Effect of phonological training on reading and writing acquisition

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ABSTRACT. The aim of our study was to determine the effect of training of phonological abilities upon the acquisition of reading and writing during the first year of primary school. An experimental design, with five groups of subjects matched by age, sex, IQ, phonological abilities and reading and writing level was used. Every group received twenty training sessions, over a period of six months. Four groups had different training procedures depending upon the type of task used (phoneme versus concept discrimination) and the way that the task was carried out (using or not using manipulative materials). The fifth group served as control. Post training measures were taken in reading, writing, and mathematics, besides the teacher's estimated scores, twice: immediately after the end of training sessions and two months later. Significant effects on both reading and writing measures were obtained for the groups trained on phonological activities using manipulative materials. The effects were reliable for the two tests. The theoretical implications of the results are discussed and their implications for educational practice are indicated.

KEY WORDS: Phonological abilities, Phonological training, Reading acquisition, Writing acquisition

INTRODUCTION

Generally it can be said that alphabetic writing systems represent the elementary sounds of words, whereas logographic writing systems represent the meaning of words. Strictly speaking, alphabetic writing systems represent the elementary sounds of words. These are abstract units representing a variety of acoustically different but highly related sounds that function in the same way in a given language. Alphabetic systems are extremely economic and flexible, but at the cost of a very high level of abstraction.

Given the close relationship between speaking and writing, there have been many attempts to investigate the influence of children ability to analyze and handle spoken sounds on their initial stages of learning to read and write. For example, Gleitman & Rozin (1977) found a positive relationship between knowledge of the alphabetic principle and segmentation abilities that play a central role in the acquisition of reading. Several lines of research that support this positive relation deserve to be mentioned.

A number of studies dealing with phonological processes and reading have used either simultaneous or longitudinal correlational designs. Simultaneous correlational design studies have shown a positive correlation between phonological abilities and reading performance (Calfee, Lindamood & Lindamood

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1973; Evans, Taylor & Blum 1979; Liberman & Shankweiler 1979; Lundberg & Torneus 1978; Rosner & Simon 1971; Rozin & Gleitman 1977; Share, Jorm, Maclean & Matthews 1984). Also, longitudinal research studying the relation between phonological abilities during the pre-reading period and subsequent learning to read and write, have found a significant positive correlation (Bradley & Bryant 1983; 1985; Calfee 1977; Calfee, Chapman & Venezky 1972; Liberman 1973; Mann 1984; Mann & Liberman 1984; Treiman & Baron 1981; Tunmer, Herriman & Nesdale 1988; Zifcak 1981). These results have led some authors to consider tests of phonological ability as reliable predictors of the degree of reading and writing achievement (Bryant, Bradley, Maclean & Crossland 1989; Bryant, Maclean, Bradley & Crossland 1990; Content, Kolinsky, Morais & Belterson, 1986; Fox & Routh 1976; Lundberg, Olofsson & Wall 1980; Mann & Ditunno 1990; Mann & Liberman 1984; Morais, Bertelson, Cary & Alegria 1986; Stanovich, Cunningham & Cramer 1984; Stuart & Coltheart 1988; Yopp 1988).

Given the established positive relation between phonological abilities and learning to read and write experimental research has addressed the question of whether phonological abilities are a prerequisite, a consequence or a correlate of reading and writing skills; in other words, to establish if there is a causal relation between the two types of skills. On the one hand, experiments using a training design have shown that training in phonological abilities improve reading and writing acquisition. For example Lundberg, Frost & Petersen (1988) have shown an effect of preschool training in phonological abilities on early reading and writing acquisition. There were significant differences between the experimental and control groups, although the difference in reading in the first grade was only marginally significant. Other experiments have found similar results (Ball & Blachman 1991; Bradley 1988; Bradley & Bryant 1983; 1985; Fox & Routh 1984; Lie 1991; Torneus 1984; Treiman & Baron 1983; Wallach & Wallach 1976; Williams 1979, 1980).

On the other hand, another group of authors have found effects in the opposite direction, showing that learning to read and write within an alphabetic system improves phonological skills (Alegria, Pignot & Morais 1982; Baron & Treiman 1980; Ehri & Wilce 1979, 1980; Mann 1986; Morais, Cary, Alegria & Bertelson 1979, 1986; Read, Zhang, Nie & Ding 1986). These seemingly opposite results have produced a debate (Bertelson, Morais, Alegria & Content 1985; Bryant & Bradley 1985; Bryant & Goswami 1987; Morais, Alegria & Content 1987a; Torneus 1984) that may turn out to be, as Torneus (1984) has called it, a chicken and egg problem. It is now admitted that the influence between the two abilities is mutual (Bryant & Bradley 1985; Morais 1991; Morais et al. 1987a,b; Perfetti, Beck, Bell & Hughes 1987).

Even if that influence is reciprocal, the acquisition of reading and writing seems an instructional goal relevant enough to recommend the analysis of those conditions that facilitate it. We do not teach children to read and write so that they can discriminate phonemes. Rather, we train them to discriminate phonemes because it improves their reading and writing. Therefore it

seems practical to determine under what conditions training in phonological abilities improves reading and writing. This was the main purpose of the present research.

Our nearest precedent was the training study carried out by Bradley & Bryant (1983, 1985). They used four groups, which were homogeneous regarding IQ, sex, age and performance in a phoneme classification test. Two groups were trained to classify words according to their initial, medium or final phoneme; in addition one of these two groups used plastic letters as a learning aid. The third group was trained to classify the words used by the previous groups but employing conceptual criteria. The fourth group had no training and was used as a control group. The results showed a clear advantage of training to classify words by phoneme over training to classify by concept on both reading and writing tests. However this advantage was statistically reliable for the group using plastic letters but not for the group trained to classify words by phoneme without the aid of plastic letters.

A point that remained unclear in the Bradley and Bryant study was the extent to what the use of plastic letters, rather than phonological training per se, could account for the main significant difference found in the experiment. It could have been the case that the opportunity to manipulate and be exposed to reading material such as plastic letters was the factor responsible for the difference.

One way to separate the influence of using reading materials from the influence of phonological training was suggested by Wagner & Torgesen (1987). It consisted of employing a group that received practice with plastic letters but no phoneme classification training per se. This suggestion was incorporated by Bradley (1988) in a training study with one experimental and three control groups. The experimental group was trained to categorize words by their constituent phonemes and taught the connection between phonological and visual orthographic strategies using plastic letters. There was a control group in which children were treated in the same way as the experimental group but without an explicit connection between the two strategies. A second control group received training in phonological strategies alone and a third control group was trained only with the plastic letters. The results had a clear pattern regarding the writing test: the first group, trained in phoneme classification with the aid of plastic letters, performed significantly better than the remaining groups. However on the reading test the first group performed significantly better than the second and third group but was not significantly different from the one merely exposed to the manipulation of the plastic letters. It is difficult to explain these results.

In the present research we decided not to include a group such as that suggested by Wagner & Torgesen (1987) and employed by Bradley (1988). In pilot studies we found it very difficult to avoid inducing some implicit training in phoneme categorisation when the subjects were exposed to the plastic letters. This was probably due to the characteristic regularity of the Spanish language in the application of the phoneme-grapheme correspondence

rules. We do not know to what extent this implicit training can also account for Bradley's results.

To assess the influence of practice with reading materials on reading and writing tasks we used an alternative strategy. A group trained in classification of words based on conceptual criteria with the aid of written words was included. Thus, the comparison between the effects of practice with words representing concepts versus that of practice with letters representing phonemes could be possible.

Therefore our experimental design consisted of five groups. Two groups were trained to categorize words on the basis of their initial, middle, and final phoneme; one of the two groups used plastic letters as an aid and the other did not. Two additional groups were trained to categorize words on the basis of conceptual criteria (e.g. animals, colors); one of the groups used written words as an aid and the other did not. The fifth group was used as control and did not receive any particular treatment.

It was expected that, to the extent that practice with reading material was relevant, the two groups using either plastic letters or written words would show better performance on both reading and writing tests than the groups trained without aid materials. On the other hand, if phonological training were the relevant factor, the two groups trained to categorize words based on phoneme would show better performance than the groups trained on the basis of conceptual criteria.

An additional aspect of the present design might be of interest. There has been a long standing controversy about the appropriate initial method to teach to read and write, with opposing views between supporters of global and phonetic approaches (see Chall 1967, 1979, 1983 for a review of this question). We thought that a comparison between the reading and writing performance of the group trained with the aid of plastic letters and that of the group trained with written words could throw some additional light on that controversial issue.

Finally, another specific goal of the present research was to explore the role of phonological abilities training on learning to read and write in a language, such as Spanish, which is more regular than English with regard to the phoneme-grapheme correspondences. Regarding reading, Spanish is a complete orthographically transparent system, if we include the context dependent rules (i.e. if 'c' with 'a', 'o', 'u' then the sound is /k/; if 'c' with 'e', 'i', then the sound is /θ/). However, writing is less regular than reading since there are 29 graphemes and only 25 phonemes; that means that a few cases can be found where two or three graphemes correspond to the same phoneme (i.e. 'v', 'b', 'w', for the sound /b/).

In the present experiment subjects were randomly assigned to each of the five groups to avoid as much as possible problems of interpretation concerning the expected causal relation between training and reading and writing performance.

METHOD

Subjects

Our study was carried out in a middle class primary school in Granada, Spain. The three first level classes of this school used the same instructional approach and instructional materials. Children were introduced to reading and writing with a mixed procedure: teachers began with a global approach, using familiar and simple utterances and followed by a more analytical phase, where they focused on phonemes. We examined 96 children from three first level classes. To match children as closely as possible with each other for the experiment we used the following screening measures to select our subjects.

Pre-test. At the beginning of the academic year we administered the following tests:

1. Raven general intelligence test (RAV). Subjects with extreme scores were excluded. The score of the selected subjects ranged from eight (approximately Centile 20) to 22 (approximately Centile 95) points.
2. A vocabulary test (VB) adapted from Nieto (1984). It consisted of 18 three picture items belonging to the same semantic category (e.g., a shoulder, an elbow, and a wrist). Children had to point the picture named by the experimenter (e.g., wrist). Children were not selected on the basis of this test due to the high correlation between this and the Raven test ($r = 0.50$; $p < 0.001$).
3. We also asked the teachers to score our subjects from 0 to 10 according to their initial reading and writing ability (MAE). Few children who did not score zero were not included in the experiment.
4. A phoneme classification test (TS), constructed by us with the aim to measure the ability to detect rhyme and alliteration. To this purpose we used items consisting of a three bisyllabic word sequence, given the scarcity of monosyllabic words in Spanish. Each syllable consisted of a consonant and a vowel sound. Two of the three words began or ended with the same syllable, and the third word differed from the other two in the consonant phoneme of that same syllable. Presentation of the words was oral with the aid of pictures to avoid working memory loading. Children had to indicate which was the odd word. An example of the initial phoneme items is: 'lata, rana, rata', and an example of the final phoneme items is: 'bota, boca, gota'.

The phonemes that had to be discriminated in each sequence were chosen according to the Quilis and Fernández's phonetic list (Quilis & Fernández, 1966). We used two lists, one for the detection of alliteration (classification by initial phoneme) and another for the detection of rhyme (classification by final phoneme). Each list had 9 items thus producing a maximum score of 18 points. Children with a score lower than 13 points were chosen to participate in the experiment.

By applying the above mentioned criteria, 60 out of the initial 96 children

were selected and assigned to the five groups. Assignment was made randomly with the restriction that the number of boys and girls was equated between the groups. Given that each of the three classes participating in the study had a different teacher, we took care that an approximately equal number of subjects from each class was present in each group. Table 1 shows the mean and standard deviation of each group before training on the pretest variables. A oneway ANOVA showed no significant differences among the groups on any of these variables.

Training

Training of the groups lasted for 6 months. Subjects were organized in groups of six children and each group received one weekly training session for 20 weeks. The sessions were integrated as part of the organization of the afternoon activities in the school. Every session, lasting about 90 minutes, included both group activities related to the particular treatment of each group and individual training to insure that every child achieved an adequate performance level. Training was carried out by 4 persons who in turn had been previously prepared by one of us. They knew nothing about the main goal or the underlying hypotheses of the experiment. To avoid any differential influence of the trainer we established a rotating system which ensured that each of them had the same number of sessions with each of the five groups. The distribution of the training sessions of the groups along the week days was counterbalanced so that every group had the same number of sessions on each of the days of the week from Monday through Friday.

All groups, except the control group, were trained to classify the same

Table 1. Mean and standard deviation of the five groups, in each of the selection variables (Raven, age, phoneme classification), and Vocabulary (covariate), and frequency of boys and girls

		Group (N)					
		Total (60)	CTROL (12)	S (12)	C (12)	SL (12)	CP (12)
Raven	M	14.43	13.67	15.00	14.67	14.67	14.17
	SD	2.88	2.46	2.92	2.64	3.94	2.52
Age (months)	M	74.57	74.83	75.08	74.45	73.55	73.92
	SD	2.10	2.19	2.81	3.23	3.14	2.63
Phonemes	M	8.92	9.00	8.92	9.00	8.83	8.83
	SD	1.79	1.81	1.78	1.86	1.90	1.90
Vocabulary	M	15.37	15.58	15.83	15.58	15.17	14.67
	SD	1.90	2.28	1.12	1.51	2.62	1.67
Sex (boy/girl)	N	35/25	7/5	7/5	7/5	7/5	7/5

sets of pictures. One difference among the experimental groups was the criterion employed to carry out the classification tasks. Two of them (groups S and SL) applied a principle based on the sounds associated with the depicted object, while the other two groups (groups C and CP) applied a principle based on the concepts represented by the pictures. The second difference was related to the use of supporting materials. Groups SL and CP used either plastic letters or written words as an aid to relate phonemes or concepts to their respective written representation. On the other hand, groups S and C did not use any specific material to carry out the classification tasks.

The training procedure was based on the two criteria employed by Bradley (1980). The first criterion states that the same word can be categorized in the same way in different sets of words. As an example from phoneme categories, 'silla' starts with the same phoneme as 'sierra' and it also starts with the same phoneme as 'sello', 'saco', 'seta', and 'sol'. Groups S and SL were trained to classify in this way by giving children a 'silla-sierra-seta' set, then a 'silla-saco-sol' set and so on. Applied to the conceptual groups (C and CP), 'silla' was first categorized with 'sierra' and 'sello', and then with 'saco' and 'sol'. Both sets belong to the category 'non living things'.

The second criterion says that the same word can be classified in different ways in successive sequences of words. Thus, in the S and SL groups it was taught that 'silla' begins with the same phoneme as 'sierra' and 'seta' but also ends with the same phoneme as 'olla' and 'hebilla'. In successive sequences children learnt to classify in this way with sets such as 'silla-olla-hebilla', 'silla-saco-sol', etc. This principle was also applied to groups with training in conceptual classification (C and CP) by teaching children to classify, for example, 'silla' with 'sierra' and 'saco' as 'non living things', but with 'mesa' and 'sofa' as 'furniture'.

Training of the phoneme groups followed a phonetic opposition procedure, that is, we used phonemes differing in only a single phonetic trait. To this end the sound list constructed by Quilis & Fernández (1966) was employed. The words were pronounced very slowly with particular emphasis in the target sound. We started with fricative consonants which are the easiest consonants to pronounce in isolation. They also have a unique graphic representation.

In each session two new phonemes were introduced. We began with /f/-/s/, and then followed with /d/-/t/, /p/-/m/, /l̪/-/r̄/. /l/-/r/, /n/-/n̪/, /g/-/b/, /x/-/θ/, /y/-/ĉ/, and /k/-/x/. There were 12 pictures associated with each phoneme representing familiar objects. Half of these twelve pictures represented objects associated with nouns having the target sound on the starting position of its words, and for the other half the target sound corresponded to the last consonant of the word because in Spanish there are few nouns ending with a consonant. All the words employed in the experiment were selected from the frequency norms collected by Justicia (1985).

In summary, the activities carried out by each group were the following:

Group S. Subjects in this group worked out rime and alliteration with series

of pictures of familiar objects. All the words used in a given session had a common phoneme either initial or final. They never used written letters or words. They started to work with the initial phonemes and once the first principle was learnt they continued with the rime and the final phonemes.

Group C. Subjects in this group classified the same pictures as Group S but based on conceptual criteria. They started to classify pictures into very broad categories, and proceed to more specific criteria producing finer subclassifications. As the children became acquainted with the task, they were asked to give the classification criteria.

Group SL. Subjects were treated as those in Group S but in addition were given experience with plastic letters to help them to associate letters and phonemes. Once they became familiar with the alphabet they made each word in the set with plastic letters.

Group CP. Subjects in this group received the same treatment as Group C. Besides they were given experience with written words. The words were written underneath the picture. As training proceeded subjects also used labels with just the written representation of the word. Thus, the categorization tasks were first carried out with the labelled pictures, then with both the labelled pictures and then written labels without pictures.

Group CTROL. Subjects in this group received no training but had the same number of sessions as the other groups. During the sessions they just had manipulative activities such as coloring, cutting away, sticking, etc.

The activities for all groups took place in an amusing 'playing games' environment. For example, we used several different versions of 'card playing', 'lotto' and 'contest'. These games were carried out either individually, by pairs, or fostering the interactions in small groups.

Final tests

The post-treatment evaluation included reading, writing and mathematics tests. These tests were administered at the end of the training sessions (Proof 1) and two months after the training had ended (Proof 2).

1. *Reading evaluation.* It included two parts: A reading test with different scales and the assessment of the reading level by the school teachers.

Reading test. We used the reading test constructed by Cabrera (1985) and included an additional scale of syllable reading. The number of items was not the same in Proof 1 and in Proof 2. We reduced the number of items in Proof 1 because at that time we thought that the task would be too long for our subjects. The number of items is given in brackets for each scale together with the acronym of the task; the first number corresponds to the number of items on Proof 1 and the second to the number of items on Proof 2. The scales entering the test were the following:

- *Visual discrimination* (TA; 8-16): subjects had to discriminate when two letters or words share the same form among four alternatives.

- *Reading of syllables* (TB; 8-20): subjects had to read different nonword syllables (e.g.: pla, oc, lu, etc).
- *Grapheme-phoneme correspondence* (TC; 16-16): subjects had to apply the grapheme-phoneme correspondence rules by choosing the letter corresponding to the first phoneme of a drawn object among four possible alternatives.
- *Reading vocabulary* (TD; 16-16): subjects had to point among four written words to the one corresponding to the represented object.
- *Spoken-written word correspondence* (TE; 8-16): given an orally presented word subjects had to choose the correct response among four phonemically similar written alternatives.
- *Phoneme discrimination* (TDA; 14-14): subjects had to choose among three pictures the one sharing the first phoneme with an orally presented word.
- *Sentence and written orders comprehension* (TF; 4-7): subjects had to complete or to choose a drawing following written sentences.
- *Sentences comprehension using the context* (TG; 4-10): subjects had to complete sentences based on context by choosing the correct word among four alternatives.
- *Silent reading comprehension* (TH; 5-5): after reading a text subjects were questioned about it.

Teachers assessment (MAE). The three teachers who had been tutoring the children along the academic year were asked to rate them on a scale from 0 to 10. The teachers neither were aware of the goals of the experiment nor they knew the group to which a given child was assigned.

2. *Writing test* (TO). For Proof 1 the subjects had to write the words corresponding to ten pictures of familiar objects, and a sentence corresponding to a represented scene. For Proof 2 they had to write 15 words (TO1) and two sentences (TO2). The proposed words contained the different syllabic combinations of the Spanish language, as well as some of the phonemes with two possible corresponding graphemes. We considered as an error every substitution, addition, or omission of a grapheme in a word. Every correct word scored one point. In scoring sentences three different aspects of the sentence were taken into account: length (at least 6 words were required), correct syntactic structure, and the correct orthography of the words employed. Each of these aspects contributed equally to the sentence score.

3. *Mathematics test* (TM). It included, in both proofs, seven tasks referred to the knowledge about number series, elementary operations, and problem solving, including addition and subtraction of numbers with one or two digits. The difficulty of the tasks was calibrated by the teachers. This test was included as a control measure to see if our experimental treatments had a general effect on several abilities or an effect specific to reading and writing.

RESULTS

Three children dropped out of the experiment because they left school during the training period, and two more were excluded because of their lack of collaboration and motivation at the moment of the final tests. The subjects lost belonged to the S and SL groups. Thus, the analysis of the dependent variables was carried out for the 55 remaining subjects. The Vocabulary test scores were always used as a covariate, since this was the only measure taken in the pretest phase that was not used as a selection variable of the subjects.

Training

To control the efficiency of our training methods we made two evaluations, one after the tenth session and the other at the end of the training period. All groups attained an almost perfect performance level at the end of training and all groups except group C showed a t-test significant improvement from the first to the second evaluation. For group C performance was already at the highest level after the tenth session.

Proof 1

Table 2 presents the scores of each group corresponding to the reading scales.

Reading scales. As can be seen, for most of the reading scales the score of the SL group was higher than that of the other four groups. A multivariate analysis of covariance (MANCOVA) applied to the analysis of the reading scale set showed no significant differences among the groups. However the univariate analysis (ANCOVA) of each scale showed significant differences for the scales TC [$F(4, 49) = 3.34$; $p = 0.02$], TF [$F(4, 49) = 3.03$; $p = 0.03$] and marginally for TD [$F(4, 49) = 2.22$; $p = 0.08$]. An LSD post hoc contrast showed that group SL performed significantly better in the three scales than the remaining groups. These in turn were not significantly different among themselves. Table 3 presents the scores of each group corresponding to writing, mathematics tests and teacher's assessment.

Writing test (TO). The ANCOVA showed a significant difference among the groups [$F(4, 49) = 3.32$; $p = 0.02$], and the LSD contrast test revealed that group SL performed significantly better than the other groups which were not significantly different among themselves.

Mathematics test. There were no significant differences among the groups on performance in this test.

Teachers assessment (MAE). The score for the SL group was higher than for the other groups, but an analysis of variance showed no significant difference.

Table 2. Mean, standard deviation, and adjusted mean of each group, with VB (Vocabulary) as covariate, in the final reading test of Proof 1

		Group (N)						
		CTROL (12)	S (9)	C (12)	SL (10)	CP (12)	*P*	LSD
Visual discrimination (TA)	M	6.75	6.22	5.92	6.90	6.00		
	SD	1.06	1.20	1.08	1.37	1.76		
	M_A	6.68	6.11	5.85	6.99	6.15		
Syllables reading (TB)	M	4.75	5.44	5.67	6.80	5.08		
	SD	2.53	2.01	1.78	1.14	2.15		
	M_A	4.69	5.34	5.60	6.88	5.22		
Grapheme-phoneme correspondence (TC)	M	11.42	12.89	11.67	14.80	12.08		
	SD	3.06	2.26	3.39	1.81	3.06		
	M_A	11.25	12.61	11.50	15.02	12.44	0.02	2.29
Reading vocabulary (TD)	M	12.33	13.00	11.42	14.40	12.33		
	SD	3.37	2.24	3.37	1.84	2.67		
	M_A	12.18	12.75	11.27	14.61	12.66	0.08	2.31
Phoneme discrimination (TDA)	M	9.33	11.33	9.00	11.10	9.42		
	SD	2.53	3.08	2.98	2.51	2.47		
	M_A	9.30	11.28	8.97	11.14	9.48		
Spoken-written word correspondence (TE)	M	4.58	4.44	4.00	6.20	4.58		
	SD	2.67	2.74	2.49	2.39	2.23		
	M_A	4.52	4.37	3.96	6.26	4.68		
Written orders comprehension (TF)	M	2.68	2.44	2.17	3.80	3.17		
	SD	1.67	1.89	1.70	0.42	0.94		
	M_A	2.60	2.33	2.10	3.90	3.32	0.03	1.19
Comprehension by context (TG)	M	1.68	2.00	1.17	2.00	1.42		
	SD	1.23	1.41	1.19	1.70	1.24		
	M_A	1.60	1.89	1.10	2.09	1.56		
Silent reading comprehension (TH)	M	2.67	2.78	2.50	2.80	2.25		
	SD	1.97	2.11	2.15	2.10	2.09		
	M_A	2.54	2.57	2.38	2.97	2.51		

The last two columns show the probability associated with the ANOVA *F* value for each variable, and LSD critical value.

Table 3. Mean, standard deviation, and adjusted mean of each group, with VB (Vocabulary) as covariate, in writing test, and mathematics test of Proof 1; Teacher's assessment is also included

		Group (N)						
		CTROL (12)	S (9)	C (12)	SL (10)	CP (12)	*P*	LSD
Writing scale (TO)	M	6.25	6.33	5.08	9.40	5.67		
	SD	3.64	3.20	3.50	2.27	3.77		
	M_A	6.09	6.06	4.92	9.63	6.03	0.02	2.83
Mathematics test (TM)	M	7.93	7.69	7.89	8.00	7.63		
	SD	2.47	1.86	1.86	2.55	2.93		
	M_A	7.77	7.42	7.72	8.22	7.98		
Teacher assessment (MAE)	M	5.50	6.11	5.92	7.20	6.00		
	SD	2.39	1.83	2.39	1.75	1.86		

The last two columns show the probability associated with the ANOVA *F* value for each variable, and LSD critical value.

Proof 2

The results, administered two months after the training was finished, are presented on Tables 4 and 5.

Reading scales. Table 4 shows the results for the reading scales. As in Proof 1, there is a clear tendency for group SL to score higher than the remaining groups on all scales. A MANCOVA analysis showed statistically significant results (Hotelling $T^2 = 1.60$; $p = 0.01$). The univariate ANCOVA revealed significant results for the following scales: TB [$F(4,49) = 2.75$; $p = 0.04$], TC [$F(4, 49) = 2.88$; $p = 0.03$], TG [$F(4, 49) = 2.93$; $p = 0.03$], and marginally significant for TDA [$F(4, 49) = 2.19$; $p = 0.08$] and TE [$F(4, 49) = 2.28$; $p = 0.07$]. The LSD contrast test showed a significant superiority of group SL over the other groups in all these scales. Table 5 presents the scores of each group corresponding to writing, mathematics tests and teacher's assessment.

Writing test. The MANCOVA analysis applied to the two scales was significant (Hotelling $T^2 = 0.547$; $p = 0.003$). The univariate ANCOVA produced significant F values for both subscales, TO1 [$F(4, 49) = 3.44$; $p = 0.02$) and TO2 [$F(4, 49) = 5.87$; $p = 0.001$]. Again the LSD test demonstrated a clear superiority of the group SL over the other groups that were not significantly different among themselves.

Mathematics test. No significant difference among the groups was found.

Teachers assessment (MAE). These evaluations also showed a tendency for the group SL to score higher than the other groups, but the ANOVA analysis showed no significant differences.

DISCUSSION

The present results show that training in phonological abilities during the process of initial learning has a positive causal influence upon reading and writing acquisition. Thus our results are in agreement with findings previously reported by other authors (Ball & Blachman 1991; Bradley 1988; Bradley & Bryant 1985; Fox & Routh 1976, 1984; Lie 1991; Lundberg et al. 1988; Treiman & Baron 1983). However, in our experiment the positive influence of phonological training seems to be restricted to the situation in which plastic letters were used during the training phase. When phonological training was carried out without plastic letters, as it was the case for group S, no significant effect was found.

On the other hand groups C and CP did not show a performance level different from the control group. This result indicates that training in conceptual tasks does not produce differential effects in reading and writing acquisition. It is interesting to note that subjects in group CP were trained with the aid of written words, however their performance was not better than that of subjects in group C who were trained without written words. It appears

Table 4. Mean, standard deviation, and adjusted mean of each group, with VB (Vocabulary) as covariate, in the final reading test of Proof 2

		Group (N)						
		CTROL (12)	S (9)	C (12)	SL (10)	CP (12)	*P*	LSD
Visual discrimination (TA)	M	13.50	13.78	12.75	13.80	12.58		
	SD	1.31	1.09	2.18	1.62	2.81		
	M_A	13.43	13.66	12.68	13.90	12.74		
Syllables reading (TB)	M	10.42	11.33	10.00	17.20	10.08		
	SD	7.12	7.47	7.24	2.97	6.76		
	M_A	10.11	10.83	9.70	17.61	10.73	0.04	5.50
Grapheme-phoneme correspondence (TC)	M	12.17	11.56	12.42	14.90	13.08		
	SD	3.46	2.74	3.85	0.99	2.47		
	M_A	12.00	11.28	11.25	15.12	13.43	0.03	2.39
Reading vocabulary (TD)	M	12.50	14.11	13.42	15.40	13.92		
	SD	4.80	2.52	2.81	0.84	2.39		
	M_A	12.40	13.94	13.32	15.53	14.13		
Phoneme discrimination (TDA)	M	10.00	10.56	9.00	11.70	9.33		
	SD	3.16	2.30	2.13	2.50	3.75		
	M_A	9.79	10.21	8.79	11.97	9.77	0.08	2.22
Spoken-written word correspondence (TE)	M	10.92	11.00	8.50	12.80	8.83		
	SD	3.68	3.32	5.18	2.82	4.65		
	M_A	10.72	10.67	8.30	13.07	9.26	0.07	3.41
Written orders comprehension (TF)	M	5.33	5.78	4.83	6.80	5.33		
	SD	2.67	2.28	3.04	0.42	2.02		
	M_A	5.25	5.63	4.75	6.92	5.52		
Comprehension by context (TG)	M	4.58	4.33	4.67	8.00	4.92		
	SD	3.55	4.42	3.98	1.76	3.48		
	M_A	4.35	3.95	4.44	8.31	5.41	0.03	2.82
Silent reading comprehension (TH)	M	3.00	3.00	2.75	3.90	2.42		
	SD	2.04	1.87	1.86	0.74	1.51		
	M_A	2.94	2.90	2.69	3.98	2.55		

The last two columns show the probability associated with the ANOVA *F* value for each variable, and LSD critical value.

Table 5. Mean, standard deviation, and adjusted mean of each group, with VB (Vocabulary) as covariate, in writing test, and mathematics test of Proof 2; Teacher's assessment is also included

		Group (N)						
		CTROL (12)	S (9)	C (12)	SL (10)	CP (12)	*P*	LSD
Words writing (TO1)	M	7.50	7.00	7.08	11.80	7.50		
	SD	5.37	5.00	4.27	2.66	4.74		
	M_A	7.17	6.45	6.76	12.24	8.20	0.02	3.50
Sentences writing (TO2)	M	0.92	0.56	0.50	1.70	0.58		
	SD	0.79	0.88	0.52	0.48	0.79		
	M_A	0.89	0.51	0.47	1.74	0.65	0.001	0.60
Mathematics test (TM)	M	5.13	5.12	4.61	5.75	5.32		
	SD	1.89	2.20	2.50	1.54	1.84		
	M_A	5.02	4.94	4.50	5.89	5.55		
Teacher assessment (MAE)	M	5.75	5.56	5.92	7.50	5.92		
	SD	2.30	1.67	2.35	1.35	1.62		

The last two columns show the probability associated with the ANOVA *F* value for each variable, and LSD critical value.

that using supporting material during training does not produce *per se* a positive influence on reading and writing acquisition. As a matter of fact, in our experiment both group SL and group CP manipulated either plastic letters or written words during training, however only group SL showed a clear superiority over the remaining groups.

There are other aspects of our results that deserve to be pointed out. First, the superiority of group SL over the remaining groups was specific to the reading and writing tests but did not show up for the mathematics test. This pattern of results strongly suggests that our treatment was specific to reading and writing and did not produce a general effect on learning skills. Second, it is interesting to note that the superiority of group SL over the other groups was present after 20 weekly training sessions which is a training period much shorter than the training periods generally reported in previous research. This result makes our training method very practical since it can be easily included as part of the course activities within the first academic year. Finally, the effect of our treatment lasted for two months after the end of training so that when the course ended the superiority of group SL was not only maintained but even slightly improved. This conclusion seems supported by the fact that the MANCOVA of the reading scale was significant on Proof 2 though it had not been so on Proof 1.

The experimental nature of our research allows to infer the *causal* influence produced by phonological training with plastic letters on reading and writing. Our subjects were homogeneous at the start of training and received the same kind of formal teaching on reading and writing along the course. However only the SL group showed a significant difference on both Proof 1 and 2. Of course we do not want to deny the general possibility that learning to read and write can in turn influence phoneme discrimination. Based on our present results we simply want to stress the importance of phonological training in order to improve the acquisition of reading and writing skills. The design of our experiment was aimed to insure the existence of a causal influence going from our training methods to reading and writing acquisition. Our results showed that influence only for the group receiving phonological training with plastic letters.

Our results are in agreement with an interpretation in terms of phonological awareness. As emphasized by other authors (Ball & Blachman 1991; Bradley 1988; Bradley & Bryant 1985; Fox & Routh 1984), the execution of the training tasks may have helped children in the SL group to become aware of the segments of the language, making explicit the connection between spoken and written language, that is between phonemes and their written symbols. Although this explanation seems reasonable, we can not be sure that it was precisely the awareness of the relation between phonemes and written symbols the factor accounting for our results, because we did not use an independent measure of awareness as such. Therefore we prefer to talk about phonological discrimination rather than about phonological awareness.

In our experiment group S did not show any significant difference from the

control group. This result is in agreement with the findings of Bradley and Bryant who reported a small but non significant effect for the group trained in phoneme discrimination without plastic letters. Although it is possible that with more training sessions our group S could have shown an improvement in reading performance, our results emphasize the influence of using plastic letters as a training aid. It appears that the manipulation of letters provides children with a concrete referent, a visible model of phonemes (Ehri 1980), that speeds the achievement of phonological discrimination. This explanation is in agreement with the results reported by authors who have investigated different methods to help children to learn to segment (Hohn & Ehri 1983; Lewkovicz & Low 1979).

An analysis of the reading scales that produced a significant difference in favor of the SL group shows that the effect is concentrated on those scales concerned with word or syllable decoding, such as scales TB, TC, and TE. For the scales measuring reading comprehension the effect is also present but it appears unstable since it is present for the TF scale on Proof 1 but not on Proof 2, and for the TG scale on Proof 2 but not on Proof 1. This lack of consistency for the effect found on the reading comprehension scales could be explained by assuming, as some reading models do (Hogaboam & Perfetti 1978; Just & Carpenter 1987; LaBerge & Samuels 1974; Perfetti 1985; Perfetti & Hogaboam 1975) that reading comprehension is a stage of processing that follows a previous decoding process. To the extent that children have not yet achieved enough mastery of the decoding process, as may be the case for our beginning readers, a loss of comprehension is likely to take place. The fact that the superiority of group SL is concentrated on scales dealing with the decoding of words and syllables is in agreement with the opinion advanced by Stanovich, Cunningham & Cramer (1984), and Tunmer & Nesdale (1985), in the sense that phonological awareness indirectly affects comprehension, through its influence on decoding speed. To the extent that decoding becomes automatized, the comprehension process is facilitated. In the light of these ideas, our data can be interpreted as showing a situation in which the training procedure employed with the SL group has produced enough automatization of the decoding process to influence the comprehension process but not enough to make this influence stable.

It is interesting to point out that the assessment of the children's reading level carried out by the teachers tended to agree with the results produced by the reading scales. Group SL received a score higher than the remaining groups on both Proof 1 and 2. To the extent that teachers did not know either the purpose of the experiment or the particular assignment of subjects to groups, the agreement of their judgment with the reading test results adds converging evidence in favor of the SL group training procedure.

In our data the superiority of the SL group over the remaining groups on the writing tests was clear and reliable on both Proof 1 and Proof 2. This result is in agreement with previous findings supporting a crucial role of phonological coding on writing acquisition (Bruck & Waters 1988; Frith 1980; Rohl

& Tunmer 1988; Waters, Bruck & Seidenberg 1985). There are also studies showing that the effect of phonological awareness is higher on writing than on reading (Bradley 1988; Perin 1983; Snowling & Perin 1982). However in our experiment the different number of scales used for the reading and the writing tests does not allow a meaningful comparison which could throw some light on this last issue.

It is worth pointing out that our results confirm, for the Spanish language, the influence of phonological training on the acquisition of reading and writing already found in English and other alphabetic languages (e.g. Ball & Blachman 1991; Bradley 1988; Bradley & Bryant 1983, 1985; Fox & Routh 1984; Lie 1991; Lundberg et al. 1988; Torneus 1984; Treiman & Baron 1983). It is likely that, despite differences in phonological structure, the use of an alphabetic system in different languages contributes similarly to reading and writing acquisition.

Finally, our results also throw some light on the longstanding controversy concerning methods for teaching children to read. Reviews on this issue by Beck (1981), Chall (1967, 1979, 1983), and Johnson & Bauman (1984) have generally favored the phonetic over the global methods. In our experiment the comparison of groups SL and CP show a clear advantage of the phonetic approach. The acquisition of reading (and writing) during the first school year was better for children trained to discriminate phonemes with the aid of plastic letters, than for children trained to discriminate concepts with the aid of written words.

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