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.

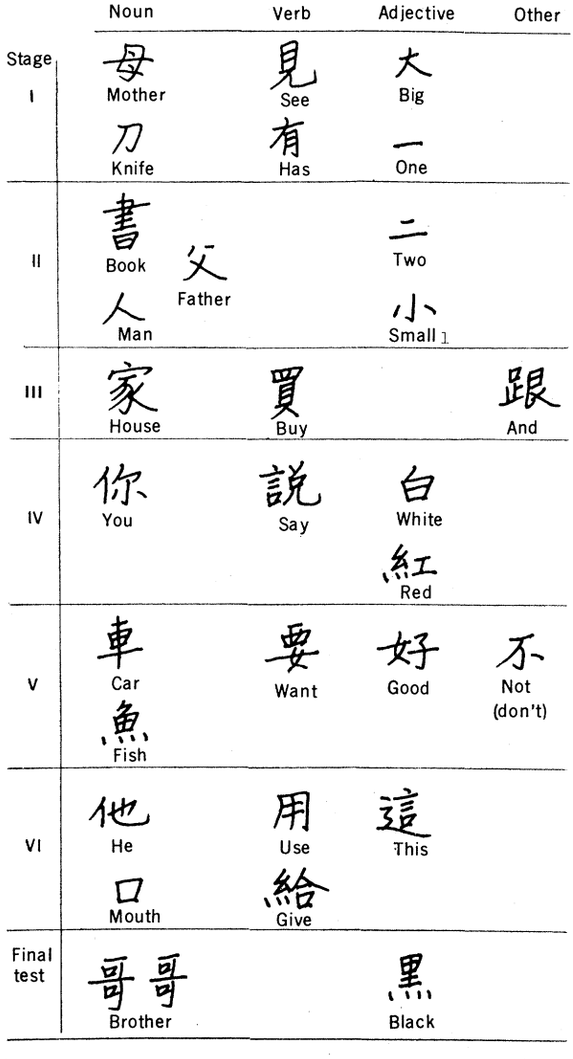
The set of actual characters selected, with their English equivalents, is presented in Fig. 1. For convenience in instruction, the set was divided into six subsets, to be presented in sequence. The subsets were planned to allow formation of many English sentences from the very beginning.

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 arranged 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 introduced to a few symbols at a time, were given a few rote-memorization trials, and were then presented with a sequence 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. Occasionally, 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 between them.

When a child seemed to have mastered the materials in one stage, one new symbol from the next stage was introduced, and a set of test sentences was constructed, each sentence containing the new symbol. This procedure guaranteed that the representation of the test sentences in Chinese orthography 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 performance, the children were presented with a set of sentences (Fig. 2) that incorporated 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 include 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



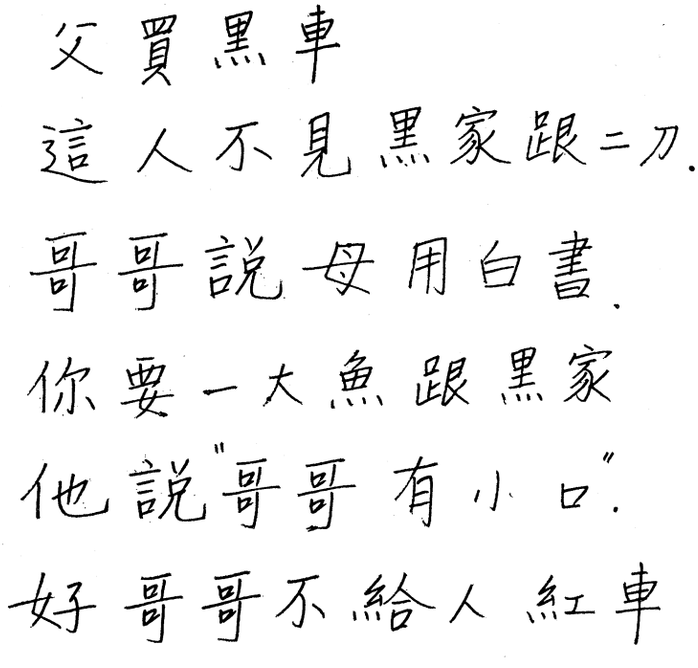


Fig. 1 (left). Order of presentation of Chinese symbols. Fig. 2 (above). Final test. Sentences including all symbols. The sentences read: "Father buys black car. This man doesn't (not) see black house and two knives. Brother says mother uses white book. You want one big fish and black house. He says '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.

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.

Subjects		Tutoring		Stage II		Final sentences		Mother-car story			IQ	Reading level (*5*)	
Sex	Age (years: months)	Total (hours: minutes)	Chinese (hours: minutes)	Time (minutes: seconds)	Errors (No.)	Time (minutes: seconds)	Errors (No.)	Time (minutes: seconds)	Errors (No.)	Comprehension		Before	After
M	7 : 11	10 : 03	4 : 28	0 : 36	1	2 : 08	6	2 : 42	5	1/3	83	1	2
M	7 : 9	14 : 10	4 : 42	0 : 54	0	1 : 43	0	2 : 07	6	1.5/3	85	2	2
M	7 : 11	11 : 00	5 : 24	1 : 15	0		4	0 : 56	4	3/3	80	2	3
F	7 : 11	10 : 42	5 : 00	1 : 05	0		4	1 : 06	3	1/3	82	3	3
M	8 : 0	11 : 51	4 : 06	0 : 34	2	1 : 50	6		4	2/3	96	2	3
M	8 : 8	8 : 30	3 : 30	0 : 40	0		2	1 : 00	0	2/3	80	2	3
M	8 : 2	8 : 26	2 : 35	1 : 00	0	1 : 00	1	1 : 30	1	3/3	96	2	2
F	7 : 5	9 : 10	2 : 36	0 : 50	2		1	2 : 40	0	3/3	107	3	4

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 about half 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 correspondences of the appropriate 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 negotiated 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 "fixated." 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.

In a total of about 4 hours we taught children to read English represented by Chinese characters that were in many ways more complex than normal English orthography. Yet these same children had failed to acquire the basics of English reading in almost 2 years of schooling. The private tutoring situation cannot account for the success with Chinese, since we also tutored these children privately in English orthography. Furthermore, in our experience of traditional tutoring with standard orthography and procedures, there is no marked improvement over equivalent time periods. We suggest that the main value of this demonstration is to highlight the factors that *cannot* be used to account for the reading backwardness of these children and the many like them in the Philadelphia and other school systems. There was clearly no problem with learning to associate more than 26 complicated and arbitrary visual symbols with certain sounds (words). Furthermore, there was no difficulty in ordering these sounds or symbols so that they could be read in a systematic pattern. Much of this ability, of course, such as the left-to-right reading habit, had already been acquired by the children in their minimum learning of English reading in school.

What, then, accounts for the large difference between the performance in Chinese and that in English? One factor may be increased motivation produced by the novelty of the Chinese material. Another factor is intrinsic to the nature of Chinese orthography,

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

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2. P. Katz and M. Deutsch, in *The Disadvantaged Child*, M. Deutsch and associates, Eds. (Basic Books, New York, 1967), p. 233.
3. J. C. Baratz and R. W. Shuy, *Teaching Black Children to Read* (Center for Applied Linguistics, Washington, D.C., 1969).
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 grade. Level 3 (Primer) includes learning of words by sight and "developing skill in 'attacking' new words through phonics." Level 4 (Book I) includes "developing additional skills in 'word attack' including compound words, contractions and possessives." Levels 5 and 6 are expected to be completed in the second year and involve completion of Books II-1 and II-2, respectively. The above descriptions are taken from the description of reading levels in "Progress Reports" 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 a few hours spent reading 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 was: "Mother wants 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." The eight subjects made a mean of 3 errors (total of 23 errors) on this 40-item story. Seven timed subjects read it in a 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? A correct answer on each question is worth one point. Out of a possible total of 24 points, the eight subjects achieved 16.
10. Two of the children in the 24- to 33-day retest were tested without any practice or "warm-up." The remaining three were allowed to read one set of six sentences, with corrections, before proceeding to the retest. The practice set contained each character at least once.
11. A. Liberman, F. S. Cooper, D. P. Shankweiler, M. Studdert-Kennedy, *Psychol. Rev.* **74**, 431 (1967); H. Savin and T. Bever, *J. Verbal Learn. Verbal Behav.* **9**, 295 (1970).
12. J. S. Chall, *Learning to Read: The Great Debate* (McGraw-Hill, New York, 1967).
13. It is interesting to note that in Japan, where the written language consists of a syllabary (a much more "natural" transcription of the language), plus logographs, there is reported to be a very low rate of illiteracy [K. Makita, *Amer. J. Orthopsychiat.* **38**, 599 (1968)].
14. In a sense this experiment is simply a particularly clear demonstration of the fact that children with reading disability can learn many names of things in the visual world and can learn, to some extent, the connection between whole written words and their spoken equivalents ("look-say" method). The Chinese material may be easier because it is novel and because Chinese symbols are perhaps easier to discriminate visually than whole words written in English orthography. The point of the experiment is to highlight areas of competence and areas of specific difficulty in a type of reading disability commonly encountered in inner-city children, and to suggest new approaches to the problem.
15. Supported by NSF grant GB 8013 to one of us (P.R.). We thank the research office of the Philadelphia Board of Education and the staff of the Drew School for their cooperation; and H. Gleitman, L. Gleitman, E. Rozin, and H. Savin for their contribution to the formulation of the issues discussed and constructive comments on the manuscript.

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

A number of incorrect statements concerning the formation constant for $KATP^{3-}$ appeared recently (*1*). 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 K_{fI} to calculate the concentrations of $KATP^{3-}$, ATP^{4-}, and so forth at appropriate ionic strengths should do their work again using a number 25 times as great for K_f.

The authors provided a preprint of another paper (*5*) which contained more information about their measurements. They had measured the *p*H and the activity of K^+ in a number of aqueous solutions prepared by adding measured amounts of KOH solution to measured amounts of K_2ATP. For each solution it was then possible to calculate the concentrations of ATP^{4-}, $KATP^{3-}$, free K^+, and so forth from the relationship:

$$K_{f_0} = \frac{a_{KATP^{3-}}}{a_{K^+} \times a_{ATP^{4-}}} = \frac{c_{KATP^{3-}}}{c_{K^+} \times c_{ATP^{4-}}} \times \frac{f_{KATP^{3-}}}{f_{K^+} \times f_{ATP^{4-}}}$$

where a_y is the activity of the ion indicated, c_y is the concentration, and f_y the activity coefficient. Mohan and Rechnitz obtained values for K_{f_0} by assuming that the activity coefficients (f_y) of each ion were given by the equation:

$$-\log f_y = AZ_y^2 \left[\frac{I^{0.5}}{1 + I^{0.5}} - 0.3I\right]$$

Z_y is the charge on the ion y at the ionic strength I. This amounts to an algebraic extrapolation of K_{fI}

$$K_{fI} = \frac{c_{KATP^{3-}}}{c_{K^+} \times c_{ATP^{4-}}}$$

from the ionic strength of measurement to zero ionic strength. K_{f_0} obtained in this manner was quoted as