Analysis of Phonemes, Graphemes, Onset-Rimes, and Words with Braille-Learning Children

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Abstract: Six primary school–aged braille students were taught to name 4 to 10 braille letters as phonemes and another 4 to 10 braille letters as graphemes (Study 1). They were then taught to name 10 braille words as onset-rimes and another 10 braille words as whole words (Study 2). Instruction in phonemes and onset rimes resulted in fewer trials and a higher percentage of correct responses.

Decoding, or the phonological recoding of words, is one way of learning to read unfamiliar words (Ehri, 1994, 2005). It involves the transformation of graphemes (names of letters) into phonemes (sounds of letters) and the blending of phonemes into recognizable words. The phonemic skill is blending from decoding letters (Ehri, 1994, 2005; National Institute of Child Health and Development [NICHD], 2000). The correspondence between speech and print (Adams, 1990) and speech and braille (Millar, 1997) is possible because written English is based on an alphabetic principle that is the English language's set of grapheme-phoneme correspondences (Adams, 1990). Phonemic recovery mechanisms are not automatically and unconsciously available to reading processes as they are to language processes. Thus, reading acquisition must be managed separately from language acquisition, and phonemes must be brought to consciousness through explicit instruction (Adams, 1990; Liberman & Shankweiler, 1991). Letter-sound correspondence provides a powerful mnemonic system for young readers. Knowledge of the sounds of letters provides the substance that bonds the letters in written words to their pronunciation in memory, including the meanings of the words. Young readers then build a vocabulary of sight words during reading (Ehri, 1994, 2005).

During braille reading, unfamiliar words are decoded by transforming graphemes into phonemes and then blending the phonemes or syllabic units to form words with recognized meanings. Grapheme-phoneme correspondence is used during braille reading by beginning readers, less-skilled readers, and skilled readers when the text is relatively difficult. The reader's phonological

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coding changes with reading proficiency and experience (Millar, 1975, 1990, 1997). Practice is required in detecting, manipulating, segmenting, and blending phonemes and the connection with the mutually dependent process of reading. Instruction in contracted braille is also essential to focus attention on the logographic orthography of graphemes (for example, the letter *k* represents the word *knowledge*), including braille contractions and short forms. A child's ability to recognize braille patterns (letters) spatially depends largely on the deliberate practice of smooth, lateral, left-to-right hand movements in reading (Millar, 1997).

Instruction in onset-rimes is another way of learning to read words (Treiman, 1992). Learning to read words involves detecting and pronouncing orthographic patterns or chunks of letters and blending the intrasyllabic and syllabic units into recognizable words (Ehri, 1994, 2005; Treiman, 1992). Onset-rime is the two-part division of words into units that are intermediate in size between the syllable and the phoneme. The onset (such as *m* in *mat*) is the initial consonant, and the rime (such as *at* in *mat*) is the vowel and any consonants that follow. It is a phonemic analysis of reading words and is considered an alternative to the whole-word approach in which there is no explicit emphasis on phonemes (Treiman, 1992). Instruction in analogy reading is another way of learning to read words. It involves reading words that the reader already knows and using this knowledge to read new words (Ehri, 1994, 2005). The phonemic skill in analogy reading is onset-rime segmentation (for instance, *g - ate*) and blending the rime (like *ate*) with a new letter (such as *l*) to read the word *late* (NICHD, 2000).

The goal of reading instruction is to read words accurately and automatically and to know their meaning. It is the overlearned, effortless, automatic, visual (Adams, 1990), and tactile (Millar, 1997) recognition of letters, letter sequences, and whole words that is crucial for fluent reading. The importance of phonemes in early instruction in braille reading is supported by research related to braille reading (Millar, 1997), but there has been little research on onset-rime braille reading, in contrast to the whole-word approach to braille reading. The studies reported here were designed to investigate this topic.

The aim of Study 1 was to compare the performance of two methods of reading using braille letters: instruction in phonemes and instruction in graphemes. The hypothesis was that teaching braille letters as phonemes will result in more efficient performance than teaching braille letters as graphemes. The independent variable was instruction in phonemes and instruction in graphemes. The two dependent variables measured the number of trials needed to reach the criterion and the percentage of correct responses that was calculated from the trials. Graphemes and phonemes were compared because they are of the same construct, sharing a functional relationship that results in learning to read braille. The aim of Study 2 was to compare the performance of two methods of reading using braille words: instruction in onset-rimes and instruction in whole words. The hypothesis was that teaching braille words as onset-rimes will result in more efficient performance than teaching braille words as whole words. The independent variable was instruction in onset-rimes and instruction in whole words. The two dependent variables measured the number of trials needed to reach the

criterion and the percentage of correct responses that was calculated from the trials. Onset-rimes and whole words were compared because they are of the same construct, sharing a functional relationship that results in learning to read braille.

Study 1

Method

Participants

Six primary school children who were blind or had low vision and were learning braille were selected from six public primary schools (kindergarten to Grade 6) in Sydney, Australia. These students, two boys and four girls, spoke fluent English; their average age (in years and months) was 6.9. The ages in years and months and the year-grades of the boys were Participant 1 (6.9, Year 2) and Participant 2 (7.8, Year 2), and of the girls were Participant 3 (6.1, kindergarten), Participant 4 (6.7, Year 1) Participant 5 (6.11, kindergarten), and Participant 6 (7.7, Year 2). Participants 3, 4, and 5 had started school as braille learners. At the time of the study, Participants 1 and 2 had been learning braille for about 12 months, and Participant 6 had started braille instruction. Measures of the children's general intellectual ability and reading ability were not available, and policy prevented testing the children for this purpose.

Materials and procedure

Materials. Twenty-six English braille letters were placed on 26 small cards using a Perkins Braillewriter and braillable sheets (which were used for durability). Each child was rewarded with stickers for participation.

Design. A single-case study with a simultaneous-treatment design (also referred to as alternating treatments) was followed; baseline observation was used with two different treatment conditions, implemented as separate interventions that were alternated and administered simultaneously (Kazdin, 1982). Random assignment established the first intervention, and then the interventions were alternated. The target behaviors were instruction in phonemes and instruction in graphemes.

Response measurement and reliability. Interobserver agreement data (Kazdin, 1982) were collected for each participant during Study 1 and 2. The two observers and the instructor recorded exactly the same number of correct responses for each participant during each trial, resulting in 100% interobserver agreement.

Baseline phase. The design commenced with baseline observation of the target behaviors. Each child was observed during periods of structured and unstructured reading. The children were asked to identify randomly the 26 letters of the alphabet and the 26 sounds of the alphabet on individual cards. Each child received a reading score for his or her recognition of phonemes (/26) and a reading score for his or her recognition of graphemes (/26). The stimuli on which the child gave a correct response were not used in the study. The stimuli used in the intervention were those to which the child gave an incorrect response for both phoneme and grapheme recognition in his or her baseline measurement.

The stimuli that required instruction were randomly divided into two lists: one for phoneme instruction and one for grapheme instruction. A third baseline

measurement was carried out on these stimuli. Each child was assessed on his or her randomly assigned phonemes and graphemes. General motivational reinforcement was given (such as "good try" or "well done"). The single braille letters were read with the finger pads (both hands) laterally in a left-to-right direction. As a result of this baseline measurement, a stable baseline phase with no trend or variability (zero baseline) was created, and then the intervention phase began.

Intervention phase. Each child was presented with different stimuli according to his or her baseline phase. Participant 1 was randomly presented with 6 letters as phonemes (*b, h, m, q, u, w*) and 6 letters as graphemes (*d, f, i, n, r, z*). Participant 2 was randomly presented with 6 letters as phonemes (*c, e, f, j, r, v*) and 6 letters as graphemes (*d, h, i, m, u, z*). Participant 3 was randomly presented with 7 letters as phonemes (*d, h, i, o, t, w, y*) and 7 letters as graphemes (*e, j, m, r, s, u, z*). Participant 4 was randomly presented with 4 letters as phonemes (*e, h, j, z*) and 4 letters as graphemes (*d, f, i, y*). Participant 5 was randomly presented with 6 letters as phonemes (*d, g, j, r, t, v*) and 6 letters as graphemes (*f, h, p, q, w, z*). Participant 6 was randomly presented with 10 letters as phonemes *(d, f, i, m, o, q, s, u, w, y*) and 10 letters as graphemes (*e, h, n, j, p, r, t, v, x, z*). Baseline observation for Participant 6 indicated that instruction of 10 letters as a list of letters would be too much for an introductory intervention, so 3 letters (as a minimum to obtain reliable data) were presented during each trial until the criterion was reached. Criterion performance was reached when each child named his or her stimuli (sounds and letters) on three successive test trials. For Participant 6, once the criterion was achieved for one stimulus (or more stimuli), one randomly selected stimulus (or more stimuli) was added to the list. Participant 6 continued instruction until 10 letters were in the phoneme list and 10 letters were in the grapheme list. Baseline measurement was used to determine the number of graphemes and phonemes that were used in each child's instruction (because of the child's unique learning needs).

Learning and test trials

Phoneme intervention. Each child read a phoneme on a card while the instructor sang an alliteration sound song (such as "horses in the hay, /hhh/"). A slash is used to set off English phonemes (such as */h/*). See Crawford, Elliott, and Hoekman (2006) for the instructional songs. The instructor sang the song three times, and the child repeated it three times as he or she read the stimuli. During the trial, each child read his or her randomly assigned list of sounds. A test trial followed each learning trial. For the test trial, the cards were shuffled, and the child was asked to name the sound on each card. A response was recorded as correct if the child said the correct sound (such as */b/*) for the correct tactile stimulus (such as *b*). The responses were classified as correct (1) or incorrect or unknown (0). No feedback was given on correct or incorrect responses during the test trials to ensure the reliability of the data. (Correction of the responses during the test trial would have given the children an advantage.) For data recording, a child learning six phonemes would give a total of six responses

Table 1
The word lists used in the onset-rime and whole word instruction.

List 1	List 2	List 3	List 4
beg, cop, dig, gum, job, lag, nun, ran, wet, zip	box, fin, jot, hem, kit, leg, mug, pup, sat, yap	bent, dock, fund, hunt, kick, lamp, pack, ring, soft, zest	band, colt, gong, junk, kept, pick, rang, sift, tuck, weld

in a test trial, the number of correct responses totaled, divided by the total number of test trials needed to reach the criterion and multiplied by 100. Once the child achieved criterion performance with his or her phonemes, the intervention was stopped but continued for the other intervention (graphemes). The intervention was recorded for comparison. The length of each learning and test trial was approximately 15–30 minutes.

Grapheme intervention. Each child read a grapheme on a card while the instructor sang a letter-name song (such as "'p' is in the alphabet, /ppp/"). The instructor sang the song three times, and the child repeated it three times as he or she read the stimuli. During the trial, each child read his or her randomly assigned list of letters. A test trial followed each learning trial. For the test trial, the cards were shuffled, and the child was asked to name the letter on each card. A response was recorded as correct if the child said the correct letter (for example, *d*) for the correct tactile stimulus (for instance, *d*). Once the child achieved criterion performance with his or her graphemes, the intervention was stopped.

Study 2

Method

Participants

The same children who participated in Study 1 participated in Study 2.

Materials

Four braille word lists, with 10 words in each list, were used. List 1 and List 2 were consonant-vowel-consonant (CVC) words. List 3 and List 4 were consonant-vowel-consonant-consonant (CVCC) words (see Table 1). The words were placed on small cards.

Procedure

Design. The design for Study 2 was the same as the design for Study 1. Random assignment established the first intervention, and then the interventions were alternated. The target behaviors were instruction in onset-rimes and instruction in whole words.

Baseline phase. Participants 1, 2, 3, 4, 5, and 6 were assessed on the random selection of List 1 and List 2. Participants 1 and 4 were assessed on the random selection of List 3 and List 4 (since they received a near-perfect or perfect score on Lists 1 and 2). Each child received a reading score for his or her onset-rime recognition and a reading score for his or her whole-word recognition. The stimuli on which the child gave a correct response for both onset-rime and whole-word recognition were not used in the study. The stimuli used in the intervention were those to which the child gave an incorrect response for both phoneme and grapheme recognition in his or her baseline measurement. As a result of this measurement, a stable baseline phase

with no trend or variability (zero baseline) was created, and then the intervention phase began.

Intervention phase. Each child was presented with different stimuli according to his or her baseline phase. Participants 1 and 4 were given List 3 and List 4. As a random assignment, Participant 1 read List 3 as onset-rimes and List 4 as whole words, whereas Participant 4 read List 4 as onset-rimes and List 3 as whole words. Participants 2, 3, 5, and 6 were given List 1 and List 2. As a random assignment, Participants 2, 3, and 5 read List 1 as onset-rimes and List 2 as whole words, whereas Participant 6 read List 2 as onset-rimes and List 1 as whole words. The random assignment of the word lists reduced any unforeseen bias of using one word list over another with one type of instruction and, therefore, confirmed the pattern of learning. Baseline observation for Participants 3 and 5 indicated that instruction of 10 words as a list of words would be too much for an introductory intervention and thus 5 words were randomly presented during each trial until the criterion was reached. Criterion performance was reached when each child correctly named his or her onset-rime and whole-word stimuli (words) on three successive test trials. Once the criterion was reached for one stimulus (or more stimuli), one randomly selected stimulus (or more stimuli) was added to the list of stimuli. This instruction continued until 10 words were in the onset-rime list and 10 words were in the whole-word list. The interventions continued until the criterion was reached and were recorded for comparison. The length of each learning and test trial was approximately 30 minutes.

Onset-rime intervention. Each child read his or her randomly assigned onset-rime word list. The instructor read each CVC word in two parts (such as *l - ag*) and then as one part (for example, *lag*), or the instructor read each CVCC word in two parts (for instance, *l - amp*) and then as one part (like *lamp*). The instructor read the word twice, and the child repeated it twice as he or she read the stimuli. A test trial followed each learning trial. For the test trial, the cards were shuffled, and the child was asked to read the words as onset-rimes. A correct response required the correct pronunciation of the onset-rime (such as *l - ag, lag*) to the correct stimulus (such as *l - ag, lag*). Data for Study 2 were recorded following the same procedure as in Study 1. Once the child achieved criterion performance with his or her onset-rimes, the intervention was stopped for this condition but continued for the other condition (whole words).

Whole-word intervention. Each child read his or her randomly assigned whole-word list. The instructor read each CVC word as a whole word (such as *jot* as *jot*) or read a CVCC word as a whole word (for example, *rang* as *rang*). The instructor read the word twice, and the child repeated it twice as he or she read the stimuli. A test trial followed each learning trial. For the test trial, the cards were shuffled, and the child was asked to read the words as whole words. A correct response required the correct pronunciation of the whole word (such as *jot* as *jot* or *rang* as *rang*) to the correct stimulus (for instance, *jot* as *jot* or *rang* as *rang*). Once the child achieved criterion performance with his or her whole words, the intervention was stopped.

Table 2
Number of trials and percentage correct in the phoneme and grapheme instruction and the onset-rime and whole-word instruction.

	Number of trials		Percentage correct		Number of trials		Percentage correct	
Participants	Phoneme	Grapheme	Phoneme	Grapheme	Onset-rime	Whole word	Onset-rime	Whole word
1	6	12	86.11	73.61	9	18	77.77	61.66
2	15	36	75.55	63.88	9	24	77.77	61.66
3	15	30	77.14	63.80	18	36	77.77	66.33
4	12	15	81.25	61.66	6	9	98.33	87.77
5	18	36	83.33	69.44	9	18	86.36	75.88
6	33	42	76.62	63.63	15	21	80.00	68.57

Results

In Study 1 and Study 2, two measures of performance were collected for each child's learning: the number of trials required to reach the criterion and the percentage of correct responses that was calculated from the trials. For the latter, the correct responses were totaled and calculated as a percentage of the total number of test-trial responses that were required of each child. The performance measures were collected and recorded separately for the phoneme and the grapheme instruction and recorded separately for the onset-rime and whole-word instruction. Table 2 shows the number of trials that were needed to reach the criterion and the percentage correct in the phoneme and grapheme instruction and the onset-rime and whole-word instruction.

Table 2 shows that each child needed fewer trials to reach the criterion in the phoneme instruction than in the grapheme instruction. For Participants 1, 2, 3, and 5, the number of trials that were needed to reach the criterion for the phoneme instruction was half the number of trials for the grapheme instruction. For Participants 4 and 6, the number of trials that were needed to reach the criterion for the phoneme instruction was approximately 20% less than for the grapheme instruction. The average number of trials that the children needed to reach the criterion were 16.5 in the phoneme instruction and 28.5 in the grapheme instruction—an increase of 72.7%. Figure 1 shows the number of trials in the phoneme and grapheme instruction. Fewer trials indicate faster learning.

Table 2 also shows that all the children had a higher a percentage of correct responses for the phoneme instruction than for the grapheme instruction. The average difference between the phoneme and the grapheme instruction was 14%. Figure 2

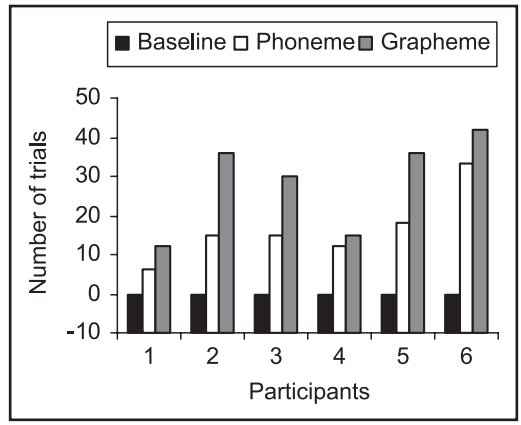

Figure 1. Number of trials in the phoneme and grapheme instruction.

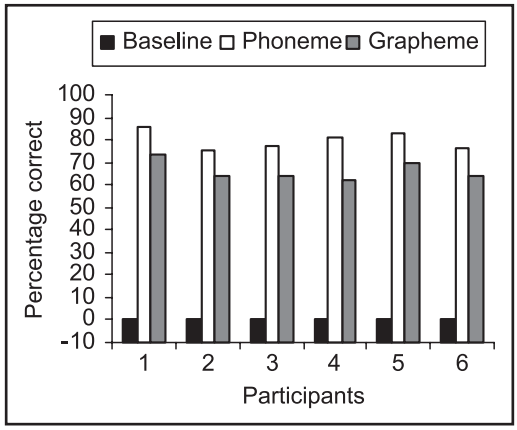

Figure 2. Percentage correct in the phoneme and grapheme instruction.

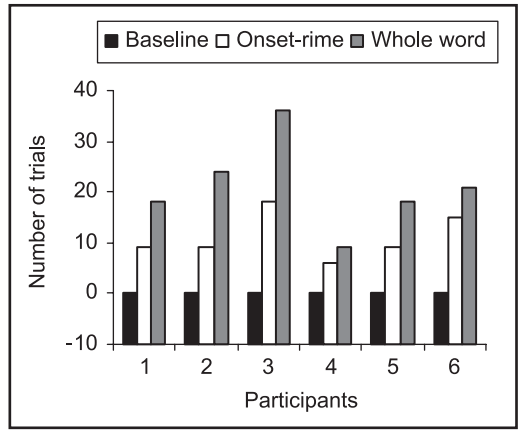

Figure 3. Number of trials in the onset-rime and whole-word instruction.

shows the percentage correct in the phoneme and grapheme instruction. Higher percentages of correct responses indicate better performance because of the effectiveness of the phoneme intervention.

Furthermore, Table 2 shows that in Study 2, each participant needed fewer trials to reach the criterion in the onset-rime instruction than in the whole-word instruction. For Participants 1, 2, 3, and 5, the number of trials needed to reach the criterion for the onset-rime instruction was half the number of trials for the whole-word instruction. For Participants 4 and 6, the number of trials needed to reach the criterion for the onset-rime instruction was one-third less than for the whole-word instruction. The average number of trials that the children needed to reach the criterion was 11 in the onset-rime instruction trials and 21 in the whole-word instruction—an increase of 90.0%. Figure 3 shows the number of trials in the onset-rime and whole-word instruction.

Table 2 also shows that all the participants had a higher percentage of correct responses for the onset-rime instruction than for the whole-word instruction. The average difference between the onset-rime and whole-word instruction was 12.7%. Figure 4 shows the percentage correct in the onset-rime and whole-word instruction. Higher percentages of correct responses indicate better performance because of the effectiveness of the onset-rime intervention.

In Study 2, the mean for word frequency was calculated for the words (Carroll, Davis, & Richman, 1971) and a *t*-test was conducted to ensure that there was no statistical difference between the word lists: List 1 (300) and List 2 (279), $t(1, 18) = .100$, $p = .922$; List 3 (227) and List 4

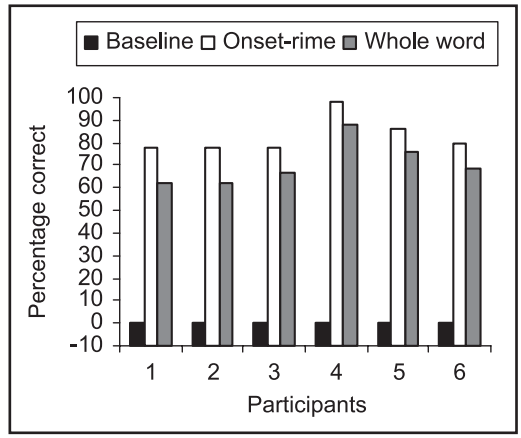

Figure 4. Percentage correct in the onset-rime and whole-word instruction.

(237), $t(1, 18) = .071$, $p = .944$. There was no statistical difference between the pairs of word lists, and hence the lists were matched for level of difficulty.

Discussion

In the two studies, the children's performance was better when reading braille letters as phonemes than as graphemes and for reading braille words as onset-rimes than as whole words. These results support the hypotheses. It is possible that the phonemic approach allows for a direct route from the stimulus to the response, whereas the graphemic (shape) approach requires mediation (translation to sound) between the stimulus and the response (Millar, 1975, 1997). The phonological coding of speech sounds is built in and automatic, but the grapheme-to-phoneme translation must be learned through reading instruction. Part of the process of teaching reading involves instruction in the sound structure of speech. Once the grapheme-to-phoneme translation has been learned, it becomes automatic during the reading of words (Adams, 1990; NICHD, 2000). Learning how to code or represent the physical, tactile, textural features of braille patterns in memory requires experience. The small size of the six-dot braille matrix (approximately 6.3 × 2.5 millimeters [or approximately 0.25 × 0.09 inch]), combined with the lack of distinctive features of the braille patterns that could be used as reference cues for spatial coding by touch, makes coding by shape difficult. It is possible to explain the evidence for small spans of tactile memory as a consequence of the small braille matrix and the lack of reference cues because it is difficult for input to be spatially organized in terms of global patterns (Millar, 1997). In comparison, the spans of phonological memory are greater, and the ability to recall information encoded phonologically had been shown to be superior to the encoding of information tactilely in the short-term memory of young children studying braille (Millar, 1975).

The two studies are an extension of two previous studies on comparative braille reading behavior. One previous study found a statistically significant advantage for braille reading instruction in phonemes and onset-rimes with young sighted children under nonvisual conditions (Crawford et al., 2006). The other previous study reported better performance for reading braille letters as phonemes and reading braille words as onset-rimes with adults with visual impairments (Crawford & Elliott, 2007). The results of these previous studies are similar to the results of the studies reported here.

Study 1 (and the previous studies) used an alliteration sound song (for example, "fish in the flower, /fff/") for phoneme instruction and a letter-name song (for instance, "'d' is in the alphabet, /ddd/") for grapheme instruction as the verbal repertoire. It is possible that the use of alliteration with braille reading instruction is an effective method of learning phonemes. Alliteration focuses attention on the first sound in the braille word (such as "blowing bubbles, /bbb/"), and repeating the sound with song reinforces auditory learning. It is considered an effective strategy for connecting braille letters with phonemes in reading instruction (Troughton, 1992), whereas graphemes are taught as graphemes (Millar, 1997), rather than by using an alliteration technique. The use of alliteration in phoneme instruction gives the child a mnemonic clue, whereas grapheme instruction uses no mnemonic

clue. Songs were used in the study, since teaching letters, sounds, and words to the tunes of familiar songs is used regularly with young children (Yopp, 1992). Young children are usually introduced to the "Alphabet Song" to the tune of "Twinkle, Twinkle Little Star" (Adams, 1990).

In Study 2, the children's performance in reading words as onset-rime words was better than their performance in reading whole words. Segmenting the onset from the rime is a phonemic approach to reading because there is a focus on the first phoneme (onset) and the rime unit. It is possible that during onset-rime instruction, there is conscious attention to the sounds that occur during the encoding process (input of auditory sounds to phonological codes), whereas during whole-word instruction, there is no conscious attention to the sounds, since the words are taught as whole units, and any transformation occurs after this process. The end result of both processes is automatic word recognition, but for the whole words, it is restricted to the specific words that are learned, whereas instruction in grapheme-phoneme correspondence means that this knowledge is generalized to similar words that can be processed automatically.

Although reading by analogy was not the focus of the current studies, Adams (1990) and Treiman (1992) suggested that learning to read lists of words as phonograms or word families (such as *-ot* in *cot, dot, got*) is advantageous for young children in early reading and spelling instruction. Instruction in segmenting the onset from the rime focuses attention on the phonemic similarity of the words and learning to read words by analogy. Regarding the limitations of the current studies, posttests were not conducted because of time constraints, and, as a result, it is not possible to determine whether the phoneme and onset-rime advantage is transferable to further learning. Additional research on the basis of these studies would involve onset-rime and whole-word reading with regular and irregular braille words. The findings of these studies supply evidence of the importance of phoneme and onset-rime reading in early braille reading instruction with this sample of children.

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