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Feature Article

A Cross-Linguistic Perspective on the Relation Between Temporary Memory Skills and Early Reading Ability

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This study of Japanese second graders reveals that, like successful readers of the alphabet, good beginning readers of Japanese excel in memory for linguistic material. It documents significant associations between children's reading ability, memory for Hiragana, Kanji, and spoken nonsense words, but not between these measures and memory for photographs of faces. However, unlike good readers of the alphabet, good readers of Japanese may further excel in one form of nonlinguistic memory. Japanese children's reading ability and their memory for Kanji both associate with their memory for visual nonsense designs. The implication is that linguistic memory skills may contribute to successful acquisition of all orthographies, whereas the importance of nonlinguistic memory skills can vary.

TEMPORARY MEMORY IS important to the would-be reader of any orthography. Whether material is written in an alphabet, a syllabary, or a logography, the reader who intends to comprehend its full meaning must be able to retain the information represented by individual characters until such larger units as words, sentences, or paragraphs can be apprehended. How beginning readers of syllabaries and logographies meet these temporary storage requirements is the concern of this study, which examines the relation between temporary memory skills and success in learning to read Japanese Kana and Kanji. Several different types of material will be considered, as an accumulating body of evidence from the psychological literature (Ellis, 1975; Woodhead & Baddeley, 1981) and neuropsychological literature (Kimura, 1963; Milner & Taylor, 1972; Warrington & Shallice, 1969) reveals that temporary memory can involve separable components. One such component employs phonetic representation as a means of retaining linguistic material such as names of objects, spoken or printed words, etc., and is localized within the left, language dominant hemisphere. This stands in contrast to other components, which employ nonlinguistic representations to retain such materials as abstract designs and faces, and are localized within the right hemisphere. The question to be asked over the course of two experiments is whether these linguistic and nonlinguistic components of temporary memory make equivalent contributions to success in learning to read Kana and Kanji.

In recent years, studies in America and in Europe have examined the association between various memory skills and success in learning to read alphabetic orthographies. Not all temporary memory abilities tend to distinguish good and poor beginning readers of the alphabet. For example, good and poor readers in the second grade do not significantly differ in the ability to remember photographs of people's faces or abstract visual designs (Liberman, Mann, Shankweiler, & Werfelman, 1982; Vellutino, Steger, Desetto, & Phillips, 1975). Yet it is quite evident that good readers surpass poor readers in temporary memory for syllables, words, and sentences—whether these are heard or read (Byrne & Shea, 1979; Mann, 1984a; Mann, Liberman, & Shankweiler, 1980; Mark, Shankweiler, Liberman, & Fowler, 1977; Shankweiler, Liberman, Mark, Fowler, & Fischer, 1979). This has been explained by appeal to the view that successful readers make effective use of phonetic representation in temporary memory (Shankweiler et al., 1979).

To date, studies of the association between phonetic rep-

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resentation and early reading skill have tended to focus on beginning readers of English (for recent reviews, see Mann, 1984a; in press) or of other alphabetically transcribed languages such as French (Alegria, Pignot, & Morais, 1982), Swedish (Lundberg, Olofsson, & Wall, 1980) and Dutch (Mann, 1982). One possibile explanation of this association is that learning to decode a phonetic transcription of spoken language places certain demands on memory for phonetic material (Shankweiler & Liberman, 1976). If so, the association between use of phonetic representation and reading skill might be restricted to readers of the alphabet, conceivably extending to readers of a syllabary, since a syllabary is a type of phonological transcription, but not to readers of a logography, since logographies do not transcribe the phonological structure of words directly. Another possibility is that phonetic representation is critical to all language processing, spoken and written alike, because it meets the temporary storage requirements involved in recovering phrases, sentences, and paragraphs from sequences of individual words (Liberman, Liberman, Mattingly, & Shankweiler, 1980; Mann, 1984a). In this case, the relationship between phonetic representation and reading ability should extend to readers of any orthography—alphabet, syllabary, or logography.

Studies of the reading of Japanese can decide between these two alternatives, because Japanese has the virtue of using both syllabaries (the two Kana, Hiragana and Katakana) and a logography (Kanji). To date, relatively little is known about the temporary memory skills associated with acquiring Kana and Kanji. However, as some type of temporary memory should be essential to readers of syllabaries and logographies, we would expect some relationship between temporary memory skills and success in learning to read Japanese. Indeed, there is evidence to suggest that the relationship may involve linguistic memory, and phonetic memory in particular. For Japanese and American children alike, memory for the meaning of spoken text, as well as serial memory for words and digits, has been found to associate with reading ability in the fifth grade (Stevenson et al., 1982).

Certainly it is possible that effective use of phonetic representation characterizes good readers of nonalphabetic orthographies just as it characterizes good readers of the alphabet. All orthographies function to transcribe spoken language; hence, it would be parsimonious if all reading drew upon some of the processes that otherwise support spoken language use. Apparently, phonetic representation is one such process, as skilled readers appear to rely on phonetic representation both in the service of temporary memory for orthographic material and in the comprehension of written text. Most importantly, phonetic representation is employed in the service of temporary memory and comprehension of written material whether subjects are reading the English alphabet (Conrad, 1964; Daneman & Carpenter, 1980; Kleiman, 1975; Levy, 1977; Slowiaczek & Clifton, 1980) or the Chinese logography (Hung & Tzeng, 1981; Tzeng, Hung, & Wang, 1977).

Yet it is possible that the acquisition of nonalphabetic writing systems demands less of phonetic memory than the acquisition of the alphabet does. All orthographies transcribe the words of spoken language, but they differ in the nature of the units that they transcribe: Alphabets transcribe phonemes, the Japanese Kana transcribe syllables, and Japanese Kanji transcribes words. These distinctions could influence the degree of importance of phonetic representation to children's initial acquisition of word decoding skills. The beginning reader of the alphabet, for example, who is attempting to recognize a written word like "kitten," must be able to recover and integrate the phonemes that the letters represent, and this may require effective use of phonetic representation. For the reader of a syllabary, recovering and integrating a sequence of syllables like "neko" into a word may also involve phonetic representation, but the demand could be milder than that of the alphabet, insofar as syllables are less abstract phonological units than phonemes, and there are typically fewer of them in a word. For the readers of a logography, word decoding may place almost no demand on phonetic representation; as the characters of logographies transcribe words on a one-to-one basis, recognizing a word could be an all-or-none process which does not require that phonemes or syllables be retained in temporary memory.

Thus it is an open question whether use of phonetic representation distinguishes good and poor beginning readers of Japanese. Likewise, it is an open question whether, like good and poor readers of the alphabet, good and poor readers of Kana and Kanji tend to possess equivalent nonlinguistic memory skills. The possibility that such is the case is suggested by findings that, for mature readers of Japanese, the reading of both Kana and Kanji tends to be associated with the linguistic memory faculties of the left hemisphere more than with the nonlinguistic ones of the right hemisphere (Sasanuma, 1975; Sasanuma & Fujimura, 1971). Yet it is nonetheless conceivable that the acquisition of Kana and/or Kanji places greater demands on visual memory than acquisition of the alphabet. Syllabaries to some extent—and logographies in particular—involve considerably more orthographic units than the alphabet. Would-be readers of Japanese must be able to encode and remember more visual shapes than would-be readers of the alphabet, and this could place a greater demand on effective use of nonlinguistic memory skills.

To answer these questions about the relationship between various types of temporary memory skill and success in learning to read Kana and Kanji, two experiments were conducted. The research design drew on a previous study of American children (Liberman, Mann, Shankweiler, & Werfelman, 1982) which used the recurring recognition paradigm of Kimura (1963) to assess good and poor readers' ability to remember alphabetically written material, visual nonsense designs, and photographs of unfamiliar faces. The first experiment extends this methodology to the use of spoken nonsense materials, to determine whether effective use of phonetic representation dis-

tinguishes a population of good and poor Japanese readers in the second grade. The second experiment compares these children's memory for Kana and Kanji with that for two types of nonlinguistic visual material, abstract designs and faces.

Experiment 1

Methods

Subjects. The subjects were second-grade children attending the primary school attached to Ochanomizu University in Tokyo, Japan. All available children participated, including 50 girls and 50 boys, of mean age 86.6 months (SD = 3.5 months). At the completion of the study, each child was rated by his or her classroom teacher as either good, average, or poor in reading ability.

Materials and Procedure. The materials were 52 two-mora (i.e., disyllabic) nonsense words which were phonologically plausible according to the intuitions of five native speakers of Japanese. They contained a sampling of Japanese consonants and vowels in a variety of combinations. Memory was assessed according to Kimura's (1963) recurring recognition paradigm, which required that 8 series of 10 items be formed from the corpus of 52 nonsense words. Four of the words (the recurring stimuli) were duplicated in each series; the remaining 48 (the nonrecurring stimuli) occurred only once. One series of 10 words was the inspection set; the remaining 7 constituted the recognition set of 70 test items.

The test was administered in a single session by a male native speaker of Japanese who read each item aloud with a neutral intonation contour at a rate of one every 5 seconds. All children were tested in their classrooms while seated with their classmates in their normal seating arrangement. Their task was to first listen to the words in the inspection series, and then to listen to the test items and to mark on a response sheet whether each item was "new" or had been heard before (further details of the methodology appear in Mann, 1984b).

Results and Discussion

The main purpose of this experiment was to determine whether, like beginning readers of the English alphabet, children who differ in the ability to read Japanese differ in memory for spoken nonsense words. The answer is affirmative; good readers surpassed poor readers in memory for the nonsense words, as the following analyses will show. On the average, the number of correct responses (out of a maximum of 70) was significantly better than the chance level of 50% correct, $t(99) = 40.0$, $p < .001$, although children differed considerably in the accuracy of the responses. The highest score was 65 items correct (out of 70); the lowest was 36, and the mean was 57. Most importantly, the 15 children whom their teachers rated as good readers achieved a mean score of 62.4 correct, which is significantly better than the mean score of 45.0 correct achieved by the 10 children rated poor readers, $t(23) = 6.18$, $p < .001$. When the memory scores of the entire population of children are considered in relation to their reading ability, a modest, but significant correlation is found, $r(100) = .25$, $p < .006$.

As phonetic representation must be employed in tasks that require temporary memory for spoken nonsense materials, the implication of these findings is that better readers of Japanese tend to make more effective use of phonetic representation than children who read less well. Whether use of phonetic representation is as important for successful reading of the Kana syllabary and the Kanji logography remains to be explored in the second experiment, along with the question of whether memory for nonlinguistic material is related to successful acquisition of either Kana or Kanji.

Experiment 2

Methods

Subjects. The subjects of Experiment 2 were the same 100 children who participated in Experiment 1.

Materials and Procedure. The materials included four different types of visual stimuli: abstract designs, photographs of Japanese faces, Hiragana, and Kanji. Memory for each type of stimulus was assessed separately, using the methodology employed in Experiment 1. The abstract designs, taken from Kimura (1963), were the same as those employed by Liberman et al. (1982). The photographs were frontal view, black and white pictures of male faces selected from a Japanese high school yearbook according to the selectional criteria in Liberman et al. (1982). The Hiragana materials were written transcriptions of the nonsense words from Experiment 1. The Kanji materials were drawn from the government-approved set of Kanji that children master in the first grade. The preparation of the memory test for each type of material was as described in Experiment 1.

Experiment 1 was run in conjunction with Experiment 2 in two experimental sessions run 1 week apart. The Kana digraphs and the faces were presented in the first session; the Kanji and the nonsense designs were presented in the second one. All stimuli were projected in black and white on a large screen at the front of the room by means of a Kodak carousel projector. Children's responses were gathered as in Experiment 1 (for details, see Mann, 1984b).

Results and Discussion

The main purpose of Experiment 2 was to determine the relation between reading ability, memory for non-

linguistic visual information, and memory for Kana and Kanji. As was the case in Experiment 1, the data were scored in terms of the total number of correct responses given to each type of material, and scores were considered in relation to children's designation as good, poor, or average in reading ability. A first analysis concentrated on the performance of the 15 good and the 10 poor readers, to permit a direct comparison of the present results and those obtained in Liberman et al.'s (1982) study of American children. The results are summarized in Figure 1, where it can be seen that the good readers of Japanese achieved superior scores on both the Hiragana, $t(23) = 18.7$ $p < .001$, and Kanji materials, $t(23) = 6.12$, $p < .001$. Note also that, whereas the good readers had achieved equivalent scores on the two types of orthographic material ($p > .01$), the poor readers were markedly worse on the Hiragana than on the Kanji, $t(9) = 7.18$, $p < .01$. Consequently, the extent of difference between children in the two reading groups is greater in the case of the Kana materials.

As for the two types of nonlinguistic material, the left side of Figure 1 reveals that, in contrast to good and poor beginning readers of English, the good readers of Japanese surpassed the poor readers in memory for the abstract designs, $t(23) = 4.76$, $p < .01$. Like beginning readers of English, however, the good readers of Japanese did not significantly differ from the poor ones in their memory for the faces (although the good readers tended to achieve slightly higher scores, any difference failed to reach significance, $p > .1$).

A second analysis involved computing a series of Pearson correlations to assess the interrelations between children's performance on the various types of materials employed in Experiments 1 and 2, and the teacher's ratings of their reading ability. Performance on the Hiragana materials was positively correlated with performance on the Kanji materials, $r(100) = .19$, $p < .03$, the teachers' ratings, $r(100) = .32$, $p < .001$, and performance on the spoken utterances employed in Experiment 1, $r(100) = .27$, $p < .01$. Performance on the Kanji materials was likewise correlated with the teachers' ratings, $r(100) = .36$, $p < .01$, and performance on the spoken utterances of Experiment 1, $r(100) = .30$, $p < .01$. Neither the correlation between memory for Kanji and teacher ratings nor that with memory for spoken utterances was significantly different from the correlations that obtained in the case of the Kana materials. There was one difference, however, between memory for Kanji and that for Hiragana. Memory for Kanji significantly correlated with memory for the nonsense designs, $r(100) = .18$, $p < .03$, whereas memory for Kana did not ($p > .1$). Thus the differences between good and poor readers' performance on the abstract designs would appear to be more closely associated with their differences in memory for Kanji than Kana. Further findings include correlations between memory for the abstract designs and the teachers' ratings, $r(100) = .36$, $p < .01$, and memory for the faces $r(100) = .26$, $p < .01$. Neither memory for Kana nor memory for Kanji correlated with memory for faces ($p > .1$), and all other correlations failed to reach significance at the .05 level of confidence.

Discussion

The purpose of this study was to clarify the types of temporary memory skills that are most pertinent to children's ability to learn to read Japanese, a language whose orthography consists of syllabaries (the Kana) and a logography (Kanji) instead of an alphabet. It has been claimed that all children readily learn to read Japanese (except those markedly deficient in intelligence), and that reading difficulty is a problem peculiar to Western children learning to read the alphabet (Makita, 1968; 1974). A recent study, however, offers some evidence that reading disabilities occur as often in Japan as in America (Stevenson et al., 1982), implying that differences in the level of early reading success can occur in syllabaries and logographies as well as in the alphabet. With this in mind, the present study focused on a population of second-grade children whom their teachers rated as good, average, or poor in reading ability.

The data summarized in Figure 1 confirm that the children rated good readers by their teachers were indeed better readers than those rated poor readers. Relative to the poor readers, the good readers demonstrated superior memory for both the Kana and Kanji materials, which would be consistent with the fact that they possessed a superior ability to read each type of character. A further finding about early reading ability in Japanese, also evident in Figure 1, is that the poor readers encountered more difficulty in remembering the Hiragana nonsense words than the Kanji words, whereas the good readers were equally accurate on the two types of materials. The performance of the poor readers might have been handicapped by the nonsense materials, as such. However, Kana may have been problematic because learning an orthography that transcribes abstract phonological subcomponents of words could be more demanding than one that transcribes language at the level of the word.

A primary goal was to ascertain whether use of phonetic representation, a temporary linguistic memory skill, associates with success at learning to read Kana and Kanji. It was found that children with superior reading ability demonstrated a superior ability to remember spoken nonsense words, as well as superior abilities to remember Kana and Kanji. It was also the case that children's memory for the nonsense syllables was equally related to their memory for Kana and Kanji. Apparently, the association between phonetic representation and early reading success is not limited to orthographies involving some type of phonological transcription. Rather, the present findings suggest that effective use of phonetic representation may characterize superior beginning readers whether they are learning to read an alphabet, a syllabary, or a logography. This is consistent with what we know of the memory strategies of skilled readers, namely that they tend to recode any type of

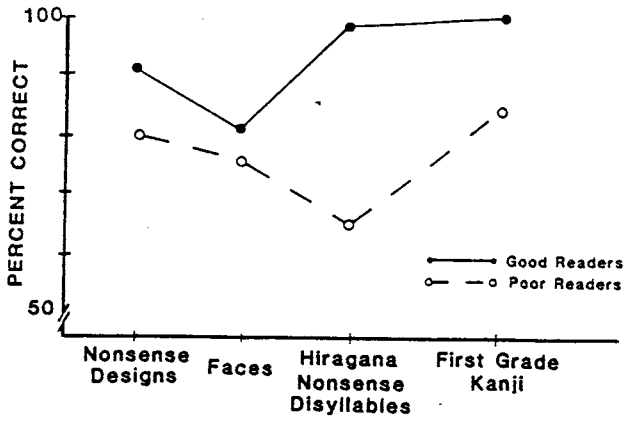

Figure 1. Mean percentage of correct responses made by good and poor readers of Japanese on nonsense designs, Japanese faces, Kana digraphs and Kanji.

orthographic material into a phonetic representation (see, e.g., Conrad, 1964; Levy, 1977; Slowiaczek & Clifton, 1980; Tzeng et al., 1977).

Another goal was to determine whether nonlinguistic visual memory skills associate with success in learning to read Japanese. Here there proves to be a commonality between beginning readers of English and Japanese, but also an interesting difference. The commonality is that, like American children, the Japanese children who differed in reading ability tended not to differ in the ability to encode and remember new faces. Thus it cannot be concluded that the good readers possess a superior memory, in general. At least one component of nonlinguistic memory may not be particularly relevant to success in learning to read any orthography. The difference between beginning readers of Japanese and English concerns the abstract visual designs. The Japanese children who differed in reading ability also differed in memory for these materials, and, in particular, their memory for Kanji appeared to be related to that for the nonsense designs.

Two observations suggest a plausible explanation of the orthography-specific relationship between reading ability and memory for abstract designs. The first is that, on the average, the nonsense designs were remembered more accurately by Japanese children in the present study than by the American children studied in Liberman et al. (1982; a mean score 58 items correct, as compared to 49 items correct, respectively). This suggests that the Japanese children might have employed a more effective strategy for remembering these materials. The second observation clarifies the nature of this hypothetical strategy. During testing, I noted that, unlike American children, when Japanese children saw a design, they often attempted to trace it with their fingers or even with a motion of their head, as if they were encoding the design into a graphomotor representation, just as they might encode an unfamiliar Kanji character when the teacher first presents it in class. A graphomotor coding strategy could explain why memory for Kanji correlated with that for the designs (but not the absence of a correlation between memory for nonsense designs and that for Kana digraphs). It could further account for the correlation between the teacher's ratings of reading ability and performance on the nonsense designs. Thus I suggest that, in addition to making more effective use of phonetic representation, superior readers of Japanese may also make more effective use of graphomotor representation.

In summary, for second graders who are learning to read Japanese, only certain temporary memory skills are related to reading success. First and foremost, a linguistic memory skill, use of phonetic representation in temporary memory, is pertinent to the ability to read well. It associates with the ability to remember either Kana or Kanji materials for a brief period of time. As for nonlinguistic memory skills, those skills that support memory for faces do not prove to be associated with successful reading of either Kana or Kanji. However, effective use of a graphomotor coding strategy may be associated with the ability to learn to read Japanese Kanji. It can be concluded that acquisition of syllabaries and logographies, like that of the alphabet, demands adequate linguistic memory skills. Beyond this common requirement, acquisition of a logography, in contrast to that of other orthographies, may place additional demands on certain forms of nonlinguistic memory. The outcome of having to master both Kana and Kanji is that, for the beginning reader in Japan, both linguistic and nonlinguistic memory skills are associated with early reading success.

Virginia A. Mann *received the PhD in experimental psychology from the MIT Department of Psychology. Her research interests include speech perception and its development, and she has recently completed a cross-linguistic study of Japanese and English listeners that clarifies the role of native language experience in speech perception. She is also involved in studies that show the importance of linguistic skills to the attainment of early reading ability, the paper in this volume being an outgrowth of her research into the association between linguistic short-term memory and reading ability. Other studies of Japanese and American children have concerned the role of orthographic experience in the attainment of linguistic awareness.*

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