying causes that are believed to be neurological conditions that influence the ability to read written language [16].

The following conditions may be contributory or overlapping factors or underlying cause of the dyslexic symptoms as they can lead to difficulty reading:

Auditory processing disorder is a condition that affects the ability to process auditory information. Auditory Processing Disorder is a Listening Disability [17]. It can lead to problems with auditory memory and auditory sequencing. Many people with dyslexia have auditory processing problems including history of auditory reversals and may develop their own Logographic cues to compensate for this type of deficit. Auditory processing disorder is recognized as one of the major causes of dyslexia [18]. Some children can acquire auditory processing disorder as a result of experiencing otitis media with effusion and other severe ear conditions [19].

Scotopic sensitivity syndrome, also known as Irlen Syndrome, is a term used to describe sensitivity to certain wavelengths of light which interfere with visual processing [19].

Developmental dyspraxia is a neurological condition characterized by a marked difficulty in carrying out routine tasks involving balance, fine-motor control, kinesthetic coordination, difficulty in the use of speech sounds; problems with short term memory and organization are typical of dyspraxics [20].

The aim of this study was to investigate the effects of morphological and phonological interventions on dyslexic children's word reading and spelling. The effectiveness of these two interventions can be conceived as a comparison between either teaching to the strengths or compensating for the weaknesses in the dyslexic children' linguistic awareness. Although the use of morphological strategies in reading and spelling is unlikely to be completely independent of the children's phonological abilities, the question that we wished to examine was whether it is possible to improve dyslexic

children' word reading and spelling through the conscious use of morphological strategies (for a detailed report, see Teaching to strengths or overcoming difficulties [21].

### **Methods**

**Participants:** Participants were drawn from 10 schools and were initially identified by their psychiatrist and speech and language therapist as dyslexic children. After consent was obtained from the parents and the children, the children were assessed through the WISCIII and the WORD test to verify whether they fit the inclusion criteria of IQ in the normal range and average delay in reading and spelling of at least 18 months. Some children originally identified by the psychiatrist were excluded because their delay in reading and spelling was not sufficiently severe. The sample included 47 children from 10 schools in 37 different classes (6 children from Year 4, 19 children from Year 5 and 22 children from Year 6). The children's mean chronological age was 135.85 months (SD=7.87); their mean reading age was 93.95 months (SD=9.87); their mean spelling age was 92.44 months (SD=7.21); the mean delay in word reading and spelling was 29.68 months (SD=8.12); their mean verbal IQ was 98.9 (SD=9.53); their mean performance IQ was 94.10 (SD=12.69); their mean overall IQ was 98.29 (SD=9.63).

**Design:** Two treatments were used to allow for comparison between a phonological and a morphological intervention; for both groups, games designed to promote linguistic awareness were co-ordinate with reading and spelling. The control group was unseen. The children were randomly allocated to a group with the restriction that there was at least one child in each school allocated to the each group. In order to extend the treatment to more children, in schools where at least five participants were identified, an extra child was randomly allocated to each treatment group. The final number of participants by group was: 17 children in the phonological intervention group, 17 in the morphological intervention group and 13 in the control group. A one-way ANOVA did not indicate significant differences between the groups at pre-test. However, the control group had higher chronological, reading and spelling ages, so the analyses will include statistical controls for these differences.

**Pre- and Post-test Measures:** The pre- and post-test measures included a standardized word reading and spelling measure, the final examinational school which included reading and spelling questions and the word and

pseudo-word reading and spelling measures developed for Study 1. This assessment produces specific scores for reading and spelling words with conditional phonological rules and conditional morphological rules. At pre-test the children were also given an abbreviated form of the WISC.

**The Treatments:** The treatments consisted of 22 weekly sessions of approximately 50 minutes each. They were administered individually by one of eight trained researchers or teachers; each worked with all the children in the treatment and control groups in the same school. The sessions comprised activities developed for each intervention group, administered at the child's own pace. This allowed for a flexible approach to the treatment but a great degree of uniformity in the core activities. Five children completed all the activities in fewer than 22 sessions. Similarly to Study 1, the intervention programs - phonological and morphological - were designed for children whom we expected to have made some progress in the initial stages of reading and to have learned simple letter-sound correspondences.

However, our initial assessments revealed that 5 of the 34 children in the treatment groups did not meet this target: three of these were in the phonological treatment group and two were in the morphological treatment group. They were not excluded from the treatments but they were excluded from the analysis of the effects of the intervention because the treatments were designed for children who could use letter sound correspondences.

The activities used in the interventions were those developed for Study 1 but adapted for individual work. A larger number of activities were used because more intervention sessions were delivered; some conditional rules not taught in Study 1 were included

### **Results**

**Standardized Measures:** The increase in the children's mean reading age varied from the pre- to the post-test with their group membership. The mean increase in the control group was 7.2 months, which is equivalent to the time elapsed between pre- and post-test. The mean increase in the phonological treatment group was 14.23 months and in the morphological treatment group was 12.08 months. The mean adjusted standardized reading scores at post-test were 80.07 for the control group, 86.79 for the morphological treatment group and 90.03 for the phonological treatment group. An analysis of co-variance was carried out with standardized reading scores (to control for age differences) at post-test as the dependent variable, group membership as the independent variable

and the standardized reading score at pre-test as a covariate. No overall effect of group membership was observed ( $F=2.75$ ;  $p=0.14$ ). Post-hoc tests showed that the phonological treatment group differed significantly from the control group ( $t=2.43$ ;  $p=0.062$ ) but the morphological treatment group did not differ significantly from the control group ( $t=1.41$ ;  $p=0.23$ ). The two treatment groups did not differ significantly from each other ( $t=0.79$ ; ns). Analysis of the treatment effects on word spelling showed that the groups improved much less from pre- to post-test in spelling than in reading. The improvement was of 3.92 months in the control group, 4.21 months in the phonological treatment and 4.86 months in the morphological treatment group. The mean adjusted standardized word spelling scores at post-test were 73.52 for the control, 75.83 for the morphological and 75.27 for the phonological treatment groups. An ANCOVA with the standardized spelling scores at post-test as dependent variable, pre-test standardized spelling scores as covariate and group membership as the independent variable did not reveal any significant differences.

We conclude that the phonological intervention was effective in improving dyslexic children's word reading but the morphological intervention, in spite of producing a large positive effect, failed to show significant results.

**Specific Effects on Words with Conditional Morphological and Phonological Rules:** Standardized assessments do not allow for the analysis of specific effects, which were evaluated through the different scores observed in our own assessments. The children made different levels of progress in the assessment of their use of morphology in spelling but not in the reading measure as a function of group membership. In spelling, the control group improved on average by 2.03 words; the phonological treatment group improved 1.92 words and the morphological treatment group improved 6.78 words. An ANCOVA with group membership as the independent variable, post-test scores as the dependent variable and pre-test scores as a covariate showed a marginally significant effect on the spelling measure ( $F=3.13$ ;  $p=0.08$ ).

Post-hoc tests showed that only the difference between the morphological treatment group and the control group approached significance ( $p=0.093$ ). The specific measures of progress in *reading* words that involve conditional phonological rules showed an average improvement equal to 7.02 words for the control group, 8.23 for the morphological treatment group and 11.05 for the phonological treatment group. An ANCOVA with this assessment at post-test as the dependent variable and pre-test scores on the same assessment as

covariate showed a significant effect of group membership ( $F=5.12$ ;  $p=0.03$ ). Post-hoc tests showed that the only significant difference was between the phonological treatment group and the control group ( $t=2.96$ ;  $p=0.005$ ). No significant differences were observed in *spelling* words and pseudo-words with conditional phonological rules. Thus specific assessments of reading words and pseudo-words with conditional phonological rules showed a significant effect of phonological treatment but no effects were observed in spelling. The reverse was observed with respect to morphological rules, where a tendency towards a significant effect was observed as a function of morphological training on word spelling but not reading.

## DISCUSSION AND CONCLUSION

The results of the two studies converge in demonstrating unequivocally the effectiveness of the phonological intervention on *word reading* even when administered at a later stage in literacy learning and even if the children have fallen significantly behind in reading and spelling. The results failed to show a similar improvement on *word spelling* as a function of phonological training.

Morphological training was effective in producing significant improvements in word reading with normal readers but the effect with dyslexic children, though sizeable, did not reach significance. The small number of children in the second study might explain this failure to show significant improvements; the level of progress observed in the dyslexic children can be seen as encouraging. The weaker results with morphological training in comparison to phonological training suggest that dyslexic children must find ways of conquering their phonological difficulties: compensating for these through the use of morphological strategies is insufficient. It can be hypothesized that the level of skill in phonological representation interacts with the possibility of using morphological strategies; this interaction might explain why morphological training was successful with normal readers but not with dyslexic children.

The results also converge in showing that specific effects of morphological interventions on word spelling can be expected in future studies: these effects were unambiguous in Study 1 and almost reached significance in Study 2. In contrast, there are a much more limited number of occasions when morphology is called into play in word reading to override usual grapheme-phoneme correspondences and thus the evidence suggests a much less important effect of morphology on word reading.



These intervention studies extend current knowledge of processes involved in word reading and spelling in three ways. First, they provide clearly identifiable facts for the effectiveness of interventions at a later stage in reading, in spite of claims that dyslexia is refractory to intervention after the age of eight [9]. Second, they provide evidence for a dual route model for literacy, a morphological and a phonological route, both of which can be used by normal and dyslexic children. Finally, the studies reveal an asymmetry in the effect of phonological and morphological interventions as far as reading and spelling goes: both showed general effects on reading and neither showed general effects on spelling. Furthermore, phonological intervention showed specific effects on word reading whereas morphological intervention showed specific effects on word spelling. To conclude, it seems appropriate to reiterate the educational implications drawn from Study 1: though each route proves effective in promoting word reading, it is much more likely that teaching that involves both phonology and morphology is the best route to literacy.

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