American Children with Reading Problems Can Easily Learn to Read English Represented by Chinese Characters

Abstract. With 2.5 to 5.5 hours of tutoring, eight second-grade inner-city school children with clear reading disability were taught to read English material written as 30 different Chinese characters. This accomplishment eliminates certain general interpretations of dyslexia, for example, as a visual-auditory memory deficit. The success of this program can be attributed to the novelty of the Chinese orthography and to the fact that Chinese characters map into speech at the level of words rather than of phonemes. It is proposed that much reading disability can be accounted for in terms of the highly abstract nature of the phoneme (the critical unit of speech in alphabetic systems) and that an intermediate unit, such as the syllable, might well be used to introduce reading.

American urban school systems are experiencing great difficulties in teaching reading. In many major cities, average reading performance is a few grades behind national norms; many children never learn to read adequately. This enormous problem undoubtedly has many causes (1), including (i) our failure to understand the reading process and thus to design a most effective method for teaching it; (ii) difficulty in motivating and engaging children, particularly those in inner-city schools, in activities related to reading; (iii) the possibility that some perceptual (2) or cognitive abilities necessary for reading are not well or equally developed in all 6-year-olds; and (iv) dialect differences between teachers (or texts) and students (3).

In attempts to teach second graders with reading backwardness in a Philadelphia inner-city school, one of us (P.R.), in collaboration with H. Savin, found two characteristic problems. One was clearly motivational: the children had had difficulty in the past with reading and seemed to be deliberately and actively uninvolved in reading or anything that they considered to be reading. The children's interest was easy to engage, but not in reading. Second, the children seemed to have particular difficulty in giving phonological interpretations in response to visually presented letters; that is, they could not, at least overtly, recognize such letters as representing components of their own or others' speech. Thus, they had difficulty (i) in identifying words by initial or final sounds and (ii) in combining a sequence of letters into a known English word (what is often called "blending"). Many of the children did not know all the alphabetic symbol–sound correspondences, which was surprising since they seemed to have excellent memories and could be taught arbitrary new symbols rather quickly.

If we assume that this "phonetic mapping" inability and inadequate motivation are two fundamental causes of reading disability in this inner-city population, then it should be possible to teach such children to read a simplified version of the Chinese logographic system, with interpretation into English. Such material would obviously be new to the children and thus might provide adequate motivation. The phonetic mapping inability would also be circumvented, because Chinese characters map into language at the morphemic (word) level rather than at the phonemic level. We emphasize that the purpose of this experiment was not to devise a new curriculum for reading but to highlight specific problem areas for future research and enrichment programs.

Nine black children in the second semester of the second grade in an inner-city Philadelphia school were randomly selected from the class list of one second-grade homeroom class (4), with the restriction that no child have a reading level higher than level 3 (middle first grade) according to the system in use in the Philadelphia school system (5). The nine children selected were individually tested for reading skills by the experimenters. The basic criterion for acceptance in the experiment was that the child be unable to read a series of six simple consonant-vowel-consonant trigrams (pip, zif, wat, lag, ren, gub) and be unable to read reliably a set of rhyming words (cat, fat, mat, sat) after being given the pronunciation for at. Eight of the nine children were unable to handle this material adequately. They were usually unable to guess even the initial sound of the unfamiliar trigrams. The child who showed some competence at these tasks was not continued in the experiment.

Tutoring sessions were held in supply closets or small rooms with minimum furnishings. Individual sessions lasting from 20 minutes to 1 hour were held during the afternoon school hours approximately two to three times a week. The tutoring took place from March through June 1970 and involved a total of 14 to 25 sessions, or 8 to 14 hours per child (see Table 1). Each child dealt with only one of the three experimenters throughout the entire period, and tutoring was always on a one-to-one basis.

The tutoring sessions were informal; an initial session or two was devoted to getting to know the child and gauging his reading ability. A tutoring session was generally made up of four components:

1) Gaining rapport. A small portion of the time was spent in talking informally with the child or in playing games with him.

2) Tutoring in normal English reading. This consisted of practicing letter-sound relationships, "blending" sounds, and reading primer and preprimer material. It occupied about one-third of the total tutoring time.

3) Intelligence testing. The Wechsler Intelligence Scale for Children was administered to each child during the course of the experiment. No more than three subtests were given in any one session.

4) Chinese tutoring. The material to be taught consisted of 30 Chinese characters. They were read directly in their actual English translation. Chinese was never spoken. The symbols were read from left to right in the customary pattern of English orthography. The characters were selected primarily for their ability to fit together to form a wide variety of English sentences (Fig. 1). The sentences used could be read and understood by a native Chinese (6). An additional criterion was the avoidance of characters of great visual complexity or high similarity to already selected symbols.

The set of actual characters selected, with their English equivalents, is presented in Fig. 1. For convenience in instruction, the set was divided into six subsets, to be presented in sequence. The subsets were planned to allow formation of many English sentences from the very beginning.

For the first unit, symbols of minimum visual complexity were selected from the full set of 30. At the beginning of the experiment these symbols (Xerox copies from an introductory Chinese
reader) were pasted on 1-inch (2.54-
cm) squares of cardboard and were ar-
anged in different sequences. In later
stages, pages with written material
(similar to the test page in Fig. 2) were
also used (7). The children were intro-
duced to a few symbols at a time, were
given a few rote-memorization trials,
and were then presented with a se-
quence of characters that could be
translated into simple English sentences.
They were encouraged to make up
sentences of their own. In the tutoring
sessions, the children were corrected
when they misread a word, unless they
offered a word that was semantically
equivalent, such as little instead of
small. Since the Chinese orthography
maps directly into the meaningful units,
synonyms constitute correct responses.
Of course, the fact that these children
have quite different pronunciations for
some of these words in their dialect was
ignored. When children had particular
difficulty in learning particular words,
additional practice was given. Occa-
sionally, when a child had consistent
difficulty with a pair of symbols, we
asked him to describe the differences
between them or pointed out what we
considered distinctive differences be-
tween them.

When a child seemed to have mas-
tered the materials in one stage, one
new symbol from the next stage was
introduced, and a set of test sentences
was constructed, each sentence contain-
ing the new symbol. This procedure
guaranteed that the representation of
the test sentences in Chinese orthogra-
phy had not been seen before by the
child. Tests were administered after
each of the first five stages (8). Each
of the tests included, at least once,
every character taught up to that point.
As a result of this constraint, plus the
absence of articles and the use of the
new symbol in each sentence, some of
the resultant sentences were not “well
formed.” We attempted to administer
the tests at the beginning of a session,
but, when that was not possible, the
test was preceded by at least 10 minutes
of non-Chinese material. No prompting
was given, and the performance was
recorded word for word. When we were
convinced that a child had mastered a
stage, by virtue of his performance on
a test, material from the next stage was
introduced.

For a final evaluation of perform-
ce, the children were presented with
a set of sentences (Fig. 2) that incor-
porated all of the 30 symbols taught.
Each sentence included one of the two
new symbols (Fig. 1, bottom line)
introduced after completion of stage
VI. In addition, the children read aloud
three short stories, which were made up
from the 30 symbols but did not in-
clude all of them. In all cases, no cues
or corrections were provided. The time
required to complete the sentences and
to complete each story was measured,
and the experimenters made a written

<table>
<thead>
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<th>Verb</th>
<th>Adjective</th>
<th>Other</th>
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<td>母</td>
<td>見</td>
<td>大</td>
<td>Big</td>
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<tr>
<td></td>
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<td>有</td>
<td>一</td>
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<td>这</td>
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<td>用</td>
<td>這</td>
<td>跟</td>
<td>Black</td>
</tr>
</tbody>
</table>

Fig. 1 (left). Order of presentation of Chinese symbols. Fig. 2 (above). Final test. Sentences including all symbols. The sentences read: “Father buys black car. This man doesn’t (not) see black house and two knives. Brother says mother uses white book. You want one big fish and black house. He says ‘brother has small mouth.’ Good brother doesn’t (not) give man red car.” Eight subjects made a mean of three errors on this 40-item test. The four timed subjects took a mean of 1 minute and 40 seconds to complete this task.

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transcription of what the children said. Errors were then tabulated. After each story, the children were asked a few questions about the "plot" but were not allowed to refer back to the story to answer these questions (9). In three cases, the final readings were tape-recorded.

The basic results are presented in Table 1. Unfortunately, relatively little progress was made in reading the English alphabet. In no cases were there any major improvements in this area, although in most some improvement in letter-sound correspondences or word formation was obvious (Table 1). The improvement in reading level was probably due primarily to the regular classroom instruction.

In contrast, the tutoring with Chinese characters progressed rapidly and was quite successful. Children who had failed to master the English alphabet sounds in over 1½ years of schooling immediately understood the basic demands of the task and were able to read stage I sentences in the first 5 or 10 minutes of exposure to Chinese. As a measure of early progress, the performance on the stage II test (8) is presented in Table 1. In an average of 52 minutes of Chinese tutoring, the children were able to read the new material in the stage II test with few or no errors (Table 1). In an average of about 4 hours of Chinese tutoring, they were able to negotiate the final sentences and one story with relatively few errors and some comprehension (Table 1). Performance on two additional stories was comparable to that indicated for the mother-car story (9) (Table 1). On the total of three stories, there were 50 errors (137 characters in the three stories for eight children, or 1096 items). The comprehension score was 22.5 correct answers out of 48 questions.

Five children were retested on the mother-car story and the sentences in Fig. 2 after 24 to 33 days had elapsed since the termination of the experiment (10). Two of the children seemed to have forgotten most of the characters, but the remaining three made relatively few mistakes (a total of 36 out of 240 items).

In the early stages of tutoring, a number of children had difficulty in arranging the individually mounted characters to form sentences presented orally, even though they knew the corresponding symbols and words. This difficulty disappeared as tutoring progressed. After completion of the final tests, five children were asked to use the characters to form and rearrange sentences. Their performance on this test was excellent. In problems involving a single substitution, addition, or deletion, but no rearrangement (for instance, change "mother sees white car" to "mother has white car"), of which there were five examples, all of the five children tested averaged between 6 and 7 seconds to complete the task; they proceeded systematically and without error to find and insert a new element, or to remove or exchange an old element. The most complex task of this type involved two additional characters and some rearrangement (change "father sees mother" to "father and mother see car"). Four of the five children tackled this problem in less than 1 minute.

The material in stage VI, with the notable exception of "mouth," seemed the most difficult. Some of the children began to get a little bored with the Chinese as they ran into some difficulty in stages V or VI. In a few cases, particular confusions ("see" and "say" in one case, for example) became partially "fixed." A certain amount of confusion resulting from visual similarity between certain symbols (for instance "say" and "and," or "give" and "red") was apparent.

In spite of these problems, all of the children read the Chinese materials adequately. Comprehension was clearly only partial, but it should be emphasized that we made little attempt in the tutoring to stress this aspect of the task.

Table 1. Summary of results. The test for stage II contained a total of 21 characters (12 different characters). The final test sentences contained 40 items. The mother-car story (9) contained 40 items. The IQ is the score on the Wechsler Intelligence Scale for Children.

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Age (years: months)</th>
<th>Total Chinese (hours: minutes)</th>
<th>Chinese (hours: minutes)</th>
<th>Time (minutes: seconds) Errors (No.)</th>
<th>Errors (No.)</th>
<th>Comprehension</th>
<th>IQ</th>
<th>Reading level (5)</th>
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<td>4 : 28</td>
<td>0 : 36</td>
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<td>83</td>
<td>1</td>
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<tr>
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<td>14 : 10</td>
<td>4 : 42</td>
<td>0 : 54</td>
<td>1 : 43</td>
<td>0</td>
<td>1/3</td>
<td>85</td>
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</table>
which does not map into the sound system altogether, in contrast to our alphabet, which maps (at least in large part) into the level of phonemes. What is the critical feature of the difference between the Chinese logographic and the English alphabetic system which leads to reading difficulty? It could be the complete absence of sound mapping in Chinese; it could be the particular properties of the phoneme, rather than sound mapping per se; or it could be the irregularities of the grapheme to phoneme mapping in English.

We suspect that the phonemic representation contributes most heavily to reading difficulty. We and many others have found that children with reading backwardness have difficulty in "constructing" words from these isolated sounds. There is further evidence both from speech output (articulation) and input (perception) that the alphabetic unit or phoneme is unnatural or at least highly abstract (11).

If our suspicions are correct, then some unit intermediate between the morpheme and the phoneme—for example, the syllable—might be more suitable as a vehicle for introducing reading. An efficient orthography must satisfy only two requirements. It must be easy to learn and it must be productive in the sense that, after mastery, new words can be read without learning new symbols. Hence, the ultimate unworkability of the whole word method (12). The syllabary may meet these requirements (13). It has the advantage of pronounceableness (many phonemes cannot be pronounced in isolation) but still maintains its productivity or open-endedness. It may therefore be a good step on the road toward learning to read alphabetic writing (14).

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References and Notes
4. Because homeroom classes were not graded by school performance, we can take the children selected to be representative of children with reading problems in the second grade of the school.
5. Levels 1 to 4 are intended to be completed in the first year (Level 1 is the control condition of the Philadelphia public elementary schools. The books referred to in the description of levels are in the Scott-Foresman Reading Series.
6. Our familiarity with the Chinese language consists of having read elementary books on reading Chinese. We consulted with two fluent speakers of Chinese. Certain constructions that did not translate literally into English were avoided, and some minimal liberties were taken in creating correspondences between Chinese and English.
7. The lettering for the stories and sentences was done by a Chinese member of the staff of the Library of Oriental Studies at the University of Pennsylvania. Although the written symbols appeared to us to differ significantly in some cases from the Xerox copies of individual symbols, the children had little difficulty in generalizing from one to the other.
8. The second stage test was composed of the following sentences in Chinese orthography: "Man has house. Small mother has one house. House has two books. Big father sees one small house. House has knife." The new element introduced for this test was the item "house.
9. One of the three stories was the mother-car story, which does not include all the symbols taught. It mentions white car. Brother wants red car. Father gives mother white car. He doesn't (not) give brother red car. Brother says he wants red car. Father says, 'You use white car.' Brother doesn't (not) want white car; he doesn't (not) use car.
10. Researchers have made a mean of 3 errors (total of 23 errors) on this 40-item story. Seven times as much time in the mean time of 1 minute and 43 seconds. The three comprehension questions were: (i) What did brother want? (ii) What will father let brother do? (iii) Who has the white car?

Potassium-Adenosine Triphosphate Complex: Values of and Uses for Its Formation Constant

A number of incorrect statements concerning the formation constant for KATP appeared recently (I). Among these are: "Our experiments . . . show these (previously published) values to be in error." and "Thus, our values for the formation constant are about 25 times larger than the previous estimates." These statements suggest that authors who have used the previously published (2-4) values for Kt, to calculate the concentrations of KATP, and so forth at appropriate ionic strengths should do their work again using a number 25 times as great for K. The authors provided a preprint of another paper (5) which contained more information about their measurements. They had measured the pH and the activity of K+ in a number of aqueous solutions prepared by adding measured amounts of KOH solution to measured amounts of KATP. For each solution it was then possible to calculate the concentrations of KATP, KATP, and so forth from the relationship:

\[
K_f = \frac{aK X aATP}{aK X aATP}
\]

where \( aK \) and \( aATP \) are the concentrations of the ion indicated, \( c_k \) is the concentration, and \( f \) is the activity coefficient. Mohan and Rechnitz obtained values for \( K_f \) from assuming that the activity coefficients (\( f \)) of each ion were given by the equation:

\[
-\log f_j = AZ_j^2 \left[ \frac{pH - 0.5}{1 - 0.5} - 0.5 \right]
\]

where \( A \) is the charge on the ion \( y \) at the ionic strength \( I \). This amounts to an algebraic extrapolation of \( K_t \) from the ionic strength of zero to ionic strength. \( K_f \) obtained in this manner was quoted as

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