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The ability to manipulate speech sounds depends on knowing alphabetic writing*

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Abstract

Chinese adults literate only in Chinese characters could not add or delete individual consonants in spoken Chinese words. A comparable group of adults, literate in alphabetic spelling as well as characters, could perform the same tasks readily and accurately. The two groups were similar in education and experience but differed in age and consequently in whether they had learned an alphabetic writing system in school. Even adults who had once learned alphabetic writing but were no longer able to use it were able to manipulate speech sounds in this way. This "segmentation" skill, which has been shown to contribute to skilled reading and writing, does not develop with cognitive maturation, non-alphabetic literacy, or exposure to a language rich in rhymes

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and other segmental contrasts. It does develop in the process of learning to read and write alphabetically.

For more than a decade, evidence has been accumulating that learning to read and spell in an alphabetic writing system depends upon the skills known as *phonemic segmentation*: the ability to conceive of spoken words as sequences of phonemic segments and to identify and locate those segments within words and syllables. Liberman (1971) was among the first to identify this relationship. Gleitman and Rozin (1977) and Rozin and Gleitman (1977) argued persuasively that segmentation skill is crucial to alphabetic reading. Considering the unique invention of alphabetic writing and their experience in teaching a syllabic writing system for English to children who had had difficulty with the alphabetic one, they claimed (p. 133) that:

> the basic barrier to initial progress [in reading] is in the realization of the segmentation of speech.

Several studies have found segmentation skill to be a significant predictor of success in early reading, even when the effects of educationally potent variables such as IQ and family status have been taken into account (Blachman, 1983; Bradley & Bryant, 1983; Lundberg, Olofsson, & Wall, 1980; Mann & Liberman, 1984; Zifcak, 1978). Liberman, Liberman, Mattingly, and Shankweiler (1980) reviewed studies of the development of segmentation skill and the use of phonological analysis in reading. They pointed out that segmentation is inherently difficult because speech is more like a stream than like a row of buckets: what we think of as discrete phones actually overlap and influence each other. Learning segmentation constitutes a major obstacle for some beginning readers, they concluded.

Liberman (1982) presents a view of reading and reading disability based on the premise that segmentation is crucial to reading alphabetic writing.

> In contrast [to the hearer or speaker], the reader and writer must be something of a linguist—able, at the very least, quite deliberately to divide utterances into the constituent segments that are represented by the characters of the orthography.

Liberman cites several studies which show that poor reading can be predicted from poor segmentation skills (p. 34) and that the skilled reader uses the phonological structure of words, and therefore must be able to segment (p. 38).

Making the relationship more specific, Treiman and Baron (1981) showed that "segmental analysis correlates most highly with one aspect of reading

ability—use of spelling-sound rules" (p. 194). Treiman and Baron (1983) reinforced that conclusion by showing that specific training in phonemic analysis helps preschool and kindergarten children learn to use such rules in learning to read.

In short, it appears that a crucial step in learning to read and write alphabetically is learning to conceive of speech as a sequence of discrete segments. It is a difficult step for some learners, perhaps because this conception is only indirectly related to both sound and meaning, the aspects of language that we are normally aware of. Segmentation facilitates learning to read primarily by making it possible for the reader to use spelling-sound rules, an ability which is part of skilled reading.

Another question about the relation between segmentation and literacy is that of cause or effect: is segmentation a prerequisite to literacy, a consequence of literacy, or both? Bradley and Bryant (1978) addressed this question by comparing older poor readers with younger good readers. Because of the substantial difference in age (3½ years, on the average), the two groups were the same in reading and spelling achievement, but nevertheless they differed greatly in segmentation skill, measured by judgments of rhyme and alliteration. This result suggests that the difference in segmentation ability between good and poor readers cannot be solely an *effect* of differences in reading achievement or experience; it may therefore be a partial *cause* of those differences.

Next Bradley and Bryant (1983) combined a longitudinal study with a training study. The former showed substantial correlations (about .50) between prereaders' ability to recognize sameness of sounds and their success in reading and spelling 3 years later. Segmentation accounted for significant variance in reading, even beyond the strong effects of IQ and memory. The training study showed significant effects (on reading and spelling performance) of training prereaders to recognize sameness of sounds. Separately, neither of these two kinds of evidence would permit us to infer causation, but together they indicate that sound recognition skills do contribute to reading success. They do not show that the causation is in one direction only: that learning to read does not also enhance segmental analysis. The effects of sound categorization skill and training were large enough to be important in planning pedagogy. For example, the training accounted for 4 months of additional development within a period of 2 years.

How does segmentation skill develop?

Given this persuasive evidence that segmentation skill is strongly and causatively related to reading and writing performance, we have investigated part

of the question, under what conditions does this skill develop? In particular, does segmentation ability develop without reading instruction, on the basis of cognitive maturation and experience with spoken and even written language?

Significance

The answer to this question bears on a theoretical issue: is alphabetic literacy the only linguistic performance that relies on a segmental conception of language? Are there other activities that might foster this conception, such as rhyming and alliteration in verse, committing and correcting speech or comprehension errors that interchange segments ("Spoonerisms"), or distinguishing pairs of words that differ in just one segment ("minimal pairs"), like *pin* and *tin*?

On the practical side, the answer may affect our view of children who have difficulty in learning to read and write. Do they simply lag behind their peers in developing a conception of spoken language that comes about normally with maturation and linguistic experience? If so, they might be better served by beginning reading instruction later, and adults of low literacy might be able to develop the skills that eluded them as children. Or do people rarely develop a segmental conception of language without learning to read and write alphabetically? In that case, we can not expect other linguistic experiences to help those who find literacy difficult, and second-language learners whose native language is written nonalphabetically, such as Japanese or Chinese, may lack a conception which underlies the writing system of the language they are trying to learn.

The Morais experiment

Morais, Cary, Alegria, and Bertelson (1979) investigated whether segmentation ability can develop over time *without* literacy, that is whether it can be an effect of cognitive development and experience with spoken language alone. They compared literate and illiterate adults in rural Portugal, finding that the former, but not the latter, could add and delete consonants at the beginning of words. They conclude,

> Awareness of speech as a sequence of phones is thus not attained spontaneously in the course of general cognitive growth, but demands some specific training, which for most persons, is probably provided by learning to read in the alphabetic system.

Comparing alphabetic and nonalphabetic *literates*, rather than literates and illiterates, would be a somewhat more direct test of the Morais et al. hypothesis, and it might avoid possible differences between literates and illiterates in intelligence and experience with language. Following Shankweiler and Liberman (1976), Morais et al. suggest a study of the development of segmentation skills in children learning nonalphabetic writing, as in Chinese. (Chinese characters represent one-syllable morphemes, not phonemes). But they cite Liberman, Shankweiler, Liberman, Fowler, and Fischer (1977):

> Unfortunately, a pure test will be hard to make. Children in the People's Republic of China are now being taught to read alphabetically before beginning their study of logographic characters (Liberman et al., 1977, p. 213 fn.)

This last statement is essentially correct, but a comparison of alphabetic and nonalphabetic literates is still possible in China. Most adults who completed primary school before 1958, who are now more than 35 years old, have not learned alphabetic writing, while most younger people *have* done so. We conducted a study like that of Morais et al. with workers in Beijing who fit these two patterns.

Since 1958, an official alphabetic writing system known as *Hanyu pinyin* has been taught in primary schools, particularly in a period of about 4 weeks in first grade, just before the children begin to learn to read Chinese characters. For the Beijing dialect, *pinyin* is essentially a phonemic representation, in Roman letters. It is used mainly in primary schools and in some contexts for foreigners; it is not used in ordinary communication, as in newspapers and books. As a result of the long-standing interest in Romanization, *pinyin* appears below the Chinese characters on the signs of some hotels and stores. These signs aid foreign visitors who can recognize some words that they have heard spoken, but to most Chinese adults, they are mere decoration.

Method

Our method was like that of Morais et al. except for changes which followed from differences between the two languages or the subjects.

Subjects

Our two groups of subjects were adults literate only in Chinese characters (the nonalphabetic group) and adults who had also learned *Hanyu pinyin* (the alphabetic group). Subjects were assigned to these two groups on the basis of whether they reported having learned any alphabetic writing system

in school. We checked this self-report with the dates of their schooling. Before the segmentation task, we tested each subject in the alphabetic group, asking him or her to read aloud 10 simple words printed in *pinyin* on cards.

The two groups were similar in occupation and environment; all were workers at Beijing Normal University and lived on the campus. The subjects in both groups were gardeners, waitresses, cooks, tailors, and nursery teachers. All but one subject in each group was female. As Table 1 shows, the groups differed primarily in age and to a lesser extent in years of schooling.

Comparing literates with illiterates who had had opportunities to learn to read, as in Morais et al. (1979), one might fear that the two groups differed in relevant skills, that is, that the illiterates had failed to learn to read, or chosen not to try, because they lacked skills like segmentation. In our sample, neither group had much opportunity or motivation to learn to read alphabetically as adults, because *pinyin* is not used among native-speaking adults. For that reason, we believe that the major difference was that of alphabetic instruction in primary school, which reflects age, not self-selection.

Tasks

As in Morais et al., each subject's task was to add or delete a single consonant at the beginning of a spoken syllable. Chinese syllables lend themselves to this procedure: they consist of a syllabic nucleus, such as /a/, with or without a single initial consonant, such as /d/, and a single final nasal (or retroflex) consonant, such as /n/; thus /a/, /da/, /an/, and /dan/ are possible syllables; there are no consonant clusters, initially or finally. Because of this syllable structure, Chinese provides a strong test of whether adults without training in alphabetic spelling can learn to add or delete initial consonants. It should be relatively easy to learn to do so in Chinese, where every syllable has either one initial consonant or none and there are many pairs of words that differ in just this respect. In both poetry and prose, there are also many rhyming

Table 1. *Subjects' mean ages and mean years of schooling*

Group	*N*	Mean age	Mean years of schooling
Alphabetic	12	33	10
Nonalphabetic	18	49	7

words, which might stimulate the tacit development of a segmental conception of language.

In this experiment, the phoneme to be added or deleted was /d/, /s/, or /n/; thus there were six conditions in all (add /d/, delete /d/, etc.). Subjects were assigned to conditions randomly in equal numbers.

The arrangement of tasks within each condition also followed that in Morais et al.; there were three sections, as outlined in Table 2. In the first (training) section, the experimenter explained the task and presented five examples followed by ten training trials. As an example of adding an initial consonant, for instance, he pronounced the consonant, the rime, and the result, e.g., /s /, /an/, /san/. In the training trials, he encouraged the subject and corrected the response, giving repeated examples if necessary. In the two experimental sections, the experimenter read each stimulus syllable and waited for the subject's response; he did not indicate whether the response was correct.

In the nonalphabetic group, three subjects were assigned to each condition; thus three subjects were to add /d/, three were to delete /d/, and so on. In the alphabetic group, there were two subjects in each condition. All stimuli and targets were possible syllables in Chinese; thus, for example, the nonwords included /dɔ́ŋ/ but not /djɔ́ŋ/, which is not a possible syllable in the phonological structure of Chinese.

Scoring

Each subject was interviewed individually in a quiet room. Three judges were present at each interview. Two of these, trained in phonetic transcription, transcribed each response; the third judge simply wrote down whether the response was correct. One transcriber and the third judge were native speakers of Chinese; the former was a native of Beijing, and the latter had lived there for many years. When the two transcribers agreed on whether the response was correct, that judgment was accepted. When they disagreed, the

Table 2. *Arrangement of tasks in all conditions*

Section	No. of items	Stimulus	Target	Examples: Add/delete	Feedback, correction
Training	10	Nonword	Word	ōng ⟨--⟩ dōng	yes
Exptl.	10	Word	Word	ai ⟨--⟩ dai	no
Exptl.	10	Nonword	Nonword	ou ⟨--⟩ dou	no

opinion of the third judge was accepted. A correct response was one which added or deleted the single initial consonant in one integrated production, without changing the syllable nucleus. The two transcribers agreed more than 80% of the time; most disagreements were about whether the subject had produced a single integrated syllable, rather than about what phones he or she had produced.

Results

There were no significant differences by phoneme (/d, s, n/) or by task (add vs. delete), so we have ignored these variables in subsequent analysis. Only the trials with nonword targets provide unambiguous evidence of segmentation skill; on the other trials, a subject might produce some correct responses merely by seeking a real word that "sounds like" the stimulus. Even that strategy requires a degree of phonetic awareness, however, so we have not ignored the trials with real-word targets.

The basic result was a large difference in the proportion of correct trials between the alphabetic and non-alphabetic groups, for both word and nonword targets, as shown in Table 3.

These results are strikingly similar to those of Morais et al., shown in Table 4.

There was very little overlap between individuals in the two groups, as shown in Figure 1 for nonword trials and in Figure 2 for all trials.

A two-way analysis of variance shows that mean score differs significantly by alphabetic literacy ($p < .0001$) and by word vs. nonword target ($p < .01$), and there is no significant interaction (see Table 5).

Table 3. *Main results by group*

Group	*N*	Percent correct	Mean	S.D.
	Nonword targets			
Alpha	12	83	8.3	1.4
Nonalpha	18	21	2.1	2.4
	Word targets			
Alpha	12	93	9.3	0.9
Nonalpha	18	37	3.7	3.5

Table 4. *Main results of Morais et al. (1979)*

Group	*N*	Percent correct: nonwords	Percent correct: words
Literate	30	72	~89
Illiterate	30	19	~36

Figure 1. *Number correct in nonword trials analyzed by group (Each * represents one subject)*

Number correct	Alpha group	Nonalpha group
10	**	
9	*****	*
8	**	
7	*	
6	**	*
5		*
4		
3		**
2		***
1		*****
0		*****

Thirteen of the 18 nonalphabetic subjects attempted the task a second time immediately after the first try, with a different phoneme target but the same operation (adding or deleting). For these subjects, the median change in score was zero, on both word and nonword targets. However, one subject did improve greatly on nonword targets, from one item correct on the first try to all ten correct on the second. Evidently, given enough instruction and practice, some individuals can learn to do this task without alphabetic literacy.

Figure 2. *Number correct. All trials by group (Each * represents one subject)*

Number correct	Alpha group	Nonalpha group
20	*	
19	****	
18	**	
17	**	*
16	*	*
15	*	
14	*	
13		
12		
11		**
10		
9		*
8		*
7		*
6		
5		*
4		**
3		***
2		
1		***
0		**

Table 5. *Analysis of variance 2 × 2 repeated measures*

Factor	F	df	$p <$
Alpha literacy	55.75	1/28	.0001
Word vs. nonword	7.64	1/28	.01
Interaction	<1		NS

Errors

Like those in Morais et al., our subjects tended to give a real-word response on trials with a nonword target. In Chinese, it is possible to give a response that is identical to the target in its sequence of phonemes, differing only in tone. Such responses are of particular interest: a predominance of them might

indicate that the subject can perform the phoneme manipulation but does not understand that the target is not a real word. For both groups, just 10% of incorrect responses (on nonword trials) were of this type. Other typical errors were simply to repeat the stimulus, to repeat the stimulus with a different tone, or to add the wrong consonant. Most of these latter two errors yielded real words. A few subjects who were to add a consonant consistently produced it in isolation (with a vowel if necessary), followed by the stimulus syllable.

Discussion

Clearly, these results confirm those of Morais et al., as shown in Tables 3 and 4. Our alphabetic group performed very much like Morais et al.'s literates, and our nonalphabetic group performed very much like their illiterates. This result allows us to make Morais et al.'s conclusion more specific: it is not literacy in general which leads to segmentation skill, but alphabetic literacy in particular.

The main exception, namely the nonalphabetic subject who was correct on 9 of the 10 nonword targets (and 8 of 10 word targets), seems to have known some *pinyin*. She was a 30-year-old tailor, the youngest of the nonalphabetic subjects, who admitted to having learned 'a little' about *pinyin* from her son. (We could not give her the test of reading *pinyin* that was given to the alphabetic subjects, however, because she had already denied that she could do so.)

In fact, some of our alphabetic subjects were no longer able to read alphabetic writing well. A 36-year-old cook with a primary school education, for example, said that she had learned *pinyin* from her children. She was able to read only 5 of 10 words correctly on our pretest, but she correctly deleted the initial segment on 14 of 20 experimental trials. At least two other subjects in our alphabetic group were no longer fluent in *pinyin*; on the pretest, they read words slowly and with difficulty, sounding out each letter. Yet both of them were correct on 17 of 20 experimental trials. From these cases we infer that the segmental conception acquired with alphabetic literacy may persist even when the literacy itself is dormant.

The task which we (and Morais et al.) used, adding or deleting a consonant at the beginning of a syllable, though well-suited to Chinese syllable structure, is among the more difficult manipulations of individual speech sounds (Bruce, 1964). Tasks which require less conscious and deliberate manipulation of segments (such as judgments of rhyming and alliteration, akin to the tasks in Bradley & Bryant, 1983) might not yield so sharp a distinction between al-

phabetic and nonalphabetic literates.

One might wonder whether this sharp distinction came about in part because our alphabetic subjects were familiar with the task; was a similar task used in teaching them to read *pinyin*? In fact, an exercise like our addition task is used in teaching, but any direct effect on this experiment must surely be weak: our alphabetic subjects had learned *pinyin* 27 years earlier, on average. Moreover, there is not a classroom exercise like our deletion task, but we found no difference between addition and deletion scores for either group.

Even alphabetic writing is taught in terms of syllables and morphemes in China. Letters are presented as spellings of syllables, indeed words, not phonemes; each letter has a particular syllabic value. For instance *g* is said to spell *gē* (older brother); the word *guān* (to close) is presented as the liaison of *gē* and *wān* (to bend). Similarly, Chinese dictionaries typically include a table of syllables, written in both *pinyin* and characters. In this table, there are about 21 syllables (words) representing possible initials (syllable onsets) and 35 representing finals (rimes). All other Chinese words are conceived of as combinations of those syllabic units. Thus the concept of individual phonemes remains implicit in both the school lessons and the dictionaries.

One might also wonder whether all of our subjects had not been exposed to segmentation in the "phonetic radicals" that are a part of many Chinese characters, indicating the pronunciation of the word represented. For example, the character for "eight," pronounced *bā*, occurs in the character for "to cling," which is also pronounced *bā*. But one crucial difference between these radicals and alphabetic writing is that the radicals always represent a whole syllable. When that syllable is not pronounced *exactly* like the one that it cues, the difference is almost always in the initial consonant and/or the tone, not the rime. For example, the character for "to exude an aroma," as for flowers or wine, pronounced *gìn*, contains the radical for "heart, mind," pronounced *xīn*. Thus these so-called phonetic radicals suggest phonemic segmentation only in a constrained and implicit way, as do rhyming words, speech errors, and minimal pairs. Exposure to such examples is evidently not sufficient for most people to develop a segmental conception of language that makes possible more explicit manipulations.

Conclusion

Learning to read and write alphabetically requires conceiving of speech as a sequence of phonemes and skill in locating and identifying phonemes within syllables. Morais et al. (1979) showed that that skill does not develop spon-

taneously. We can now add that it does not develop even with 7 years of schooling and 40 years of reading and writing nonalphabetically in a language rich in implicit examples like rhymes, minimal pairs, and phonetic radicals, not to mention Spoonerisms. Once a segmental conception has developed, however, it may outlast the fluency in reading.

This is not to say that no educational or linguistic experience other than reading instruction could produce segmentation skill; in fact, one nonalphabetic subject learned to perform our task well, given a second set of trials. However, in both Morais et al. and in the present study, we see very large differences in segmentation skill according to alphabetic literacy, with almost no overlap between groups, despite substantial differences in language, culture and education between the two populations.

From these strong connections between alphabetic literacy and phonemic segmentation, we can gain a greater understanding of children and adults who have difficulty in learning to read, and of second-language learners confronting alphabetic writing for the first time. To read and write alphabetically, they must not only acquire specific reading skills, but more basically, they must learn to segment spoken syllables into phonemic units. That skill, and the conception of language that underlies it, does not ordinarily develop by itself, even with nonalphabetic literacy and many examples of words that differ in just one segment. For most people, it evidently requires explicit instruction.

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Résumé

Des chinois adultes ne connaissant que l'écriture logographique se sont avérés incapables d'ajouter ou d'effacer des consonnes individuelles dans des mots chinois parlés. Un groupe comparable d'adultes, connaissant à la fois l'écriture logographique et l'écriture alphabétique, pouvaient effectuer les mêmes tâches sans difficulté. Les deux groupes avaient une éducation et une expérience comparable, mais des âges différents, et avaient donc eu des expériences différents en ce qui concerne l'apprentissage de l'écriture alphabétique à l'école. Même des adultes qui avaient appris l'écriture alphabétique mais n'étaient plus capables de s'en servir étaient capables de manipuler de la sorte les sons linguistiques. Cette capacité de "segmentation", dont on a pu montrer qu'elle contribue à la lecture et à l'écriture, ne se développe pas avec la maturation cognitive, l'acquisition d'un système d'écriture non-alphabétique, ou l'exposition à une langue riche en rimes et autres contrastes. Par contre, elle se développe au cours de l'apprentissage de la lecture et de l'écriture alphabétique.