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The genesis of reading ability: What helps children learn letter–sound correspondences?

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ABSTRACT

Knowledge of letter–sound correspondences underpins successful reading acquisition, and yet little is known about how young children acquire this knowledge and what prior information they bring to the learning process. In this study, we used an experimental training design to examine whether either prior letter awareness or prior phonemic awareness directly assists preliterate children in subsequently learning letter–sound correspondences. Here 76 preschoolers received 6 weeks of training in either letter awareness, phonemic awareness, or control tasks and then received a further 6 weeks of training in either letter–sound correspondences or control tasks. There was limited evidence that prior training in either phoneme or letter awareness directly assisted learning of letter–sound correspondences, although phonemically trained children appeared to show some advantage on recognition tasks. Overall, the data suggest that there is little value in training preschoolers in either letter forms or sounds in isolation in advance of providing instruction on the links between the two.

Introduction

The ability to sound out unfamiliar written words is widely viewed as a cornerstone of reading proficiency (Byrne, 1998). The set of skills that allow children to succeed in this are variously referred to as phonological decoding skills, nonlexical skills, or alphabetic reading skills and in very broad terms involve the ability to recognize letters (or graphemes), match them with their corresponding sounds,

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and blend the sequence of sounds together to produce a spoken response. For children learning to read, being in possession of such skills brings enormous advantages; it allows them to successfully read aloud many completely new words (e.g., *Voldemort* and *Dumbledore*) and also gives them the opportunity to "self-teach" words that they have not seen in print before but that they are familiar with orally because they can sound them out and match the output with words in their spoken vocabularies (Share, 1995). Indeed, children with poor alphabetic reading skills often struggle with learning to read and have word-level reading difficulties in addition to nonword-level reading difficulties (Rack, Snowling, & Olson, 1992).

Knowledge of individual letter–sound, or grapheme–phoneme, correspondences is an essential component of alphabetic reading ability. In their seminal work on this issue, Byrne and Fielding-Barnsley (1989), Byrne and Fielding-Barnsley (1990) argued that this skill, together with phoneme awareness, is sufficient for the acquisition of the alphabetic principle. It is perhaps surprising, then, that relatively little is known about precisely how children learn letter–sound correspondences or what factors influence this learning process (a point also made by de Jong & Olson, 2004 and Treiman, Tincoff, Rodriguez, Mouzaki, & Francis, 1998). What preexisting knowledge might children bring to the task of learning letter–sound correspondences that is of assistance to them, and how might they use this knowledge?

Given that the task children face involves learning pairings between letters and sounds, it would seem logical to focus on children's knowledge and awareness of these two components as possible factors influencing the learning process. It might be expected that if children had rich and well-established representations of one or both of these individual components, it would be easier for them to access those representations and hold them in memory when attempting to form links between the two than would be the case if their representations were weaker. Indeed, basic memory research demonstrates that paired-associated learning tasks are performed better when the stimuli and responses to be learned are familiar than when they are unfamiliar (Tulving & Craik, 2000). Therefore, we begin by reviewing what is known about each of these components separately in relation to the learning of letter–sound correspondences.

Letter knowledge

It is well documented that preschoolers' ability to name letters is highly correlated with their later word reading ability (Bond & Dykstra, 1967; de Jong & van der Leij, 1999; Muter, Hulme, Snowling, & Stevenson, 2004; Tunmer, Herriman, & Nesdale, 1988; Wagner, Torgesen, & Rashotte, 1994), but this does not tell us what the nature of the relationship is or whether any effects of letter knowledge are exerted at the level of the acquisition of letter–sound correspondences. A specific hypothesis, which does localize the effect at this level, is that knowing letter names may help children to learn letter–sound correspondences because many letter names carry information about the sound of the letter within them (e.g., at the beginnings of the letters *p* and *d*, at the ends of the letters *m* and *f*). Treiman and colleagues (1998) found that young children were indeed better at identifying the sounds of *acrophonic* printed letters such as the above than they were at identifying the sounds of nonacrophonic letters such as *h* and *y* (see also Share, 2004; Treiman & Rodriguez, 1999).

These results suggest that knowing the *name* of a letter may play a role in learning letter–sound correspondences, but they do not tell us whether any other aspects of letter knowledge, such as the quality of letter representations per se, have any influence. In addition, the acrophonic letter effects described above may be confounded to some degree with phonemic awareness ability because benefiting from the sound information provided by the letter name presumably requires that children are sufficiently phonologically aware to be able to successfully segment the relevant phoneme (Share, 2004; but see Treiman, Pennington, Shriberg, & Boada, 2008). Some exploration of the role of letter familiarity and awareness in the learning of letter–sound correspondences independent of letter name knowledge would seem to be needed. As Ehri (1986) argued, the ability to recognize and distinguish between a large number of visually similar symbols such as letters is a considerable challenge for preschoolers, and some will master this perceptual learning task better than others. Therefore, one might hypothesize that the extent to which this visual familiarity with letters has been acquired will influence the ease of any subsequent learning of letter–sound correspondences. We explored this hypothesis in the current study.

Phonemic awareness

As with letter knowledge, there is a large amount of research documenting an association between children's awareness of phonemes and their success in reading (see Castles & Coltheart, 2004 for a review). More important for the current purposes, strong correlations have been found between phonemic awareness and letter–sound knowledge during the very early stages of learning to read and spell (Caravolas, Hulme, & Snowling, 2001). Many researchers have concluded that the association between phonemic awareness and reading is a causal one, and indeed a frequently proposed causal mechanism is that phonemic awareness directly assists the acquisition of letter–sound correspondences because children who are aware of the phonemic segments in spoken words are able to learn their correspondences with letters and graphemes more easily than those who are not (Gough & Hillinger, 1980; Mattingly, 1972). Stanovich (1993) represents this view succinctly with the statement that phonological awareness is "a foundational ability underlying the learning of letter–sound correspondences" (p. 288). Of course, it is also possible, and indeed likely, that knowledge of letter–sound correspondences reciprocally affects phonemic awareness and that they both have independent effects on other aspects of reading (Hulme, Snowling, Caravolas, & Carroll, 2005b). But for the current purposes, phonemic awareness emerges as a prime candidate in the search for factors potentially influencing children's initial ability to learn letter–sound correspondences.

As we have noted previously, given the prominence of this hypothesis and its intuitive appeal, there is surprisingly little evidence available to directly support it (Castles & Coltheart, 2004). Many training studies have explored the hypothesis of a causal relationship between phonemic awareness and reading in general, but to our knowledge only the classic studies of Treiman and Baron (1983) and Fox and Routh (1984) have explicitly tested the hypothesis that phonemic awareness ability helps children to learn letter–sound correspondences.[1] Treiman and Baron (1983) gave kindergarteners phoneme awareness training on one set of spoken syllables but not on another set (which were just repeated aloud). The children were then shown printed items that corresponded to these spoken syllables, where the pronunciation of a "related" item could be deduced from the pronunciations of the other printed items in the set but the pronunciation of an "unrelated" item could not. A significant interaction between instruction type and item type was found, suggesting a causal link between phonemic analysis and the ability to benefit from spelling–sound rules. Fox and Routh (1984) found that kindergarteners who had been trained on segmenting and blending phonemes performed better on a subsequent task involving the paired-associate learning of letter-like forms and spoken words than did either a control group or a segmenting-only group. Thus, these two studies indicate that phonemic awareness may indeed play an important role in the learning of letter–sound correspondences but seem to represent a rather limited body of evidence given the centrality of this issue to our understanding of the process of learning to read.

The opportunity to find evidence for a causal relationship from phonemic awareness to the learning of letter–sound correspondences has also been limited by the fact that many studies have not controlled for the preexisting literacy skills of the participants and, therefore, for the potential for orthographic influences on performance on phonemic awareness tasks (a point also made by Blaiklock, 2004). It is well established that children draw on orthographic information when performing phonological awareness tasks. In their classic study, Ehri and Wilce (1980) showed that, in a phoneme counting task, fourth graders reported that there are more phonemes in a word such as *pitch* than in a word such as *rich*, suggesting that children evoke the words' spellings during the task (see also Castles, Holmes, Neath, & Kinoshita, 2003). Indeed, even quite young children appear to show such influences; Treiman and Cassar (1997) reported that first graders judged syllables that

[1] Byrne and Fielding-Barnsley's (1989, 1990) elegant studies explored closely related questions, but their focus was on whether phonemic awareness and letter–sound knowledge together are needed to acquire the alphabetic principle rather than on whether phonemic awareness directly affects the acquisition of letter–sound knowledge itself.

were the names of letters (e.g., *el*) to contain fewer sounds than syllables that were not letter names (e.g., *ol*).

These findings compromise the validity of concluding that there is a causal relationship from phonemic awareness to learning letter–sound correspondences even in those studies that have used a design capable of detecting such causal relations. Let us imagine a longitudinal training study where one group of children is trained in phonemic awareness and another is not and then aspects of reading performance are measured at subsequent time points. The children are first tested during kindergarten, and many already know some letter–sound correspondences prior to the commencement of the study. In the follow-up tests, the phonemically trained children are found to read nonwords better than the children who did not receive phonemic training. One might be inclined to see this as evidence for a causal link from phonemic awareness to the learning of letter–sound correspondences, but we would argue that this conclusion would not be justified for it could also be the case that the children in the phonemically trained group had an opportunity to rehearse their preexisting letter–sound knowledge during training in a way that the control group did not. Specifically, every time they heard a presented sound in a phonemic training task, they would evoke the printed letter, use it to assist them in performing the task, and further cement the link between the visual form of that letter and its sound. Thus, it is our view that direct evidence for a causal link from phonemic awareness to the learning of letter–sound correspondences requires a study in which children enter the study knowing no letter–sound correspondences. The carefully designed training study of Hatcher, Hulme, and Snowling (2004) involved preschoolers who did appear to meet this criterion. However, in that study, phonemic awareness was trained together with reading and phonics instruction; thus, the findings cannot directly address the causal question posed here.

The current study

In this study, we addressed the question of whether either letter awareness or phonemic awareness *directly assists children in learning letter–sound correspondences.* This was done in the context of an experimental training design carried out with preschoolers who were completely preliterate in the sense that they could not read aloud even the simplest printed words and could not provide the sound for any printed letter. The children were initially trained in either phonemic awareness or letter awareness, and their learning of these skills at the end of this phase was compared with that of children who had participated in control activities. Immediately following this first training phase, there was a second training phase in which half of the children received training in letter–sound correspondences and the other half participated in control activities. Their learning of the correspondences at the end of this phase was assessed. This design allowed us to determine (a) whether the children had been successfully trained in phonemic awareness or letter awareness, (b) whether the children had been successfully trained in letter–sound correspondences, and (c) whether the prior training in phonemic awareness or letter awareness during the first phase had influenced the children's subsequent learning of letter–sound correspondences during the second training phase.

The design was also constructed to allow the effects of generalization of learning to be observed. During both phases, the children received training on a single set of only eight letters/sounds (the *trained* items), but after each training phase their performance on a second set of eight letter/sounds (the *untrained* items) was examined. If the skill being acquired had generalized beyond the particular items in the training set, we would expect to see significant learning for the untrained items as well as for the trained items.

In summary, the basic hypotheses of the experiment were as follows:

1. If phonemic awareness directly assists the acquisition of letter–sound correspondences, children who had first been trained in phonemic awareness would perform better in subsequently learning letter–sound correspondences than would the control group.
2. If letter awareness directly assists the acquisition of letter–sound correspondences, the children who had first been trained in letter awareness would perform better in subsequently learning letter–sound correspondences than would the control group.

3. If training in either letter awareness, phonemic awareness, or letter–sound correspondences generalizes beyond the particular items being taught, significant transfer to untrained items would be found.

Methods

Participants

The initial sample consisted of 87 preschoolers from child care centers in Melbourne, Australia. They consisted of 46 boys and 41 girls with a mean age of 4 years 1 month (range = 3 years 1 month to 5 years 1 month).

These children were selected on the basis that (a) they could not read aloud any of the 10 most frequent nouns in a children's printed word database (Stuart, Dixon, Masterson, & Gray, 2003) and (b) they could not produce the sound of any of the 26 printed letters of the alphabet when presented to them in uppercase or lowercase, with the one exception we allowed being that they could say the sound of the initial letter of their first name (correctly produced by 18 children). A toy puppet presented the letters on individual cards, printed in uppercase and lowercase, and the children were asked to say what sound the letters made. It was not possible to obtain preschoolers who knew no letter *names*, but this ability was matched across groups (see baseline assessment).

Design

After selection, an initial *baseline assessment* of the children's general cognitive and language abilities was conducted. Based on this assessment, the children were allocated to the experimental groups using a statistical allocation method that matched them as closely as possible on these measures (see below). A *pretest assessment* on the key experimental measures of phonemic awareness, letter awareness, and letter–sound correspondences for trained and untrained items was then conducted. After the pretest, the children commenced *Phase 1 training*, during which they received three 20-min sessions of instruction per week in the relevant content (phonemic awareness, letter awareness, or control) over a period of 6 weeks (total = 360 min). Immediately after this phase was completed, the children completed an *intermediate assessment* of their phonemic awareness and letter awareness for trained and untrained items. They then proceeded to *Phase 2 training*, during which they received three further 20-min sessions of direct instruction per week in the relevant content (letter–sound correspondences or control) again for a period of 6 weeks. Immediately on completion of this phase of training, the children undertook a *posttest assessment* on the measures of letter–sound correspondence knowledge for both trained and untrained items. The design is summarized in Table 1.

Table 1
The experimental design.

		Training Phase 1 (weeks 1–6)			Training Phase 2 (weeks 7–12)		
		Group	Condition		Group	Condition	
Baseline assessment	Pretest assessment	1	PA	Intermediate assessment	1	LS	Posttest assessment
		2	PA		2	C	
		3	LA		3	LS	
		4	LA		4	C	
		5	C		5	LS	
		6	C		6	C	

Note. PA, phonemic awareness training; LA, letter awareness training; C, control; LS, letter–sound correspondence training.

Materials and procedure

Baseline measures

Verbal intelligence. Verbal intelligence was estimated using the Vocabulary subtest of the fourth edition of the Stanford–Binet intelligence test (Thorndike, Hagan, & Sattler, 1986). All subtests of this battery have a reliability of between .84 and .89. The subtest consists of 46 items divided into picture vocabulary and oral vocabulary. In the picture items, the children must name the picture or its most important detail; in the later oral items, the children are required to define an orally presented word.

Nonverbal intelligence. Nonverbal intelligence was estimated with the Quantitative subtest of the Stanford–Binet intelligence test (Thorndike et al., 1986). The subtest consists of 40 items covering a range of basic quantitative and logical concepts.

Oral language. General oral language was tested using the Memory for Sentences subtest of the Stanford–Binet intelligence test (Thorndike et al., 1986). The subtest consists of 42 sentences, varying in length and complexity, which are read aloud to the children and must be repeated exactly as read.

Rhyme awareness. Rhyme awareness was assessed using a rhyming jigsaw puzzle game that we developed. The children were shown a jigsaw piece with the picture of an animal (e.g., a goat) and then were shown three pictures of "other halves," one of which rhymed with the puzzle piece. After being familiarized with the concept of rhyme, the children were asked, for example, "Which of these three words rhymes with *goat*? Is it goat and boat, goat and chair, or goat and tree?" The children made a selection and connected the two halves of the puzzle together. There were 15 items in total.

Letter name knowledge. Letter name knowledge was assessed in the context of a story, *Little Lion Learns About Letters*, in which the 26 uppercase letters were embedded in pictures spread over four pages within the story. As the story was read aloud to the children, they were asked whether they could see any letters "hiding in the picture" and to point to them. Once the letters had been pointed to (with prompting if necessary), the children were asked to name the letters. Uppercase letters were used because these are best recognized by children of this age (Worden & Boettcher, 1990).

Anonymous data on the performance of the children on these baseline measures, and also on their ages, were forwarded to a statistical consultant who had no association with the study. The consultant wrote a program that calculated all of the possible permutations of group membership and determined an allocation of the children to the six conditions of the study that minimized the difference between the groups in baseline scores.

Experimental measures

Item sets. Two sets of eight training letters/sounds were compiled. The two sets were matched as closely as possible on number of vowels and consonants, visual distinctiveness of the letters, and number of acrophonic letters. Sounds that can be difficult for children to articulate, such as /l/ and /r/, were avoided, as were letters corresponding to more than one phoneme, such as *q* and *x*. Specifically, Set A items were *e*, *b*, *c*, *n*, *o*, *h*, *t*, *w*, and their corresponding sounds, whereas Set B items were *a*, *d*, *g*, *m*, *u*, *y*, *p*, *f*, and their corresponding sounds. Children were assigned to either Set A or Set B at the commencement of the study, with the assigned set becoming their "trained" items and the unassigned set becoming their "untrained" items.[2] We made the decision to train the children on lowercase versions of the letters because Australian children are typically taught letters in lowercase once they commence school and we wished to maximize the chance that they could transfer their knowledge to the school setting (such that benefits would be evident in follow-up studies of these children that we plan to conduct).

[2] To ensure that children were not inadvertently exposed to items from the untrained set, all children being trained at the same child care center at the same point in time were allocated the same training set. The assignment of training set to center was counterbalanced.

Phonemic awareness. Phonemic awareness was assessed using an initial phoneme identification task. There were two versions of the test corresponding to the Set A and Set B training items. Each version consisted of a large card on which were printed eight pictures of familiar objects whose initial phonemes corresponded with those of the eight items in that set (e.g., a hand for /h/, a watch for /w/). The card formed the basis of an "I Spy" game in which the children were asked to point to the picture that commenced with a presented sound.

To familiarize the children with the task, the experimenter began by using a demonstration card that contained five pictures of objects beginning with phonemes not selected for use in the study: /z/, /s/, /r/, /l/, and /j/. The children were asked to name all of the pictures first and were given the correct name for any items not named or named incorrectly. Then the children were asked, "Do you know how to play the I Spy game? I spy with my little eye something beginning with..." All of the sounds were presented, and feedback was given, until the children had correctly identified all of the pictures.

The children were then administered the A and B versions of the test, with the order of administration counterbalanced across participants. Once again, they were familiarized with the names of the pictures before proceeding with the I Spy game. The items within each version were presented in random order, and the children were not given feedback.

Letter awareness. The children's familiarity with letter forms was assessed using a letter/nonletter discrimination task. This consisted of two sets of 16 cards. The first set contained 8 cards printed with the Set A letters (in lowercase) and 8 cards printed with nonletter typewriter symbols (e.g., %, &). The second set contained the 8 Set B letters and 8 nonletter typewriter symbols.[3] Tho two sets were combined for presentation, with the experimenter saying to the children, "I have some cards here. Some have letters of the alphabet on them, and some have other things that are not letters. Can you help me sort the letters from the things that are not letters?" The children "posted" the cards into either a "letter" box or a "nonletter" box. The items were presented in random order, and no feedback was given.

A subset of the children was also administered a more exploratory letter awareness task that was designed to be directly analogous to the initial phoneme identification task used to measure phoneme awareness and so is referred to as *initial letter identification.*[4] There were two versions of the test, again corresponding to the Set A and Set B training items. Each version consisted of a large card on which were printed eight words whose initial letters corresponded with those of the eight items in that set (e.g., the word *hand* for *h*, the word *watch* for *w*) and eight letter cards with the target letters printed on them in lowercase. This formed the basis of an "I Spy Letters" game in which the children were asked to point to the printed word that commenced with a presented letter.

To familiarize the children with the task, the experimenter again began by using a demonstration card that contained five printed words beginning with letters not selected for use in the study: /z/, /s/, /r/, /l/, and /j/. The children were shown letter cards individually and were asked to find the word on the demonstration card that began with that letter. Feedback was given. In the main assessment, the children were shown each letter card for approximately 2 s, and then it was turned face-down and the word card was turned face-up for the children to respond. This ensured that the children needed to briefly hold the letter representation in memory (as they are required to do for presented phonemes in a phoneme awareness task) and that the task was not simply a visual matching task. However, if the children were struggling, the letter card was presented one more time. The order of presentation of the two sets was counterbalanced, and items were presented in random order within each set.

[3] Numbers were initially included in the task as nonletters, but because this appeared to confuse many children, these were removed and replaced with symbols. A small number of children undertook the study with the original test, but these were evenly spread across conditions.

[4] The idea of testing letter awareness in this way occurred to us only after we had begun the first wave of training, so no data are available for the children in this wave.

Letter–sound correspondences. The children's success in acquiring letter–sound correspondences was assessed using four tasks: letter–sound recall, letter–sound recognition, nonword reading aloud, and nonword recognition.

In the letter–sound recall test, the children were shown 16 individual cards with the Set A and Set B letters printed on them in lowercase and were asked, "What sound does this letter make?" The items were presented in random order. Letter–sound recognition was assessed using the *Little Lion Learns About Letters* story mentioned earlier. The story was read aloud to the children, and they were asked to point to the letters they could see on a page. They were then asked, for example, "Can you point to the letter that makes a /b/ sound?" Accuracy for the Set A and Set B letters was scored.

In the nonword reading aloud task, the children were told that they were to learn about some elves with "funny names" and were presented with eight simple nonwords (four vowel–consonants [VCs] and four consonant–vowel–consonants [CVCs]) constructed from the letters in their training set and were asked to try and read them aloud. For example, those children allocated to Set A received nonwords such as *oc* and *neb*, and those allocated to Set B received nonwords such as *ag* and *fup*. Two practice items were given for each item type (VC and CVC) with feedback. In the nonword recognition task, simple nonwords constructed from the letters in the children's training set (four VCs and four CVCs) were spoken aloud to the children, and they were asked to point to the printed nonword that "matched the elf's name." The correct nonword was presented along with five same-length foils constructed from recombinations of the Set A and Set B training set letters. Again, two practice items of each nonword type (VC and CVC) were given.

All experimental measures were administered at pretest and posttest, with the exception that the nonword reading and recognition tasks were given only at posttest because these were found to be too difficult for the children to attempt prior to training; on a short trial test of VC nonword reading attempted at pretest, no children scored above zero. During the intermediate testing session, our aim was to assess whether the Phase 1 training had been successful, so only the measures of phonemic awareness and letter awareness were administered.

Training methods

Training Phase 1. During this phase of the study, the children in each condition engaged one-on-one with the experimenter in a range of activities and games targeting the skill, and the particular items (i.e., Set A or Set B), to be trained.[5] Each of the 18 20-min sessions contained a mix of such activities, the details of which are provided in Appendix A. Although the activities were intermixed throughout the training, there was a general gradation for difficulty in that more complex activities, such as those involving a memory component, were introduced after the more basic activities, such as simple matching tasks. For nearly all of the children, there were occasions throughout the program where a session needed to be cut short, for example, when it interfered with other center activities (e.g., meal times, nap times) or when the children appeared to be losing concentration (this tended to happen during sessions later in the day or toward the end of the week). In these instances, the session was made up on another day, ensuring that the total amount of training time was the same for all children.

The phonemic awareness training games focused entirely on exposing children to the relevant individual phonemes to be trained. Short vowel sounds were trained, and the consonants were presented with a schwa. Most of the activities involved initial phoneme identification because this was all that most of the children in the sample were capable of learning during the time frame. No activity or material used corresponded directly with that used in the phonemic awareness assessment. The letter awareness training games focussed on exposing children to the letters to be trained in lowercase. Because letter names can contain some phonological information, and because we were interested in the quality of letter representations independent of letter names, names were not provided as part of the training activities. Finally, the control preexposure activities involved no letter or sound exposure and typically involved pictures.

[5] On some occasions, two children in the same condition and same training set were permitted to play the games with the experimenter together when doing so appeared to improve their engagement.

The format of the games was identical across the conditions; only the content of the games changed. For example, there were three versions of a "dominoes" game designed for each of the three conditions. In the phonemic awareness condition, the children connected dominoes that had pictures containing the same initial sound; in the letter awareness condition, the children connected dominoes that had the same letter; and in the control condition, the children connected dominoes that had the same picture. Throughout the activities, the children were kept in a dialogue with the experimenter centering on the skill to be trained. For example, in the phonemic awareness dominoes game, the experimenter might say, "So you've got to find a match for a picture of a pumpkin. What sound does that start with? Yes, it's a /p/ sound. What other domino starts with a /p/ sound?" In the letter awareness dominoes game, the conversation centered on the shape of the letter and how to recognize it: "Can you describe what that letter looks like? Yes, it has a big hook at the bottom. Can you find a match with another letter that looks the same?" Further details about the games can be found in Appendix A.

Training Phase 2. During this phase, the children assigned to the experimental condition were taught letter–sound correspondences for their trained items (i.e., Set A or Set B). The training again took place in the context of a range of games and activities, the details of which can be found in Appendix B. In this case, all of the games involved matching printed letters with their appropriate sounds or remembering letter–sound pairings. All letters were presented in lowercase. During the final two sessions, the children were presented with the trained letters in various combinations as part of the activities to give them an opportunity to blend together individual trained letter sounds. There were again 18 20-min sessions, with children being given the opportunity to make up sessions on another day if required by circumstances. Feedback was given throughout. Control activities again involved similar games, with only the content of the games being varied (see Appendix B).

Results

Missing data

Of the 87 children initially selected to participate, 1 did not complete the experiment due to having left the child care center, leaving a final sample of 86. Of these, a further 14 children had missing data on particular tests within a phase due to either center absences or unwillingness to complete them on the day. Given the causal nature of the hypotheses being tested, we felt it was important that all of the primary analyses be conducted on the same set of children and that missing data not be estimated. Therefore, we made the decision to exclude from the analyses those participants who were missing data in any of the core pretest and posttest measures of letter awareness, phoneme awareness, letter–sound recall, and letter–sound recognition. There were 10 children in this category. The 4 children who were missing data from other tests remained in-

Table 2
Mean scores of children in the six training conditions on the baseline measures (with standard deviations in parentheses).

Task	Group					
	PA/LS	PA/C	LA/LS	LA/C	C/LS	C/C
n	11	12	13	15	12	13
Age (years;months)	4;0 (0;5)	4;2 (0;4)	4;2 (0;6)	4;0 (0;6)	4;1 (0;6)	4;1 (0;6)
Stanford–Binet Vocabulary	54.8 (8.8)	52.2 (9.2)	54.9 (5.1)	51.3 (6.5)	54.8 (4.4)	54.1 (6.1)
Stanford–Binet Quantitative	53.4 (8.2)	50.8 (6.5)	52.2 (7.1)	54.7 (8.4)	56.7 (5.3)	53.9 (5.3)
Stanford–Binet Memory for Sentences	52.2 (5.5)	47.4 (6.6)	53.4 (8.4)	50.7 (5.8)	51.2 (5.8)	52.8 (5.7)
Rhyme awareness	9.6 (4.7)	7.2 (4.2)	9.1 (4.4)	7.8 (3.4)	9.4 (4.1)	10.0 (4.3)
Letter name knowledge	4.7 (5.1)	6.6 (8.4)	4.5 (5.1)	5.5 (7.9)	5.4 (7.4)	5.9 (7.4)

Note. Standard deviations are in parentheses. PA, phonemic awareness training; LS, letter–sound correspondences training; C, control; LA, letter awareness training. The Stanford–Binet subtests are all standard scores with a mean of 50 and a standard deviation of 8. Rhyme awareness is a raw score out of 15, and letter name knowledge is a raw score out of 26.

cluded, with the relevant analyses being conducted on the reduced sample. Therefore, the data from a total of 76 children were submitted for analysis. The children who were excluded from analysis appeared to have a profile similar to that of those who remained included, not differing significantly from them on any of the baseline measures.

Performance on baseline measures

Table 2 presents the performance of the children in the six experimental conditions on the baseline measures. As would be expected based on the matching procedure used, the six groups did not differ significantly on any of these measures (Stanford–Binet Quantitative: $F(5,75) = 1.04$; Stanford–Binet Memory for Sentences: $F(5,75) = 1.38$; all other Fs < 1).

Performance on experimental measures at pretest

Table 3 presents the performance of the children in the six conditions on the experimental measures at pretest (scores for trained and untrained items are combined here because no training had yet occurred). There were no significant differences between the groups on any of the measures (all Fs < 1), indicating that the groups were well matched on the experimental measures at the outset of the study.

Effectiveness of Phase 1 training

Before examining the key experimental hypotheses, it was necessary to determine whether training during each of the phases had been successful in that it had produced significant improvements in the relevant treated group compared with the control group. For the Phase 1 training, this involved comparing the pretest and intermediate test performances of the children in the training conditions with those of the controls on phoneme awareness (PA) and letter awareness (LA). The results are presented in Table 4. For both measures, we conducted planned comparisons comparing the relevant training group with the control group for the trained items. If an effect was found, we conducted a further analysis on the untrained items to determine whether any generalization of the learning had occurred.

Looking first at phoneme awareness, we examined whether the PA group had been successfully trained in this skill by conducting an analysis of variance on performance on the trained items with the factors of time (pretest or intermediate) and Phase 1 training group (PA or control). This revealed significant main effects of time, $F(1,45) = 17.82$, $p < .001$, $\eta^2_p = .28$, and training group, $F(1,45) = 5.97$, $p < .05$, $\eta^2_p = .12$, qualified by a significant interaction between time and training group, $F(1,45) = 18.79$, $p < .001$, $\eta^2_p = .30$. Bonferroni-corrected post hoc tests revealed that the PA trained group improved significantly from pretest to intermediate testing but that the control group did not.

Table 3
Mean percentage correct scores of children in the six training conditions on the pretest measures (with standard deviations in parentheses).

Task	Group					
	PA/LS	PA/C	LA/LS	LA/C	C/LS	C/C
Phonemic awareness	10.2 (15.6)	9.9 (10.4)	11.1 (15.5)	10.4 (12.8)	19.2 (16.0)	11.5 (12.9)
Letter awareness: Letter/nonletter discrimination	75.5 (22.5)	70.3 (23.9)	76.9 (17.2)	70.3 (19.2)	70.6 (21.1)	71.2 (19.8)
Letter awareness: Initial letter identification (N = 54)	55.5 (20.6)	57.5 (18.1)	65.6 (20.0)	66.5 (20.5)	62.5 (19.1)	60.2 (20.0)
Letter–sound recall	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.8 (3.2)	1.0 (3.6)	0.0 (0.0)
Letter–sound recognition	6.8 (9.9)	17.1 (18.4)	6.7 (12.1)	10.0 (16.5)	14.1 (17.5)	10.6 (21.1)

Note. Standard deviations are in parentheses. PA, phonemic awareness training; LS, letter–sound correspondences training; C, control; LA, letter awareness training.

Table 4
Mean percentage correct scores of children in the three Phase 1 training conditions on phoneme and letter awareness measures before and after training (with standard deviations in parentheses).

Task	Phase 1 training group	Pretest		Intermediate		Change score	
		Trained items	Untrained items	Trained items	Untrained items	Trained items	Untrained items
Phonemic awareness	PA	10.3 (15.8)	9.7 (14.1)	48.3 (34.1)	37.5 (34.2)	38.0	27.8
	LA	9.8 (13.8)	11.6 (16.6)	13.8 (20.7)	15.2 (23.1)	4.0	3.6
	C	17.0 (21.0)	13.5 (14.8)	16.5 (18.9)	16.0 (20.2)	−0.5	2.5
Letter awareness: Letter/ nonletter discrimination	PA	76.3 (22.9)	69.3 (25.2)	78.7 (20.5)	75.8 (20.2)	2.4	6.5
	LA	73.4 (19.6)	73.7 (20.9)	85.2 (15.0)	86.2 (12.3)	11.8	12.5
	C	70.0 (18.8)	65.7 (21.5)	75.5 (18.5)	75.2 (19.0)	5.5	9.5
Letter awareness: Initial letter identification (*N* = 54)	PA	55.5 (19.7)	57.6 (23.9)	70.5 (22.5)	71.3 (18.1)	15.0	13.7
	LA	63.7 (27.1)	68.4 (20.3)	80.9 (23.2)	80.3 (16.1)	17.2	11.9
	C	60.8 (28.7)	61.7 (19.2)	62.5 (27.1)	69.2 (22.6)	1.7	7.5

Note. Standard deviations are in parentheses. PA, phonemic awareness training; LA, letter awareness training; C, control.

To look for effects of generalization of training, the analysis above was rerun on the untrained items. This again produced a significant main effect of time, $F(1,45) = 13.87$, $p < .001$, $\eta^2_p = .23$, an effect of training group that approached significance, $F(1,45) = 3.21$, $p = .08$, and a significant interaction between time and training group, $F(1,45) = 9.61$, $p < .01$, $\eta^2_p = .18$. Post hoc tests again confirmed that the PA trained group improved significantly from pretest to intermediate testing but that the control group did not, indicating that members of the former group showed generalization of their learning in phoneme awareness.

For completeness, we also examined whether the LA trained group had shown any selective improvements in phoneme awareness from pretest to intermediate testing, although no effect was expected given that this group had not received the relevant training. An analysis of variance on performance on the trained items with the factors of time (pretest or intermediate) and Phase 1 training group (LA or control) revealed no significant main effect of time, $F(1,51) = 1.63$, $p > .05$, or training group, $F < 1$, and no significant interaction, $F < 1$. Thus, the children trained in letter awareness showed no improvements in their phonemic awareness over the training period.

There were no significant effects of training set (Set A or Set B) on the success of phonemic awareness training or on any of the other training effects during Phase 1 or Phase 2, so this factor is not considered further.

Turning to the effects of training in letter awareness, we first examined performance as measured by the letter/nonletter discrimination task. A comparison of the LA trained group with the controls on this measure between pretest and intermediate testing revealed a significant main effect of time, $F(1,51) = 13.64$, $p < .01$, $\eta^2_p = .21$, but no significant effect of training group, $F(1,51) = 2.91$, $p > .05$, and no significant interaction, $F(1,51) = 2.36$, $p > .05$. Thus, there was an overall improvement on the task from pretest to intermediate testing, but there was no evidence of a training effect specific to the LA group. Although there is a trend evident in Table 4 for the LA trained group to improve more on this task than did the controls, it was not reliable in this analysis. Because there were no significant effects in the trained items, we did not examine generalization effects.

A comparison of the PA trained group with controls on the letter/nonletter discrimination task revealed that, as expected, this group also did not show any selective improvements on this task, with the analysis revealing no significant main effects (both *Fs* < 1) and no significant interaction, $F(1,45) = 1.65$, $p > .05$.

One reason why the apparent improvements of the LA group on the letter/nonletter identification task might not have reached significance is that this task was relatively insensitive; there was a 50% chance level, and children performed well above chance at pretest. Therefore, to provide a more sensitive test of improvement, we determined the score on the task that was significantly above chance ($\geqslant$12/16, binomial test exact $p = .038$, one-tailed) and examined whether the number of children scoring above chance on the trained items in each of the training groups increased from pretest to intermediate testing. For the LA group, the number of children scoring above chance increased from 15 to 23 (of 28), and this increase was significant, $\chi^2(1) = 9.23$, $p < .01$. Interestingly, there was also a significant increase in the number of children scoring above chance on the untrained items (from 16 to 25), $\chi^2(1) = 11.91$, $p < .01$. There were no significant increases for the PA and control groups for either trained or untrained items.

Finally, to further explore improvements in letter awareness as a result of training, we looked at the supplementary measure of letter awareness that we had conducted on a subset of the sample, namely the initial letter identification task ($N = 54$ in total; subgroup *ns*: PA/LS = 8, PA/C = 10, LA/LS = 10, LA/C = 11, C/LS = 7, C/C = 8, where LS is letter–sound correspondence training and C is control). Comparing the LA group with the control group from pretest to intermediate testing resulted in a significant main effect of time, $F(1,34) = 4.99$, $p < .05$, $\eta^2_p = .13$, but no significant main effect of training group, $F(1,34) = 1.84$, $p > .05$. However, the interaction between the two approached significance, $F(1,34) = 3.34$, $p = .07$. Bonferroni-corrected post hoc comparisons revealed that the LA group improved significantly on the task from pretest to intermediate testing but that the control group did not. Thus, there was some evidence that the training in letter awareness that we provided produced selective improvements on this measure.

For this task, the learning did not appear to generalize beyond the trained items; when the analysis was rerun on the untrained items, there again was a significant main effect of time, $F(1,34) = 5.03$, $p < .05$, $\eta^2_p = .13$, but no main effect of training group, $F(1,34) = 3.28$, $p > .05$, and no hint of an interaction, $F < 1$.

Although members of the PA group had not received the relevant training, we also examined whether they had shown any selective improvements from pretest to intermediate testing on the initial letter identification task. The analysis revealed no significant main effects of time, $F(1,30) = 2.60$, $p > .05$, or training group, $F < 1$, and no significant interaction, $F(1,30) = 1.57$, $p > .05$. Thus, although examination of Table 4 suggests that the PA group may have shown greater improvement on this task than did the controls, this effect was not reliable.

Effectiveness of Phase 2 training

To determine whether the Phase 2 training in letter–sound correspondences had been successful, we compared the pretest and posttest performances of the children in the two Phase 2 training conditions (collapsed across the Phase 1 training condition) on the core letter–sound recall and letter––sound recognition measures. The results are presented in Table 5.

For letter–sound recall, the children were at floor on the pretest measure (because they were selected on this basis), so the analysis was carried out on posttest scores only. An analysis of variance on the trained items with the factor of training group (LS or control) revealed a significant main effect, $F(1,74) = 22.62$, $p < .001$, $\eta^2_p = .23$, reflecting the fact that the LS group performed significantly better on letter–sound recall at posttest than did the control group. For letter–sound recognition, an analysis

Table 5
Mean percentage correct scores of children in the two Phase 2 training conditions on measures of letter–sound correspondence before and after training (with standard deviations in parentheses).

Task	Phase 1 training group	Pretest		Posttest		Change score	
		Trained items	Untrained items	Trained items	Untrained items	Trained items	Untrained items
Letter–sound recall	LS	0.3 (2.0)	0.3 (2.1)	37.8 (29.5)	15.3 (22.0)	37.2	15.0
	C	0.3 (2.0)	0.6 (2.7)	10.9 (19.2)	10.9 (16.3)	10.6	10.3
Letter–sound recognition	LS	8.7 (15.8)	9.7 (14.7)	41.3 (27.1)	28.5 (27.1)	32.6	18.8
	C	12.2 (20.1)	12.5 (19.4)	30.3 (26.8)	27.8 (25.2)	18.1	15.3

Note. Standard deviations are in parentheses. LS, letter–sound correspondence training; C, control.

of variance with pretest and posttest scores included (because the participants were not at floor at pretest) revealed a significant main effect of time, $F(1,74) = 62.76$, $p < .001$, $\eta^2_p = .46$, but the overall effect of training group did not reach significance, $F < 1$. The main effects were qualified by a significant interaction between time and training group, $F(1,74) = 5.13$, $p < .05$, $\eta^2_p = .07$, reflecting the fact that, although both groups improved in their recognition of letter sounds for trained items, the LS group improved more than the control group. Thus, there was evidence from both measures that the children receiving training in letter–sound correspondences benefited from that training.

To examine generalization effects, a rerun of the analyses above with the untrained items was conducted. For letter–sound recall, conducted only on the posttest scores, there was no hint of an effect of training group, $F < 1$, indicating that the LS group did not perform better on the untrained items at posttest than did the control group. For letter–sound recognition, there again was a significant main effect of time, $F(1,74) = 41.65$, $p < .001$, $\eta^2_p = .36$, but no other main effects or interactions were significant (both Fs < 1). Thus, there was no evidence from either measure that the benefit the children gained from instruction in letter–sound correspondences extended beyond the particular items trained.

As noted earlier, a small proportion of the children were able to produce the sound of the first letter of their first name on screening ($n = 15$ of the final sample of 76 submitted for analysis). To examine whether this subgroup showed a different pattern of letter sound learning from that of the other children, we reran the analyses on the trained items above with knowledge of one letter sound (yes or no) as a factor. The children with this prior knowledge were found to have higher scores on letter–sound recall at posttest than did those without this knowledge, $F(1,72) = 16.92$, $p < .001$, but there was no interaction with training group, $F < 1$, suggesting that this general advantage did not interact with the effects of the training. The same was true for letter–sound recognition: There was a significant main effect of knowledge of one letter sound, $F(1,72) = 9.71$, $p < .01$, but there was no significant interaction with either time or training group (all Fs < 1).

Summary of Phase 1 and Phase 2 training effects

The training we provided in phonemic awareness was very successful, producing significant and large effects in the treated group. This learning also generalized beyond the particular items trained. Letter awareness training appeared to be somewhat less effective, although there was some evidence for a benefit; a larger number of children scored above chance on the letter/nonletter discrimination task after the training than before the training, and a subset of the LA trained group also showed significant improvements on the initial letter identification task. However, the effects were weaker than in the case of the phonemic awareness training; therefore, this qualifies the conclusions that can be drawn about the influence of letter awareness on the learning of letter–sound correspondences. During Phase 2, the training in letter–sound correspondences was highly effective overall, although the improvements shown by the trained children did not generalize beyond the specific correspondences on which they had received instruction. Therefore, we were able to move to the key research question of whether the Phase 1 training, and particularly the successful phonemic awareness training, had affected the learning of trained letter–sound correspondences during Phase 2.

Effect of Phase 1 training on learning of letter–sound correspondences

Fig. 1 displays the children's performance on letter–sound recall and letter–sound recognition for trained items as a function of Phase 1 and Phase 2 training conditions. Although all of the data are shown for completeness, the key analyses for the current purposes consisted of planned comparisons examining whether the particular type of training given during Phase 1 had influenced the success in learning of letter–sound correspondences during Phase 2 for those who had received such training (i.e., the LS group). The analyses were conducted only on trained items because the previous analyses of letter–sound correspondence learning had shown no evidence for generalization.

Looking first at letter–sound recall, the effect of prior phonemic awareness training on the task was examined via an analysis of variance on the posttest scores as a function of the Phase 1 training condition (PA or control). As noted earlier, only posttest data were examined because the children were at

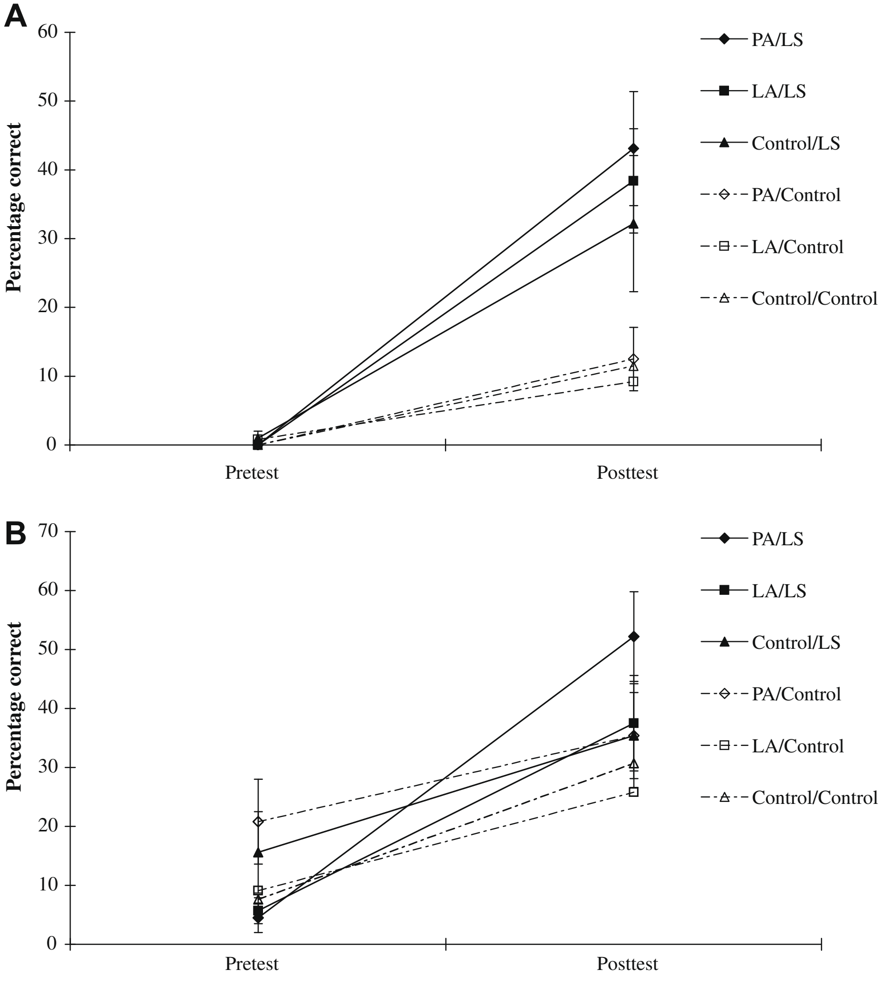

Fig. 1. Pretest and posttest performances on letter–sound recall (A) and letter–sound recognition (B) for trained items as a function of Phase 1 and Phase 2 training conditions.

floor on the task at pretest. There was no hint of an effect, $F < 1$. Thus, there was no evidence that prior training in phonemic awareness for particular sounds assisted the children in subsequently learning to produce those sounds in response to their corresponding printed letters. There was similarly no effect of prior training in letter awareness on letter–sound recall, with the corresponding analysis of variance comparing the Phase 1 LA group with the control group also producing no significant effect, $F < 1$. Thus, when the dependent measure was letter–sound recall, there was no indication that the nature of the Phase 1 training had influenced the children's acquisition of letter–sound correspondences during Phase 2.

For letter–sound recognition, the effect of prior phonemic awareness training on learning was examined via an analysis of variance with the factors of time (pretest or posttest) and Phase 1 training group (PA or control). This revealed a significant main effect of time, $F(1,21) = 37.19$, $p < .001$, $\eta^2_p = .63$, no significant effect of training group, $F < 1$, but a significant interaction between the two, $F(1,21) = 6.37$, $p < .05$, $\eta^2_p = .23$. Bonferroni-corrected post hoc comparisons revealed that, as can be seen from Fig. 1, the children who had received phoneme awareness training during Phase 1 improved more in their recognition of trained letter–sound correspondences after Phase 2 training than did the Phase 1 control group.

The corresponding analysis of the effect of prior letter awareness training on subsequent letter–sound recognition, with time (protest or posttest) and Phase 1 training group (LA or control) as factors, again revealed a main effect of time, $F(1,23) = 24.84$, $p < .001$, $\eta^2_p = .52$, but no main effect of training group, $F < 1$, and no significant interaction, $F(1,23) = 1.33$, $p > .05$. Prior training in letter awareness did not appear to modulate the children's ability to learn to recognize the corresponding sounds of those letters.

Finally, we looked at the effect of the Phase 1 training on the children's ability to read aloud and recognize the simple VC and CVC nonwords made up of trained items. The results are presented in Fig. 2. Because we did not conduct these tests at pretest, the data are only for posttest. For reading aloud (Fig. 2A), the first point to note is that scores overall were extremely low; the children were nearly at floor on the task. Nevertheless, an analysis of variance revealed a significant main effect of

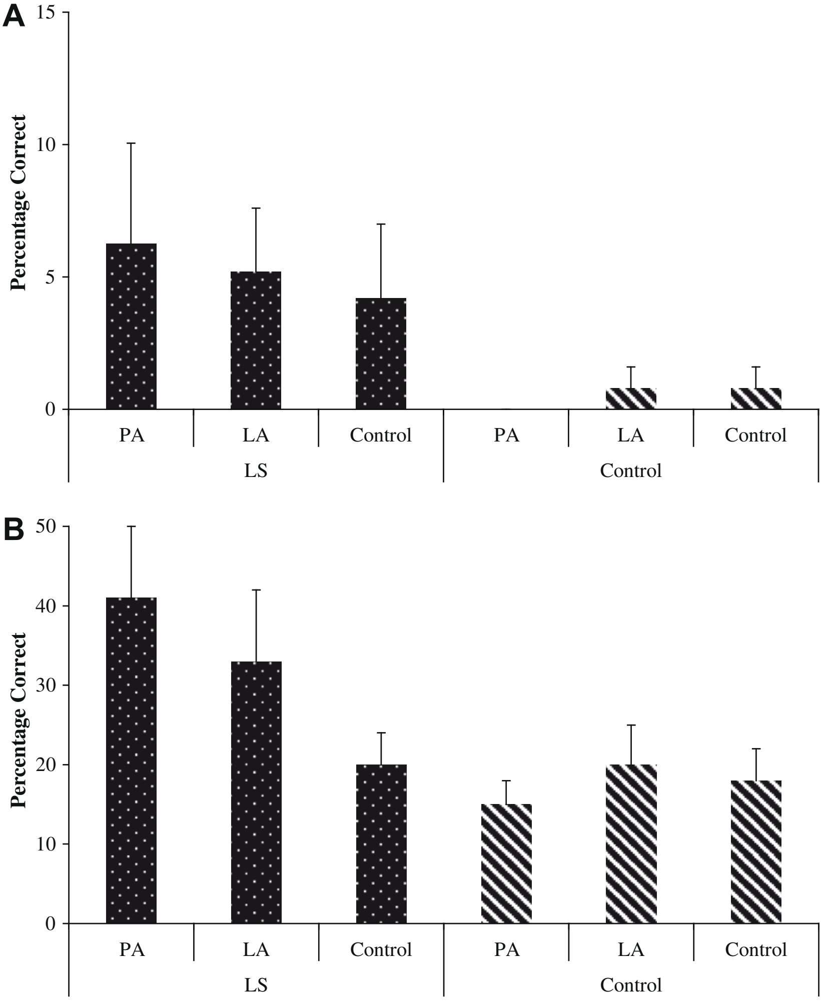

Fig. 2. Posttest performance on reading aloud nonwords (A) and recognizing nonwords (B) as a function of Phase 1 (diagonal bars) and Phase 2 (dotted bars) training conditions.

Phase 2 training condition, $F(1,70) = 7.65$, $p < .01$, $\eta^2_p = .15$; the children who had received training in letter–sound correspondences performed better on the task than did those who had not received such training. However, within the LS group, there was no significant main effect of Phase 1 training on performance when comparing either the PA group or the LA group with controls (both $Fs < 1$). This indicates that neither prior training in phonemic awareness nor prior training in letter awareness affected the degree to which the children benefited from their training in letter–sound correspondences when performing this task.

For nonword recognition (Fig. 2B), overall performance was higher. The analysis of variance again revealed a significant effect of Phase 2 training condition, $F(1,72) = 6.91$, $p < .01$, $\eta^2_p = .09$, indicating that training in letter–sound correspondences had improved performance. Comparisons examining the effect of Phase 1 training on learning within the letter–sound correspondence training condition revealed a difference between the PA and control groups that just reached significance, $F(1,20) = 4.34$, $p = .05$, $\eta^2_p = .15$, but no difference between the LA and control groups, $F(1,23) = 1.56$, $p > .05$.

Discussion

The aim of this study was to examine whether either letter awareness or phonemic awareness directly assists preliterate children in learning letter–sound correspondences. We hypothesized that if either of these abilities does provide such assistance, children who had received prior training in them would perform better in subsequently learning letter–sound correspondences than would a control group. Our findings indicated that although the children showed strong learning of associations between letters and sounds, the extent of this learning did not appear to be modulated by either prior phonemic awareness or prior letter awareness.

We were able to train phonemic awareness quite successfully in these preliterate children. Although the children rarely reached ceiling on the trained items, they scored close to 50% correct on average by the end of training, with many children performing at levels well above this. The training also clearly generalized to untrained items, supporting the notion that phonemic awareness represents a metalinguistic cognitive skill that, once acquired, can be applied across a range of speech sounds. It also shows that, consistent with the findings of Hulme, Caravolas, Malkova, and Brigstocke (2005a), it is possible for children, with sufficient training, to acquire phonemic awareness for sounds for which they do not know the corresponding letters. Most important for the current purposes, the phonemic awareness we induced was pure in the sense that performance on the tasks could not have been influenced by orthographic factors in these preliterate children. Therefore, this provided us with an ideal opportunity to test the direct effects of this ability on the acquisition of letter–sound correspondences.

The training in letter awareness produced a somewhat less clear pattern of results. Of the two different measures of this skill we employed, we were able to demonstrate reliable improvements in performance in the relevant group on only one of them, and the effect here was weak. However, supplementary analyses suggested that the failure to find a significant training effect in the letter/nonletter discrimination task may have been due to lack of sensitivity of the measure given that training effects were evident when total numbers of children scoring above chance on this task before and after letter awareness training were compared. The findings in relation to the generalization of the training were also inconsistent. The overall picture would appear to suggest that the letter awareness training produced a small positive effect on the children that could be generalized in some situations but not in others.

We can suggest two reasons why the letter awareness training effects may have been rather weak. The first concerns the possible inadequacy of the training itself. As mentioned earlier, this training involved familiarizing the children with the trained printed letters but not providing any letter names because these can carry some phonological information. Feedback from the experimenters was that this made the exercises very odd and artificial for the children, whose first inclination was to label the symbols that they were seeing in some way. It may be that familiarity with printed letter forms is not easily obtained in this manner. A second possibility is that, as suggested earlier, the children did gain some letter awareness but the measures we used were not particularly sensitive to it. At least in relation to the letter/nonletter identification task, there was some evidence that this was the case. If so, we might expect to see some evidence of the effects of this training in the further follow-ups of the children's reading progress that we plan to carry out. In the meantime, caution is called for in the conclusions that we draw from this study on the effects of letter awareness on the acquisition of letter–sound correspondences.

How, then, did the prior training in phonemic awareness influence the children's subsequent learning of letter–sound correspondences? It would appear that, in answering this question, we need to make a distinction between production tasks, where the children see a letter or letter string and must produce its corresponding sound, and recognition tasks, where both the sounds and letters are provided and the children must link the two. In the case of production tasks, there was no hint of an effect of prior phonemic awareness training on the learning of letter–sound correspondences. The children showed modest, but highly reliable, improvements in their ability to provide the sounds of printed letters after training, but the magnitude of these improvements did not differ according to the prior training they had received; children who had performed control activities during Phase 1 learned just as well as those who had received phonemic awareness training. Similarly, the reading of nonwords composed of trained letters, although performed extremely poorly overall, was influenced by the children's training in letter–sound correspondences but showed no influences of the prior training the children had received. Given that reading aloud or decoding new words requires productive skills of this nature, the current results call into question the degree to which prior phonemic awareness *directly* assists the acquisition of such skills.

In contrast, there did appear to be a small effect of prior phonemic awareness training on performance on recognition tasks. When the children were presented with individual trained sounds, or spoken nonwords made up of those sounds, and were asked to match them with their appropriate printed forms, those who had received prior phonemic awareness training performed better than those who had participated in control activities. How are we to interpret this finding in the context of the lack of effects for production tasks? It could be that, when learning is at its most fragile, the benefits of phonemic awareness are evident only when both the stimulus and response are present. Thus, had our "production" task been designed in an analogous way, such that the children were presented with a printed letter or nonword and asked to choose the correct spoken response from a series of alternatives, they might have shown the same benefits. Another possibility is that the phonemic awareness training simply gave the children some experience in hearing meaningless sounds and that this made the recognition task slightly more familiar for them. A final possibility is that phonemic awareness primarily exerts its effects via its influence on nonlexical *spelling* ability—the ability to translate presented sounds to written form—and that this may then flow through to assisting the development of nonlexical reading ability and, through it, more general reading skill. Indeed, there is evidence from longitudinal studies that children's phonemic segmentation ability predicts their subsequent phonological spelling ability and, through that, spelling ability more generally (Caravolas et al., 2001). Spelling ability itself appears to operate as a powerful self-teaching mechanism for orthographic learning (Shahar-Yames & Share, 2008). Further research should focus on distinguishing between these alternatives and especially on exploring the effects of phonemic awareness training on spelling to dictation of single letters and simple nonwords.

It should be noted that although there were some benefits of prior phonemic awareness training on recognition tasks, the effect sizes were small. Based on our data, it would be difficult to argue a strong case for training phonemic awareness in preschoolers prior to their commencing instruction in letter–sound correspondences. Indeed, there would appear to be little value in focusing on either sounds in isolation or letters in isolation during preschool in advance of instruction in letter–sound correspondences. Interestingly, there is no evidence from our data to suggest that letter–sound correspondences cannot be taught to preschoolers from the outset; even the children in the Phase 1 control group, who had no measurable levels of phonemic awareness at the commencement of the study and received no training in this ability, showed significant learning of letter–sound correspondences.

The finding that pure phonemic awareness training, without support from orthographic material, was of limited benefit in the current study is broadly concordant with previous research. In their meta-analyses of phonological awareness training studies, both Bus and van Ijzendoorn (1999) and Ehri and colleagues (2001) reported that effect sizes for pure phonemic training are smaller than those for phonemic awareness training occurring in the context of letters and words. Both of these meta-analyses nevertheless reported some significant effects on reading for phonemic training alone. However, considering that the majority of the studies contributing to these meta-analyses involved children who were not completely preliterate, and so the difficulties in interpreting the nature of the causal connections raised earlier apply, it would seem that these findings converge with ours in suggesting a very limited beneficial role for pure phonemic awareness training in assisting reading acquisition in young children.

Our study addressed a very specific question: Does prior phonemic awareness or letter awareness directly assist children in the acquisition of letter–sound correspondences? Our findings do not rule out the possibility that phonemic awareness, or indeed letter awareness, may exert its effects on other aspects of reading or that it may interact with letter–sound knowledge to produce further insights once both have been acquired in the manner suggested by Byrne & Fielding-Barnsley (1989, 1990) work on the alphabetic principle. Another possibility is that extra training in phonemic awareness is required for only a subset of children at risk for reading failure (Hatcher et al., 2004). We plan to follow up the children participating in this study once they have commenced formal schooling so that some of these possibilities can be explored.

A further caveat concerns the nature and extent of the training that we provided. One can always ask whether the amount of training given was sufficient to produce benefits or whether the type of training given was the most appropriate or effective. In relation to the extent of phonemic awareness training, it is certainly true that the children did not reach ceiling levels of performance and that more learning could have taken place. However, we selected our training period on the basis of previous studies that had reported significant effects (Bus & van Ijzendoorn, 1999). In addition, it would seem that if sufficient phonemic awareness to produce effects cannot be obtained across 18 20-min individualized training sessions, one must question the practicality of performing such training as would be sufficient in a preschool setting. In relation to the nature of training, our phonemic awareness training centered on phoneme segmentation and identification. We did not train phoneme blending and so cannot rule out the possibility that this would have produced different effects. However, our decision to train at this level was motivated by the fact that our focus was on the learning of individual letter–sound correspondences as well as by a number of studies that have reported that it is the concept of phoneme identity, and the ability to segment individual phonemes, that is most strongly associated with reading attainment (Ball & Blachman, 1988; Byrne & Fielding-Barnsley, 1989, 1990; Muter, Hulme, Snowling, & Taylor, 1998). Finally, we note that the sample sizes in all of our conditions were relatively small, and this may have limited the power of our study to produce effects.

In relation to the major aims of our study, then, we conclude the following:

1. Although when orthographic skills are present they play a significant role in children's performance on tasks traditionally used to measure phonemic awareness, preschoolers with no orthographic skills can nevertheless be taught to perform these tasks reasonably well.
2. Letter–sound correspondences can be successfully taught to preschoolers even in the absence of measurable phonemic awareness.
3. Successful training in phonemic awareness does not have any effect on how well preschoolers can subsequently be taught to convert letters into sounds unaided—an ability that is considered to be very important for reading acquisition and that forms the basis of the self-teaching hypothesis.

Acknowledgments

We would like to thank David Bjorkland, Genevieve McArthur and three anonymous reviewers for helpful comments on an earlier draft of the paper. This paper is dedicated to the memory of Walter A. Lindrum.

Appendix A
Training activities for Phase 1

Activity	Training condition		
	PA	LA	Control
Card matching	Match picture cards beginning with the same phoneme.	Match cards printed with the same letter.	Match cards with the same pictures.
Dominoes	Connect dominoes with pictures starting with the same phoneme.	Connect dominoes with the same letters.	Connect dominoes with the same pictures.
Bingo	Put tokens on pictures starting with presented phonemes. Cover all pictures to win.	Put tokens on letters matching those displayed by the trainer. Cover all letters to win.	Put tokens on shapes matching those displayed by the trainer. Cover all shapes to win.
I Spy	Look at a picture book and find hidden objects starting with a presented phoneme.	Look at a picture book and find hidden letters.	Look at a picture book and find hidden objects.
Snap!	Take turns with trainer to place down cards and say "snap!" when two sequential pictures begin with the same phoneme.	Take turns with trainer to place down cards and say "snap!" when two sequential letters are the same.	Take turns with trainer to place down cards and say "snap!" when two sequential pictures are the same.
Memory	Turn over pairs of face-down cards to find two with pictures beginning with the same phoneme.	Turn over pairs of face-down cards to find two with the same letter.	Turn over pairs of face-down cards to find two with the same picture.
Board game	Roll dice, move around the board, and match pictures that start with the same phoneme.	Roll dice, move around the board, and match letters in different colors and sizes.	Roll dice, move around the board, and match identical pictures.
Adventure story	Listen to a story and choose which way the characters should go by making a phoneme match.	Listen to a story and choose which way the characters should go by making a letter match.	Listen to a story and choose which way the characters should go by making an object use/semantic category match.

Appendix B
Training activities for Phase 2

Activity	Training condition	
	LS	Control
Letterland flashcards	Introduce each of the trained letter–sound correspondences using Letterland flashcards (which contain the printed letter and pictures beginning with the sound of that letter). Produce sounds of printed letters and words beginning with those sounds.	Discuss animal noises using animal flashcards. Produce sounds made by presented animals.

Appendix B. (*continued*)

Activity	Training condition	
	LS	Control
Tracing/Copying	Trace or copy the letter corresponding to a presented phoneme in a workbook.	Trace or copy pictures of animals in a workbook.
Bingo	Put tokens on printed letters starting with presented phonemes. Cover all letters to win.	Put tokens on pictures matching those displayed by the trainer. Cover all pictures to win.
I Spy	Look at a picture book and find hidden letters matching a presented phoneme.	Look at a picture book and find hidden pictures.
Board game	Roll dice, move around the board, and match letters that start with a presented phoneme.	Roll dice, move around the board, and match identical pictures.
Adventure story	Listen to a story and choose which way the characters should go by matching a letter to a phoneme clue.	Listen to a story and choose which way the characters should go by matching a picture to a clue.
Blending jigsaw (last two sessions only)	Combine jigsaw pieces with letters printed on them to make VCs and CVCs and say them aloud. Make the correct letter jigsaw for a spoken VC or CVC.	Combine jigsaw pieces with parts of pictures on them to make whole pictures and name them.

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