

THE RELATIONSHIPS BETWEEN SEGMENTAL ANALYSIS AND ALPHABETIC LITERACY: AN INTERACTIVE VIEW

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Résumé

La question des relations entre les habiletés d'analyse segmentale et l'acquisition du code alphabétique reste confuse dans la littérature. Dans cet article nous défendons la position que (1) les habiletés d'analyse segmentale ne se développent pas sans stimulation spécifique et qu'elles apparaissent généralement lors de l'apprentissage de la lecture et de l'écriture dans le système alphabétique. Après avoir distingué entre conscience segmentale et habiletés d'analyse segmentale, nous avançons également l'idée que (2) les habiletés d'analyse segmentale peuvent se développer en dehors de l'apprentissage de la lecture dans le système alphabétique, (3) qu'elles contribuent au succès de l'acquisition de la lecture et de l'écriture, et (4) qu'elles sont de bons prédicteurs de l'habileté de lecture même lorsque l'apprentissage est basé sur une méthode globale. L'instruction n'est pas suffisante pour promouvoir le développement des habiletés d'analyse segmentale, mais la maîtrise du code alphabétique est (presque) une indication suffisante de la présence des habiletés segmentales. Nous distinguons différentes formes de conscience phonologique : conscience des séquences phonologiques, conscience des phonemes et conscience des phonèmes. En particulier, nous affirmons que l'appréciation et la manipulation des rimes n'exigent pas une analyse segmentale. Les capacités qui pourraient sous-tendre le développement de l'analyse segmentale sont analysées. Finalement, certaines implications éducatives sont discutées.

Key words: acquisition of reading and spelling, alphabetic literacy, segmental analysis of speech, phonological awareness.

Mots clés : acquisition de la lecture et de l'écriture, alphabétisation, analyse segmentale de la parole, conscience phonologique.

Speech may be described as a sequence of phonetic or phonemic elementary units, called segments. The question of the relationships between segmental analysis ability, that is performance on tasks requiring intentional analysis of speech at the level of segments, and alphabetic literacy acquisition is important for at least three reasons: it is crucial for understanding the development of literacy, it has considerable educational implications, and it may provide interesting suggestions regarding the general issue of the development of skills.

Ten years ago, Liberman, Shankweiler, Liberman, Fowler and Fischer (1977) commented as follows on the connection between phonetic segmentation ability and early reading acquisition: "Unfortunately, the nature of the connection is in doubt. On the one hand, the increase in ability to segment phonetically might result from the reading instruction that begins between five and six. Or, alternatively, it might be a manifestation of some kind of intellectual maturation" (pp. 212-213). In an attempt to disentangle the two hypotheses, we tested two groups of adult subjects, illiterates and ex-illiterates, on tasks of segmental analysis (Morais, Cary, Alegria and Bertelson, 1979). We concluded from the results that the ability to deal explicitly with the segmental units of speech is not acquired spontaneously in the course of cognitive growth, but demands some specific training, which, for most persons, is provided by learning to read and write in the alphabetic system (cf. Abstract, p. 323, and Discussion, p. 330).

The idea that segmental analysis skills develop in the context of alphabetic literacy acquisition is not inconsistent with the idea, which is also empirically supported, that the former contributes decisively to the latter. Segmental analysis skills and alphabetic literacy acquisition may influence each other. However, from the notion that something cannot be both cause and effect of something else, some people find no escape from the two antagonistic positions. To them, neither segmental analysis skills nor alphabetic literacy acquisition can be both the chicken and the egg. We happen to be included among those who "believe that reading may be the cause and phonemic awareness the effect rather than the other way round" (Fox and Routh, 1984, p. 1059).

As Bertelson recently put forward, segmental analysis and alphabetic literacy "are both too global to expect to observe a unidirectional causal relation between them" (1986, p. 11). The purpose of the present paper is to explain in more detail, and referring to more recent data, the interactive view that was already proposed in our 1979 paper and which we have restated later on (Bertelson, Morais, Alegria and Content, 1985). We also submit a conceptual taxonomy which we think is useful in specifying more exactly the notion of segmental analysis skills.

1. Segmental analysis ability does not develop without specific stimulation; it usually appears when learning to read and write in the alphabetic system

We will first review the findings of our 1979 paper. We tested illiterate adults in Portugal who had never attended school for social reasons, and ex-illiterates of nearly the same age and of the same social origin who had not attended school before adolescence and who learned to read and write later on in special classes. The tests consisted in repeating an utterance, but either deleting the initial segment, or adding a segment at the beginning. Each test was introduced by means of 15 trials during which the experimenter provided the correct response to each item whenever the subject was unable to give it himself. No feedback was provided during the experimental trials. The average scores, using non-word items, were 19% correct responses for illiterate subjects on the addition and deletion tests, and 71% and 73% correct responses for ex-illiterates. Half of the illiterates failed on every trial and only one scored 80% correct responses. By contrast, no ex-illiterate failed on every trial and more than half scored at least 80%. These results are clearly incompatible with the notion that segmental analysis must be installed before starting learning to read and write and that it "develops naturally, spontaneously, under the influence of the linguistic stimulations provided by current life" (Leroy-Boussion, 1975, p. 185).

We also claimed, on the basis of our results, that the most frequent situation that allows the ability of segmental analysis to develop is learning to read and write in the alphabetic system. This claim, although theoretically sound, had still to be empirically validated. Segmental analysis skills might develop as a consequence of literacy in general, and not specifically as a consequence of *alphabetic* literacy. A recent study by Read, Zhang, Nie and Ding (1986) supports the more restricted claim. The authors compared alphabetic and non-alphabetic literates in China. Tests and procedure were exactly the same as those used in Morais et al.'s (1979) experiment. The mean scores of the non-alphabetic and alphabetic literates (21% and 83%, respectively) were strikingly similar to those of our illiterates and ex-illiterates. Chinese non-alphabetic literates thus share with Portuguese illiterates the inability to analyze speech at the segmental level. The literacy of the former subjects is beyond doubt: they had been reading for forty years and read at a high level. Learning to read thus provokes the emergence of segmental analysis abilities if the writing is alphabetic, but it does not if the writing is logographic. In a similar vein, Mann (1986) has observed that the development of segmental skills is much delayed in Japanese first-graders, who learn to read a syllabary, the kana, compared to their American peers. The fact that Japanese children attain a relatively high level of segmental ability by grade four is probably linked to the existence, in kana, of diacritics which permit readers to distinguish syllables with voiced stops from syllables with unvoiced stops. Kana also includes separate characters for some segments, namely vowels and one nasal consonant.

2. Segmental awareness and segmental analysis ability

Before examining in more detail the relationships between alphabetic literacy and segmental analysis, it seems necessary to introduce the concept of segmental awareness and to deal with the issue of the relationships between awareness and ability in this domain.

Segmental awareness is a necessary, but sometimes elusive concept. Someone who is able to verbally report the segments of an utterance must be credited with segmental awareness. Someone who always responds correctly and without hesitation, for instance in a task requiring the deletion of a segment, when explicitly instructed to do so or following a few examples, is likely to possess conscious knowledge of the segments. However, someone who, after a series of incorrect responses, takes advantage of any useful information provided by the examiner, for instance corrective feedback, and begins to produce the correct response shows, for practical purposes, some segmental analysis skill, but he has not necessarily acquired segmental awareness. It is merely by inference, and not by logical necessity, that we assume that he has mentally deleted a segment from a representation of a sequence of segments.

In the absence of verbal enunciation of the segments of a speech utterance, and in the absence of immediate success in manipulation tasks, how can we recognize the presence of segmental awareness in a subject? We need some minimal behavioral criterion. As suggested by Rozin (1978) and Content (1985b), this could be the observation of learning transfer effects. The acquisition of segmental awareness in the course of learning say a segment deletion task should enable the subject to perform successfully on other tasks of segmental analysis, even when material and procedure are very different between the learning and the transfer tasks.

In our view, segmental awareness is not a mere epiphenomenon of segmental analysis abilities, but plays a dynamic and interactive role in their development. The acquisition of conscious representations of segments implies some segmental analysis, and in turn contributes to increasing the efficiency of segmental manipulations. It is presumably through a constant interaction between the elaboration of conscious representations and their use in analytic operations that one becomes able to analyze complex syllabic structures and to produce relatively infrequent combinations of segments. In fact, a long process is necessary before each segment can be accurately isolated or manipulated in any context. For instance, separating the segments in a consonant cluster remains a difficult task long after the subject can manage to analyze a CV syllable. In one of our studies (Morais, Cluytens and Alegria, 1984), first-graders scored an average of 71% correct in deleting [p] or [f] before a vowel, but only 26% in deleting the same segments before a lateral. Second-graders scored 95% and 55%, respectively. Second-graders were thus worse in deleting the initial C in a CCV than first-graders in deleting C in a CV. After consonants and vowels can be separated from each other, consonant clusters still tend to appear as units that cannot be decomposed. With practice, in the

context of reading and writing activities, segmentation and blending become easier, faster, and less under conscious control. At last, conscious control becomes obsolete with the full development of the ability to which it contributed.

3. Segmental analysis ability can develop outside learning to read in the alphabetic system

The results obtained with adult illiterates from Portugal and with non-alphabetic literates from China demonstrate that segmental analysis ability is not a precondition, i.e. does not have to exist before starting learning to read and write in the alphabetic system. It does not follow from this that reading acquisition is the only way to develop some segmental analysis ability. In our 1979 paper, we admitted that segmental analysis ability could be provoked by some other experience.

It has been demonstrated that some segmental analysis ability may be acquired very rapidly by prereaders independent of confrontation with the alphabet. However, it is not certain that such acquisition implies the emergence of segmental awareness. Content, Morais, Alegria and Bertelson (1982) found that prereaders' performance on the task of deletion of the initial consonant improves after several sessions of oral games in which subjects' attention was called to the segmental constituents of speech without graphic aids. The improvement after such a training was greater than in a control group whose training time had been devoted to mathematical games. More recently, we observed improvements on the same task of consonant deletion by giving constant corrective feedback throughout the test, in both five- and (in one of two experiments) four-year olds (Content, Kolinsky, Morais and Bertelson, 1986). An incidental finding was that learning during the deletion task was transferred to a task of free segmentation in which the subject was invited to produce any segment that was present in a syllable.

These results indicate some segmental analysis ability. However, they do not imply that the children operated on the basis of conscious representations of segments. As a matter of fact, in a series of experiments (Content, 1985b), transfer effects from the deletion task to classification or counting tasks were slight or null. Improvements in initial consonant deletion tended to transfer more to classification on the basis of a common vowel than on the basis of a common consonant. Furthermore, deletion of the initial consonant displayed no effect of phonetic class, while isolated production of the same segment did. All this suggests that what the child learns from corrective feedback during the deletion task may be how to find a new attack point for his response. Thus, there is no compelling reason for interpreting the learning effects as reflecting discovery of the segmental structure of speech. The children might simply have discovered a procedure that works in a particular situation. There are other studies in which training on one task does not transfer to another task. Fox and Routh (1984), for instance, found no transfer from segmentation to blending.

In our experiments with prereaders, some subjects showed correct performance almost from the beginning of the test. In a very interesting study on the issue of developing segmental analysis outside formal reading instruction, Olofsson and Lundberg (1983) found that several kindergarteners had perfect or almost perfect scores even before training. Olofsson and Lundberg (1985) write that "this finding apparently contradicts the widely assumed notion of causality where phonemic awareness is assumed to develop mainly in the context of reading instruction" (p. 32). However, the contradiction is only apparent. We should take into account that the children tested were aged 6 years 11 months on average and that they lived in a cultural environment very different from that of our illiterates. Olofsson and Lundberg give the following explanation of the performance of their subjects: "There are reasons to suspect that our non-readers with well developed phonemic awareness skills have profited from a stimulating literate environment which nourished their development of prereading skills. The protocols often revealed the use of letter names instead of speech segments which is one indication of the influence of an informal literate environment" (p. 32). Indeed, the question is not whether learning to read in school is necessary for developing segmental analysis skills, but rather whether learning to read whatever the setting, and more generally acquaintance with the alphabetic material, is necessary.

The idea that learning to read in the alphabetic system is not necessary for the development of segmental analysis ability does not contradict the notion that segmental analysis is not an automatic consequence of cognitive growth. The last notion simply states that some exercise or activity requiring attention to the segments must intervene. For most children, the first encountered activity requiring attention to such "objects" is learning to read and write in the alphabetic system. But, indeed, though formal instruction in reading and writing begins at first grade, most children are stimulated to play with speech before they enter primary school (they are also exposed to alphabetic material, which renders the dissociation of the two factors almost impossible). One might even imagine a culture in which all children are taught speech segmentation before reading. This would not invalidate the essence of our claim of the previous section. It would still be true that segmental analysis ability is not a cognitive prerequisite for taking advantage of reading instruction. Of course, while segmental analysis is not a precondition for learning to read, prereaders' insights into the segmental structure of speech may give them a good start in learning the alphabetic code.

In sum, attempts to teach segmental analysis to prereaders suggest that some operations appropriate to particular tasks may be learned. These operations do not necessarily imply segmental awareness. The importance of distinguishing between segmental analysis abilities and segmental awareness is thus substantiated. Developing segmental awareness and learning to read and write are things that usually go together. Whether or not it is possible to become aware of the segmental structure of speech in the absence of confrontation with alphabetic material remains an open question.

4. Learning segmental analysis ability contributes to success in reading and writing

Learning to recognize on a purely visual basis all the words we encounter would be titanic. It seems a good strategy to take advantage of the fact that words are made out of letters and that letters correspond roughly to phonemes. A limited set of rules of grapheme-phoneme conversion would help reading new or insufficiently familiar words, and would assist the beginning reader in the task of acquiring a direct route to the lexicon. It should be very hard to learn to read in the alphabetic system and reach high standards of reading if the rules of grapheme-phoneme conversion are not mastered. Obviously, the acquisition of these rules implies the ability to analyze speech at the phonemic and phonetic levels (the phone being the surface form of the phoneme). Assuming that segmental analysis abilities cannot reach a high level, allowing isolation of segments whatever the context and all sorts of combinations, if conscious representations of segments are not developed, we may say that acquisition of reading in the alphabetic system depends on segmental awareness. As we proposed in our 1979 paper, "there is a reciprocal relationship between learning to read and the developmental changes in phonetic awareness" (p. 330). Being instructed to read in the alphabetic system creates a strong pressure on developing segmental awareness. On the other hand, developing both segmental awareness and segmental analysis abilities is crucial for mastering the rules of grapheme-phoneme conversion, using them in reading, and thus acquiring literacy rapidly.

Most studies have examined either to what extent segmental analysis is predictive of later reading achievement (e.g. Goldstein, 1976), or to what extent training in segmental analysis influences reading positively (e.g. Williams, 1980), or both conjointly (e.g. Bradley and Bryant, 1983). Each study has its own shortcoming. Some tested reading, but not other schooling acquisitions, thus leaving in question the specificity of the results. Others gave training on segmental analysis, but also on sound-letter correspondences, thus raising the criticism that it is trivial to show that instruction in reading improves reading. Bradley and Bryant's study does not suffer from any of these flaws. It included a group who received training on both sound categorization and letter-sound correspondences, and a group who received training on sound categorization only. Unfortunately, the last group did not show significantly greater progress in reading and spelling than a control group who received training on semantic categorization.

More microscopic analyses of the effects of segmental analysis skills on reading were performed by Treiman and Baron (1983) and by Fox and Routh (1984). These studies demonstrate that training in segmental analysis enables children to take advantage of spelling to sound correspondences and to use these correspondences in the retention of orthographic patterns. Treiman and Baron (1983) taught prereaders to orally segment CVC syllables into initial consonant and rime (example: HEM = H + EM). Then the subjects had to learn, by a paired-associate procedure, to sound out a series of four

orthographic patterns. Each series included one isolated consonant, one rime, one item combining the consonant and the rime - its pronunciation could be obtained by combining the pronunciations of the two preceding items -, and one item phonologically unrelated to the others. In the experimental condition, the first three items corresponded to syllables that had been previously analyzed orally, while in the control condition they had simply been repeated for the same amount of time. The results showed better performance for the related than for the unrelated item in the experimental condition, and the opposite in the control condition. In the control condition subjects were confused by the similarity of the related item, while in the experimental condition they took advantage of the spelling to sound correspondences. These correspondences appear to be instrumental in learning orthographic patterns. Similar results have been obtained by Fox and Routh, even though learning of associated pairs was facilitated by previous training on segmentation *and* blending, but not on segmentation only.

Both segmentation and blending are necessary in learning to read on the basis of grapheme-phoneme correspondences. Learning to read helps notice that letters correspond to rather small and subtle parts of speech and thus promotes segmentation ability. When trying to read a particular word, finding the segments of speech corresponding to the sequence of letters is not all that must be done. It is also necessary to blend or synthesize the segments in the correct order. Thus, we might expect the direction of causality to operate mainly from experience with print to segmentation, and from blending to reading, rather than the other way round. Perfetti, Beck and Hughes (1981), testing first-graders, have found some evidence supporting this view. They examined whether performance on either a blending or a segmentation (deletion) task at time t correlated more highly with reading at time $t+\Delta t$ or at time $t-\Delta t$. The correlations obtained suggest that causality is stronger, though not one-way only, from reading to segmentation (tested in october and in january, respectively) and from blending to reading (tested in october and january, respectively, or in january and april, depending on type of instruction program). This kind of work illustrates the right way to examine the complex relationships between segmental skills and literacy. To quote Bertelson (1986), "only by analyzing both processes into simpler episodes can one hope to reach a level of description at which unidirectional influences would be found" (p. 11).

Another study that used multivariate methods to determine causal relationships between phonological training and reading and spelling acquisition is Tornéus (1984). This author analyzed data from a large sample of Swedish children who had been tested for cognitive and language development, reading and spelling level, and metaphonological abilities (we respect here the author's terminology), at the end of first grade. The results suggested that spelling and reading level depend on metaphonological abilities, but not the reverse, and that metaphonological abilities depend on cognitive and language development. Discussing the unidirectional effect of metaphonological ability on reading and spelling, Tornéus says that it refers to early reading

and spelling and admits that later on the relationship might be reciprocal. Let us comment, first of all, that sophisticated statistical analyses are less convincing evidence for causality than experimental ones. Second, our findings indicate, contrary to those of Tornéus, that the influence of learning to read and write on the development of segmental analysis occurs mainly at the very early stages. In normal schooling conditions, and when learning to read according to a phonic method, some months may be sufficient to increase performance on some segmental analysis tasks from (almost) zero to (almost) total success (cf. Alegria, Pignot and Morais, 1982; Morais, Cluytens and Alegria, 1984). At this time, other tasks may yield lower performance, either because they are cognitively more demanding, or because the ability to represent segments and operate on these representations is not yet sufficiently developed, or most probably because of a combination of these two factors. The mastery of spelling and the development of phonemic representations may also give the subject more useful units to deal with. However, these changes are much less apparent than the two main phenomena that occur when the individual faces the task of learning to read and write alphabetic words: first, the extremely rapid development of segmental skills under the pressure of that task rather than as a consequence of success; second, the role of segmental skills in improving reading and writing, as indicated in Tornéus' study and others.

5. Segmental analysis ability is a good predictor of reading ability even when learning to read in a whole-word setting

Given that segmental analysis ability usually develops when learning to read in the alphabetic system, one would expect it to develop faster if the method of instruction specifies the code than if it does not. The evidence actually shows that segmental analysis ability is reached much faster in a phonic rather than a whole-word setting. Alegria, Pignot and Morais (1982) found, using a phoneme-reversing task, that the first-graders taught to read according to a phonic method scored 58% of correct responses, whereas first-graders taught to read according to a whole-word method scored only 15%. In a more recent study (Alegria, Morais and d'Alimonte, submitted), we found that first-graders taught to read according to a pure whole-word method (it was carefully checked that no analysis of the words into segments was provided by the teachers) made, on average, little progress from the fourth to the ninth month of school (6 and 18% of correct responses, respectively) in the task of initial consonant deletion. However, there were large interindividual differences. About 13% of the subjects made considerable progress, reaching a high level of performance in the retest. Either these children had received supplementary instruction at home or they had abstracted the segmental structure of speech from their experience with the alphabetic material. Anyway, such experience should not be assimilated to mere exposure. The Portuguese illiterate adults lack segmental ability despite the fact that they have been exposed for many years to alphabetically written words. In principle, experience in school is intensive and includes the intention and effort to learn.

The same study shows, on the other hand, that the segmental ability is highly correlated with the ability to read new words. At the time of retest, a word reading test was also given. Reading scores were on the average very low. Thus, it is likely that the reading test included many words that the children had never encountered before. But, here again, there were large interindividual differences: most of the subjects were totally unable to read the list, while a small number managed to read a considerable number of words. According to Uta Frith's (1985) model, the former would still be at the "logographic" stage, the stage at which only words encountered before can be read, while the latter would have reached the "orthographic" stage, implying the competence to decode unfamiliar words. The interesting point is that *all* the subjects who made significant progress in the task of consonant deletion also seem to have reached the "orthographic" stage of reading. This high correlation with word reading was not observed for other tasks, namely syllable deletion and rhyme detection, on which the subjects had also been tested. As a matter of fact, a large number of subjects with high scores on these tasks still performed very poorly on word reading. Thus, assuming that segmental ability is more than an epiphenomenon of reading, one must conclude that the ability to read new words in the first stages of learning to read depends critically on segmental ability, even when the method of instruction does not specify the segments.

6. Receiving reading instruction in the alphabetic system is not sufficient to develop segmental analysis ability, but alphabetic literacy is (almost) a sufficient indication of segmental skill

Backward readers, despite having received reading instruction, are often very poor on segmental analysis tasks (Savin, 1972, reported one of the former observations of this fact; see also Morais, Cluytens and Alegria, 1984, for performance of young severe dyslexics on the initial consonant deletion task). Clearly, experience with the alphabetic material, and backward readers certainly do have it, is not sufficient to develop segmental analysis. Some other capacities must be present. Later, we will examine what these capacities would be.

Now, the reverse question may be asked: is success in learning to read a sufficient indication of segmental skills? Since segmental skills seem to be crucial to using grapheme-phoneme correspondences, the answer seems to be "yes". But is resorting to these correspondences *absolutely* necessary during the learning process? This claim might be too strong. Very rarely individuals who read at a high level while lacking segmental analysis are found: one case is described by Campbell and Butterworth, 1985; a further case, where segmental inability may presumably be inferred from word deafness, is reported by Denes, Balliello, Volterra and Pellegrini, 1986). Such exceptional cases may result from the adoption of compensatory strategies based on exceptional capabilities. Strictly speaking, the ability to read alphabetic material is not a sufficient condition for segmental skills, but one has only an infinitesimally

small chance of being wrong when attributing segmental skills to an alphabetic literate person.

7. Several forms of phonological awareness must be distinguished

As mentioned above, Bradley and Bryant (1983) found that training children on sound classification *and* letter-sound correspondences leads to improvement in later reading performance. They concluded from this that the link between "phonological awareness" and reading is causal. Because this conclusion might look inconsistent with that of our 1979 paper we wrote a comment (Bertelson, Morais, Alegria and Content, 1985) in which we argued that "causal" may be misleading since the inverse type of relation also holds. Bryant and Bradley (1985b) replied to us saying that they did not intend to exclude the possibility of the latter relation and that they think it likely that the causal links operate in this direction also. They suggested that there are different forms of phonological awareness and that some precede reading while others follow it. In a recent book, the same authors (Bryant and Bradley, 1985a) mention the findings of our work with illiterates and comment that "we cannot conclude from it that *all* phonological awareness comes after, and as a consequence of, learning to read" (p. 46). Their main argument is that illiterates, as well as preliterates, understand rhyme. If phonological awareness is taken in a very general sense this is a suggestion with which we agree. However, it seems to us that it is extremely important to make some distinctions within this rather loose concept. In fact, we disagree with Bryant and Bradley when they say that in order to understand rhyme one "must know something about the constituent sounds of words" (1985a, p. 46). If we consider the meaning-form distinction, understanding rhyme certainly implies attention to the form dimension, i.e. to phonology, but it does not necessarily involve attention to any specific constituent of speech, and in particular the kind of unit that corresponds roughly to the letters of the alphabet: the phonemes. If phonological awareness is *awareness of phonological strings* without separate representation of constituents, then we agree that phonological awareness probably precedes learning to read in a great majority of people. But if, as it is usually meant, phonological awareness is *awareness of phonological units* (phones, phonemes and syllables), we believe that it is usually acquired, at least regarding phones and phonemes, in the situation of learning to read and write in the alphabetic system.

8. Awareness of phonological strings

Segmental awareness requires awareness that utterances are phonological strings. This implies that one is able to disregard meaning for a while. The ability to disregard meaning and concentrate on the phonological form of speech is probably necessary when the child is acquiring the phonology of his native language; it manifests itself in the attempts to reproduce words correctly and in the self-corrections of pronunciation observed in two- and

three-year olds (Clark, 1978). However, attention to pronunciation does not imply representing each segment as such. The phonology of speech may be represented, at this stage, in an unsegmented form or in constituents larger than the segment.

Young preliterate children also engage in tongue-twisters and rhyming games. Consistently with this observation, preliterates can in general succeed in tasks that involve the search for a rhyming target (cf. Lenel and Cantor, 1981; see also Stanovich, Cunningham and Cramer, 1984, where kindergarteners obtained 77% and 86% of correct responses on average for rhyme choice and rhyme supply, respectively). We are acquainted with several adult illiterates who enjoy rhyme and create rhyming verses. In one of our studies (Morais et al., 1986), a group of adult illiterates scored 66% of correct responses on finding among four pictures the one whose name rhymed with the target. Though ex-illiterates performed much better, more than 90% of correct responses on average, it is clear that illiterates as a group are not insensitive to rhyme. An interesting additional observation is that illiterates were not worse for detecting weak rhyme, based on identity of the ending vowel or diphthong, than strong rhyme, based on identity of the last two syllables. Similarity based on the vocalic kernels of the utterances or names might be the factor responsible for the subjects' judgements.

Recently, we have, with Luz Cary, studied the case of an illiterate poet. In his poems he is extremely expert at manipulating rhyme. He performed without error on several tasks of rhyme detection and production. He repeated without difficulty all the alliterating words presented within a sentence. However, in a test of initial consonant deletion he performed within the range of non-poet illiterate adults, failing most of the trials. These findings are clearly inconsistent with Bradley and Bryant's (1985a) claim that rhyme and alliteration depend on "breaking words and syllables into phonological segments" (p. 5). They show that versification and alphabetic literacy do not require exactly the same kind of awareness of speech. Rhyme and alliteration may both depend on sensitivity to phonological similarities without necessarily requiring an analytic competence.

Some other tasks that may be described in analytic terms may not require segmental analysis. This is probably the case of the substitution task. The analytic description of this task is that the subject has first to delete one segment and then to put another segment in its place. However, Stanovich, Cunningham and Cramer (1984), testing kindergarteners, found much better performance on substitution of the initial consonant (86% correct responses) than on deletion of the initial consonant (25%). The substitution of the initial segment might be similar to rhyme production. Thus, the important point is that some tasks like those involving rhyme do not necessarily require conceiving of speech as a sequence of discrete segments. Awareness of phonological strings is not segmental awareness.

Without this distinction between awareness of phonological strings and segmental awareness it would be difficult to understand why the non-alphabetic literate Chinese tested by Read et al. (1986) failed at segmental

manipulations. In fact, the Chinese logographs include an important number (perhaps 90%) of phonograms which are made of two components, one (the signfic) for semantic content, and the other (the phonetic) telling the reader how the character must be pronounced (Wang, 1981). However, as this author notes, "the method of phonetic notation is holistic, and not atomistic". An alphabet tells us that morpheme *x* must be pronounced as segment 1, followed by segment 2, followed by segment 3, and so on. A syllabary tells us that morpheme *x* must be pronounced as syllable 1, followed by syllable 2, followed by syllable 3, and so on. A phonogram tells us simply that morpheme *x* must be pronounced like morpheme *y* (Wang, 1981, p. 232). As Bertelson (1986) has already suggested, this kind of phonological orthography need not engage the reader in submorphemic segmentation. It only requires phonological awareness, i.e. the kind of awareness that allows to judge accuracy of pronunciation, similarity between utterances (cf. Treiman and Baron, 1981), and rhyming. The Chinese data show, like the case of the illiterate poet, that one may have phonological awareness without segmental awareness.

One may ask whether the ability to notice and manipulate rhyme is a precondition for learning to read in the alphabetic system. Read et al. (1986) and Bryant and Bradley (1985a) believe it is. We would not be so categorical. There may be individuals who, by lack of previous experience, have never paid much attention to the expressive form of speech and therefore perform poorly on rhyming tasks, and who nevertheless can learn to pay attention to the phonology when engaged in learning to read. After all, performance of illiterates on our task of rhyme detection was far from perfect. The performance of the ex-illiterates on the same task suggests that the illiterates would have displayed better performance than they did if they had been taught to read. It is the ability to disregard meaning and attend to the phonological form rather than the ability to notice and manipulate rhyme that probably is a precondition for learning to read. Naturally, we agree with Bryant and Bradley that children who seem to be unable to appreciate or produce rhyme despite recurrent stimulation are at a serious risk of not developing segmental abilities and failing in reading.

9. Phonetic awareness

Phonetic awareness is awareness of speech as a sequence of phonetic segments, i.e. the minimal units of expression which are relevant for perceptual differentiation. The analysis of speech into segments that is observed in kindergarteners or is elicited by former experiences with alphabetic material probably occurs at the surface level, i.e. at the phonetic rather than phonemic level. Several empirical facts support this idea. First, differences in kindergarteners' ability to isolate the consonant from a CV syllable as a function of consonant type, namely plosive versus fricative (Content, 1985b), probably reflect the importance of perceptual or articulatory properties at this stage, and suggest phonetic rather than the more abstract phonemic analysis. Second, when merely taught the conventional names of the letters of the alphabet,

children may spontaneously create a spelling that shows sensitivity to phonetic relationships (Read, 1971). For example, vowels that are similar in terms of phonetic features are spelled the same by those children. The consonants also are represented in a way that takes into account their phonetic properties (for instance affrication of [t] and [d] before [r]). Third, Treiman (1985) has shown that children may spell plosives incorrectly under the influence of phonetic cues and that the proportion of these spellings decreases with increases in reading level.

Instructional methods that insist on the perceptual and articulatory cues of speech sounds during the initial stages of the learning to read process are likely to contribute to phonetic rather than phonemic awareness.

10. Awareness of phonemes

It is likely that, as mastery of alphabetic orthography progresses, what we learn is to represent speech consciously as a sequence of phonemes rather than phones. Here, we take phoneme in the classical sense of minimal unit of expression which is relevant for meaning differentiation (phoneme in the sense put forward by the generative phonology is a unit which only highly sophisticated people among literates manipulate or are aware of.) Phonemes are three or four times less numerous than phones.

The conscious representations of phones are presumably more like mental images than concepts. They represent perceptual properties, in much the same way as the mental image of a dog represents a particular dog, not the class of dogs. Unlike representations of phones, representations of phonemes cannot be derived by simply inspecting perceptual outputs, mental images of phonological strings, or articulatory cues. They can only be derived by disregarding irrelevant phonetic variations. Some external representational system that does not represent these variations may be necessary in order to elaborate conscious representations of phonemes. During learning to read, insistence on the identical graphic representation of phonemes whatever the context (e.g. identical representation of aspirated and unaspirated plosives in English, and of released and unreleased plosives in French) is likely to favor phonemic awareness. Thus, while the acquisition of alphabetic literacy is not a necessary condition of phonetic awareness, it could be so regarding phonemic awareness. Conversely, since alphabetic orthography maps onto phonemic structure, phonemic awareness is necessary to progress in alphabetic literacy. Phones being in a many-to-one correspondence to graphemes, the elaboration of representations of more abstract units is made necessary. Awareness of phonemes may then contribute to obscure some phonetic distinctions. According to Read (1978), "beginning students of phonetics usually have to work to acquire (or re-acquire) the judgments which the kindergarten children can make" (p. 78).

Finally, the acquisition of alphabetic orthography may also influence speech analysis. There may be no other reason than spelling to interpret a nasalized vowel as two segments. Likewise, it is the knowledge of spelling

that, as Ehri and Wilce (1980) have shown, leads fourth-graders to count one segment more in the pronunciation of *pitch* than in the pronunciation of *rich*.

In sum, and in all likelihood, the metaphonological representation of speech in skilled alphabetic literates is mainly phonemic, though somewhat influenced by orthographic peculiarities. Cowan, Braine and Leavitt (1985) have recently adduced a sensible argument in favor of this idea by examining the discourse produced by fluent backward talkers: the great majority of their subjects reordered phonemic units, not phonetic segments (for instance, voiceless stop consonants were aspirated or deaspirated according to the location of the consonant in the reversed form) nor the more abstract morpho-phonemic segments (surface distinctions between say *serene* versus *serenity* were maintained); however, they sometimes followed the orthographic representation (/ks/ or /gz/ represented by the letter *x* could be treated as a single unit).

11. Basic capacities underlying segmental analysis ability

Presumably, skills are acquired by exercising cognitive capacities and/or previous skills on new materials and situations. We mean here by cognitive capacity a basic computational and representational potential. In our 1979 paper, we put forward that the precondition for learning to read and write is not segmental analysis ability but some underlying cognitive capacity. In order to identify eventual basic capacities, a more detailed account of the components of the ability under study seems necessary.

Some authors, in particular Lundberg (1978) and Hakes (1980), have introduced the Piagetian term "decentration" to refer to the ability to pay attention to the expressive or phonological properties of speech while disregarding meaning. This ability, indeed, has something in common with speech analysis ability. In one study (Content, Kolinsky, Bertelson and Morais, in preparation), we tested kindergarteners both on syllable and segment deletion and on a task requiring a comparison of the phonological length of two words presented as pictures. When the physical size of the referents of the words was nearly the same, word length was judged at roughly the same level by children who reached a particular criterion in the deletion task and by those who did not. When word length and size of the referents were incongruent, performance decreased. However, children who succeeded in the deletion task were less affected by the irrelevant referent size than those who did not succeed. Given that there was no difference between the groups in the same-physical-size condition, the finding strongly suggests that the ability to disregard meaning and the ability to analyze speech into either syllables or segments are associated.

Though disregarding meaning to focus on form seems to be of some relevance, it cannot explain a number of findings: for instance, the greater ease in manipulating rhymes and syllables rather than segments, and the effects of position and phonetic category in tasks of segmental analysis (Content, 1985a; Content et al., 1986). The fact that syllables are easier to

isolate than segments might still be accounted for by assuming that some units of speech are more salient than others. Indeed, syllables roughly correspond to unitary articulatory acts. Thus, if one enlarges the notion of "decentration", which is classically tied to the form-function distinction, one could say that segments require an additional effort of decentration.

However, other components must be hypothesized: it is hard to figure out how decentration could account for the effects of position and of phonetic category. These effects, as well as the syllable/segment difference, might be related to the analytic operations involved. The notion of analytic ability is however vacuous if the analytic operations are not specified. In connection with this point, a more detailed examination of the position effect may illustrate the kind of approach we feel appropriate.

As shown by Content et al. (1986), prereaders display both a strong tendency to produce initial parts of utterances in a free segmentation task, and better performance for deletion of the final than the initial consonant. Similarly, prereaders are better at producing the vowel from a VC than a CV syllable, and also better at producing the consonant from a CV than a VC syllable (Content, 1985b). One possible interpretation of this position effect is based on the sequential nature of speech. We proposed that in order to suppress the final segment of an utterance one could monitor his own articulatory activity and interrupt it just before the last articulatory gesture. Thus, isolating initial parts or segments would involve intentional control of one's own motor activity. On the contrary, non-initial parts cannot be directly produced, and some complementary process is necessary to locate the appropriate starting point. This process might consist of scanning the mental representation of the utterance in order to identify some particular properties that define a possible new onset. This account of position effects, though pending further clarification, provides more precise contents to the notion of analytic abilities.

Given that decentration, in the sense of focusing attention on non-salient dimensions or properties of a stimulus, may be useful in other domains, for instance in visual cognition, the question of its generality arises. We have observed that the ability to ignore the most apparent configurations and find scattered segments in a visual form is poorly developed in both first graders and unschooled adults who have learned to read and write (Kolinsky, Morais, Content, and Cary, in press), despite the fact that these populations perform at a medium to high level in segmental analysis tasks. The ability of "decentration" thus appears not to transfer automatically from one domain to another. In each domain specific experience and/or training is probably necessary to the development of abilities that require "decentration". The power of the general notion of decentration as regards the explanation of individual differences is thus significantly reduced.

The same conclusion holds for analytic abilities. These seem to depend on some particular experience to become effective. Using a task of note deletion, which is formally similar to the task of consonant deletion, we found that young dyslexics were as good as normal readers of the same age in the former task (30% and 35% of correct responses, respectively, after exclusion

of subjects with musical training), but much poorer in the latter (14% and 95%, respectively) (Morais, Cluytens and Alegria, 1984). On the other hand, unschooled adults who learned to read and write at adult age were rather poor, and in fact much inferior to sixth-graders, for **note** deletion (36% and 89% of correct responses, respectively), but relatively **good** for consonant deletion (75%) (ex-illiterates' data are reported in Morais, Bertelson, Cary, and Alegria, 1986). Some people are poor at musical analysis but not at segmental analysis of speech. The exercises that stimulate segmental analysis do not help manipulate a short melody as a sequence of notes. Conversely, the exercises that elicit musical analysis do not seem to fit the individual for segmental manipulation (among the young dyslexics, there was one who received musical instruction: she had 70% correct responses on note deletion, but completely failed at the speech task).

Briefly, neither of the two segmental ability components examined above - decentration and analytic processing - seem to generalize to non-speech materials. However, this fact does not imply that they have no resort to general capacities, since the role of specific experience may be crucial.

The concept of capacity is useful to understanding both at what age appropriate experience may produce the expected effects, and why, given appropriate age and experience, the ability develops in some individuals but not in others. These questions concern the conditions of cognitive development and the problem of learning disabled people. We will examine both as regards the ability of segmental analysis.

We know that some segmental ability may appear by age four (cf. Fox and Routh, 1975; Content et al., 1986). Hence, the cognitive capacities that underlie segmental ability must, at this age, be mature enough to be brought out by experience. To the best of our knowledge, no investigation has been made with younger children (perhaps excepting some infant studies which do not allow any general conclusion; see Jusczyk, 1982). A further developmental question is whether or not the individual remains capable during his whole life to acquire the ability. The hypothesis that the capacities underlying segmental ability atrophy to some extent after childhood is entertained by Mattingly (1984) and by Mann (1986). The question is important for practical reasons, obviously, but also for theoretical ones. Abilities that show characteristic rates of development are usually biologically important and probably depend on specific cognitive capacities, i.e. programmed to serve a particular function. The ability to decode and use the phonology of the native language in comprehension and production most probably results from capacities of that kind. It cannot be developed at any age. It is well known that children who have lived the first years of their life outside of any linguistic community are no longer capable to acquire a phonology, at least completely, when brought into a linguistic environment. The case of segmental analysis may a priori be viewed as radically different. Segmental analysis is displayed by only a minority of human beings. If the ability of segmental analysis does not depend on specific capacities but on general ones, it might be less constrained by age. The evidence is indeed consistent with this prediction. Our

ex-illiterate adults are people who have developed segmental analysis abilities as adults. Moreover, testing illiterate adults on the consonant deletion task, while giving explicit instruction and using the procedure of constant corrective feedback, we observed in most subjects an important increase of performance after less than forty trials (Morais, Content, Bertelson, Cary and Kolinsky, in press). Thus, after age four or five, there is no critical period for acquiring segmental analysis. The capacities that are necessary to develop segmental ability must be non-specific.

Weakness of these capacities and lack of appropriate experience are not the only possible causes of poor segmental ability. The determinants of the ability must also include one language-specific factor, to know the perceptual representation of speech on which the processes of postperceptual analysis operate. We propose that the important difficulties of many backward readers or dyslexics in segmental analysis are related to some peculiarity of their perceptual representation of speech. Though careful examination of the dyslexics' abilities of decentration and analysis using non-speech material is still needed, we believe that not many dyslexics are deficient in those abilities. Thus, they probably possess the non-specific capacities necessary to segmental analysis, and they do not lack appropriate experience. We are left with the possibility that the dyslexics' perceptual representation of speech is not fully adequate for analytic purpose. That many dyslexics have a story of mild disphasic problems may not be an accident. Their inadequate speech representation may result from something wrong in the specialized systems that support language activities.

12. Some educational implications

The main question is whether it is necessary for or at least beneficial to the acquisition of reading and writing in the alphabetic system to be trained previously on the segmental analysis of speech. For many individuals, and from a strictly cognitive point of view, the answer is no. Certain cognitive conditions, eventually the capacities of "decentration" and analysis, must be present, but there is no need or advantage in trying to elicit segmental analysis beforehand. Segmental analysis is instrumental in learning to read, but it can be developed perfectly well in the context of the learning to read situation.

When we say that there is no need or advantage in eliciting segmental analysis before learning to read and write, we want our reader not to forget that this must be understood (1) from a strictly cognitive point of view, and (2) for most but not all individuals. We will explain these limitations next.

The fact that the education of preliterates puts more and more emphasis on the ability to analyze the internal structure of words and syllables creates a new situation. First, since children react differently to these educational activities as a function in part of the level of development of their cognitive capacities and previous experiences, the degree of segmental ability they show may appear as an index of readiness to begin learning to read and

- write, and as a predictor of the degree of future success. Index and predictor are only valid, of course, if we assume that the same opportunities for segmental ability have been provided. This precludes comparison against norms that would not take educational diversity into account. Our concern with the psychometrization of segmental ability is that educational diversity cannot probably be taken into account to a sufficiently great extent. Children showing low segmental ability are at a risk of being unjustly considered as too immature to begin learning to read and write. The social mechanisms of the educational system may then prevail over the cognitive factors in determining one's future position as learner. This is a good reason for approving and encouraging a policy of introducing games and activities that are conducive to segmental analysis at the kindergarten level. Another good reason stems from the existence of children who, because they lack the appropriate representations of speech, risk not developing segmental abilities normally. The introduction, in preschool education, of activities that require the child first to pay attention to the phonology of his language and then to analyze his utterances into smaller and smaller constituents may help the potential backward reader when he is later faced with the task of learning to read.

While we would be tempted to advocate an early training in segmental abilities, we are much more reluctant to propose *now* an early screening of possible deficits in the cognitive conditions of segmental analysis. That screening would require the construction of tests that do not confound the cognitive and perceptual conditions of segmental analysis with cultural factors or with segmental analysis itself. Much theoretical and experimental work will probably be needed before such tests can be constructed.

A further educational question we want to bring up concerns the choice of the best instructional approach to beginning literacy. A recent study by Evans and Carr (1985), in which cognitive and linguistic abilities of first-graders in 20 classrooms were tested at the end of the year, suggests an advantage of the decoding-oriented approach over the individualized language-experience approach. The decoding-oriented approach uses relatively unfamiliar reading materials and phonics drill. By contrast, the individualized language-experience approach uses for each child a reading material drawn from his own language and aims at the mastery of about 150 sight words. Despite the equivalence of both approaches regarding the level of children's cognitive and linguistic abilities, significant differences emerged in tests of reading and mathematics. The decoding-oriented approach was associated with better scores on these tests, with a smaller number of very low scores, and with higher correlations between the different cognitive abilities and between these and reading (the cognitive tests included the reproduction of a geometric design, Raven's Matrices, and a measure of Piagetian classification operations). The last finding suggests that the decoding-oriented approach "provided learning conditions under which information-processing capabilities of the class were more likely to be reflected in reading progress" and to "interact and reinforce one another to a greater degree" (pp. 339-340). This suggestion is extremely interesting. We have mentioned in this paper several

studies indicating that abilities requiring "decentration" and analysis, once developed in one particular domain, do not transfer automatically to other domains. Evans and Carr's finding seems however to imply that the emphasis on decoding makes several cognitive abilities, which are apparently unrelated to reading, develop interactively. We need indeed much more work on the relationships between cognitive abilities in order to understand why the acquisition of one does or does not transfer to others.

Regarding the effects of instructional approach, the necessity of taking long-term effects into account must be stressed. Interrelations between cognitive abilities and between these abilities and literacy probably increase as literacy itself improves. For most children, development is probably affected by the type of instructional approach, but the end result regarding the efficiency of reading seems to be the same. The possible advantage of one approach over the other is probably most important for the backward learner.

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ABSTRACT

The question of the relationships between segmental analysis abilities and alphabetic literacy acquisition remains confused in the literature. In this paper, it is argued (1) that segmental analysis ability does not develop without specific stimulation and that it usually appears when learning to read and write in the alphabetic system. After distinguishing between segmental aware-

ness and segmental analysis abilities, it is also argued that (2) segmental analysis ability can develop outside learning to read in the alphabetic system, (3) contributes to success in reading and writing, and (4) is a good predictor of reading ability even when learning to read in a whole-word setting. Receiving reading instruction is not sufficient to develop segmental analysis ability, but alphabetic literacy is (almost) a sufficient indication of segmental skill. Then, we distinguish between several forms of phonological awareness: awareness of phonological strings, of phones, and of phonemes. It is claimed, in particular, that rhyme appreciation and manipulation do not require segmental analysis. The kind of capacities that might underlie the development of segmental analysis are examined. Finally, some educational implications are discussed.

REFERENCES

- Alegria, J., Morais, J., and d'Alimonte, G. (submitted). The development of speech segmentation abilities and reading acquisition in a whole word setting.
- Alegria, J., Pignot, E., and Morais, J. (1982). Phonetic analysis of speech and memory codes in beginning readers. *Memory and Cognition*, 10, 451-456.
- Bertelson, P. (1986). The onset of literacy: liminal remarks. *Cognition*, 24, 1-30.
- Bertelson, P., Morais, J., Alegria, J., and Content, A. (1985). Phonetic analysis capacity and learning to read. *Nature*, 313, 73-74.
- Bradley, L., and Bryant, P.E. (1983). Categorizing sounds and learning to read: a causal connection. *Nature*, 301, 419-421.
- Bryant, P.E., and Bradley, L. (1985a). *Children's reading problems*. Oxford: Blackwells.
- Bryant, P.E., and Bradley, L. (1985b). Phonetic analysis capacity and learning to read. *Nature*, 313, 73-74.
- Campbell, R., and Butterworth, B. (1985). Phonological dyslexia and dysgraphia in a highly literate subject: a developmental case with associated deficits of phonemic processing and awareness. *Quarterly Journal of Experimental Psychology*, 37A, 435-476.
- Clark, E.V. (1978). Children's awareness of language. In A. Sinclair, R.J. Jarvella & W.J.M. Levelt (Eds.), *The child's conception of language*. Berlin: Springer, 17-43.
- Content, A. (1985a). Le développement de l'habileté d'analyse phonétique de la parole. *L'Année Psychologique*, 85, 555-572.
- Content, A. (1985b). L'analyse segmentale de la parole chez l'enfant. Unpublished Ph.D. Thesis, Université Libre de Bruxelles.
- Content, A., Kolinsky, R., Bertelson, P., and Morais, P. (in preparation). Correlates of phonetic analysis abilities in kindergartners.

- Content, A., Kolinsky, R., Morais, J., and Bertelson, P. (1986). Phonetic segmentation in prereaders: Effect of corrective information. *Journal of Experimental Child Psychology*, 42, 49-72.
- Content, A., Morais, J., Alegria, J., and Bertelson, P. (1982). Accelerating the development of phonetic segmentation skills in kindergartners. *Cahiers de Psychologie Cognitive*, 2, 259-269.
- Cowan, N., Braine, M.D.S., and Leavitt, L.A. (1985). The phonological and metaphonological representation of speech: Evidence from fluent backward talkers. *Journal of Memory and Language*, 24, 679-698.
- Denes, G., Balliello, S., Volterra, V., and Pellegrini, A. (1986). Oral and written language in a case of childhood phonemic deafness. *Brain and Language*, 29, 2, 252-267.
- Ehri, L.C., and Wilce, L.S. (1980). The influence of orthography on readers' conceptualization of the phonemic structure of words. *Applied Psycholinguistics*, 1, 371-385.
- Evans, M.A., and Carr, T.H. (1985). Cognitive abilities, conditions of and the early development of reading skill. *Reading Research Quarterly*, 20, 327-350.
- Fox, B., and Routh, D.K. (1975). Analyzing spoken language into words, syllables and phonemes: A developmental study. *Journal of Psycholinguistic Research*, 9, 115-119.
- Fox, B., and Routh, D.K. (1984). Phonemic analysis and synthesis as word attack skills: revisited. *Journal of Educational Psychology*, 76, 1059-1064.
- Frith, U. (1985). Beneath the surface of developmental dyslexia. In K.E. Patterson, J.C. Marshall & M. Coltheart (Eds.), *Surface dyslexia: Neuropsychological and cognitive studies of phonological reading*. London: Lawrence Erlbaum.
- Goldstein, D.M. (1976). Cognitive-linguistic functioning and learning to read in preschoolers. *Journal of Educational Psychology*, 68, 680-688.
- Hakes, D. (1980). *The development of metalinguistic abilities in children*. Berlin: Springer.
- Jusczyk, P. (1982). Auditory versus phonetic coding of speech signals during infancy. In J. Mehler, E.C.T. Walker & M. Garrett (Eds.), *Perspectives on mental representations*. Hillsdale, NJ: Lawrence Erlbaum.
- Kolinsky, R., Morais, J., Content, A., and Cary, L. (in press). Finding parts within figures: A developmental study. *Perception*.
- Lenel, J., and Cantor, J. (1981). Rhyme recognition and phonemic perception in young children. *Journal of Psycholinguistic Research*, 10, 57-67.
- Leroy-Boussion, A. (1975). Une habileté auditivo-phonétique nécessaire pour apprendre à lire : la fusion syllabique. *Enfance*, 2, 165-190.
- Liberman, I.Y., Shankweiler, D., Liberman, A.M., Fowler, C., and Fisher, W.F. (1977). Phonetic segmentation and recoding in the beginning reader. In A.S. Reber & D.A. Scarborough (Eds.), *Towards a psychology of reading*. Hillsdale, NJ: Erlbaum, 207-225.

- Lundberg, I. (1978). Aspects of linguistic awareness related to reading. In A. Sinclair, R.J. Jarvella & W.J.M. Levelt (Eds.), *The child's conception of language*. Berlin: Springer.
- Mann, V. (1986). Phonological awareness: The role of reading experience. *Cognition*, 24, 65-92.
- Mattingly, I.G. (1984). Reading, linguistic awareness and language acquisition. In J. Downing & R. Valtin (Eds.), *Language awareness and learning to read*. New York: Springer, 9-25.
- Morais, J., Bertelson, P., Cary, L., and Alegria, J. (1986). Literacy training and speech segmentation. *Cognition*, 24, 45-64.
- Morais, J., Cary, L., Alegria, J., and Bertelson, P. (1979). Does awareness of speech as a sequence of phones arise spontaneously? *Cognition*, 7, 323-331.
- Morais, J., Cluytens, M., and Alegria, J. (1984). Segmentation abilities of dyslexics and normal readers. *Perceptual and Motor Skills*, 58, 221-222.
- Morais, J., Content, A., Cary, L., Kolinsky, R., and Bertelson, P. (in press). Is there a critical period for the acquisition of segmental analysis?
- Olofsson, A., and Lundberg, I. (1983). Can phonemic awareness be trained in kindergarten? *Scandinavian Journal of Psychology*, 24, 35-44.
- Olofsson, A., and Lundberg, I. (1985). Evaluation of long-term effects of phonemic training in kindergarten: Illustrations of some methodological problems in evaluation research. *Scandinavian Journal of Psychology*, 26, 21-34.
- Perfetti, C.A., Beck, I., and Hughes, C. (1981). Phonemic knowledge and learning to read. Paper presented to the meeting of the American Society for Research in Child Development, Boston.
- Read, C. (1971). Pre-school children's knowledge of English phonology. *Harvard Educational Review*, 41, 1-34.
- Read, C. (1978). Children's awareness of language, with emphasis on sound systems. In A. Sinclair, R.J. Jarvella & W.J.M. Levelt (Eds.), *The child's conception of language*. New York: Springer.
- Read, C., Zhang, Y., Nie, H., and Ding, B. (1986). The ability to manipulate speech sounds depends on knowing alphabetic reading. *Cognition*, 24, 31-44.
- Rozin, P. (1978). The acquisition of basic alphabetic principles: A structural approach. In C.A. Catania & T.A. Brigham (Eds.), *Handbook of applied behaviour analysis*. New York: Irvington, 410-453.
- Savin, H.B. (1972). What the child knows about speech when he starts to learn to read. In J.F. Kavanagh & I.G. Mattingly (Eds.), *Language by ear and by eye*. Cambridge, Mass.: MIT Press, 319-326.
- Stanovich, K.E., Cunningham, A.E., and Cramer, B.B. (1984). Assessing phonological awareness in kindergarten children: Issues of task comparability. *Journal of Experimental Child Psychology*, 38, 175-190.
- Tornéus, M. (1984). Phonological awareness and reading: A chicken and egg problem? *Journal of Educational Psychology*, 76, 1346-1358.

- Treiman, R. (1985). Spelling of stop consonants after /s/ by children and adults. *Applied Psycholinguistics*, 6, 261-282.
- Treiman, R., and Baron, J. (1981). Segmental analysis ability: Development and relation to reading ability. In T.G. Waller & G.E. McKinnon (Eds.), *Reading research: Advances in theory and practice, vol. III*. New York: Academic Press, 159-196.
- Treiman, R., and Baron, J. (1983). Phonemic analysis training helps children benefit from spelling-sound rules. *Memory and Cognition*, 11, 382-389.
- Wang, W.S.-Y. (1981). Language structure and optimal orthography. In O.J.L. Tzeng & H. Singer (Eds.), *Perception of print. Reading research in experimental psychology*. Hillsdale, NJ: Lawrence Erlbaum, 223-236.
- Williams, J.P. (1980). Teaching decoding with an emphasis on phoneme analysis and phoneme blending. *Journal of Educational Psychology*, 72, 1-15.