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AUTHOR Read, Charles
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ABSTRACT

A study examined basic reading skills among men in prison, comparing poor and adequate readers with respect to comprehension, decoding, short-term memory, and speech perception. Subjects, 88 inmates of normal intelligence, normal hearing, and no significant speech abnormalities, at a minimum-security prison, were given reading comprehension tests and tests of listening perception. Subjects were divided into poor readers (less than sixth grade reading level) and adequate readers (greater than sixth grade level). Results indicated that poor readers were surprisingly uniform; they differed from good ones on several cognitive and linguistic measures. Results also indicated that among poor readers, the best predictors of comprehension are decoding and short-term memory and that poor readers have a hidden deficit in that they are more affected by noise when trying to perceive familiar spoken words. Findings suggest that adult poor readers strongly resemble poor readers in elementary school in the areas of short-term memory and decoding skills. (Seven tables and 7 figures of data are included; 34 references are attached.) (RS)

Adults who read like children: the psycholinguistic bases

Charles Read
Departments of English and Linguistics
Center for Education Research
University of Wisconsin - Madison

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Abstract

We studied basic reading skills among men in prison comparing poor and adequate readers with respect to comprehension, decoding, short-term memory, and speech perception, along with nonverbal abilities and other background factors. Poor readers were surprisingly uniform; they differed from good ones on several cognitive and linguistic measures. Among poor readers, the best predictor of comprehension is decoding, and the best other predictor of decoding is short-term memory. Some men's memories may well have been affected by alcohol and drug abuse, but that is not what distinguishes good from poor readers. In perceiving familiar spoken words, the poor readers have a hidden deficit: they are more affected by noise. However, this difference does not predict reading skills. The key differences between poor and adequate readers appear to be in short-term memory and decoding skill, consistent with one view of reading processes. In these respects, our adult poor readers strongly resemble poor readers in elementary school.

Introduction

This article reports research on fundamental reading skills in adults of low literacy, men in prison who read at a third- to fifth-grade level in comprehension and skills. The ultimate question that we seek to answer is, Why do some people learn to read at only an elementary level despite adequate intelligence and educational opportunity? Our approach has been to study the relation between reading and spoken language skills in both good and poor readers.

We have found (Read & Ruyter, 1985) that adult poor readers are especially poor in decoding, that is, in reading unfamiliar words by relating their spellings to their pronunciations. These decoding skills are strongly associated with poor short-term memory for spoken words. This association suggests an explanation for the poor decoding: one cannot acquire or use a knowledge of sound-spelling relationships if one cannot retain a stable representation of a spoken word long enough to identify the sequence of sounds within it.

In the research reported here, we examined more precisely the relations among short-term memory, decoding skill, and reading comprehension, all measured with multiple tasks with both normal and poor readers. In addition, we tested whether the poor readers are also poor at perceiving spoken words. A perceptual disability may be masked in ordinary listening by the redundancy of speech. It could account for the short-term memory difficulties and hence the poor decoding skills of poor readers:

one cannot remember accurately or segment speech which one has inaccurately or vaguely perceived.

Rationale

Decoding. Good reading and spelling use many skills and call on knowledge of language at many levels, from graphic features of individual letters to formal and stylistic features of whole texts. To focus on the use of sound-spelling correspondences is not to deny the importance of other processes in reading and spelling. However, research has consistently demonstrated the fundamental role of decoding skills in reading. Calfee, Chapman, and Venezky (1972) showed that these skills are essential to learning to read; ten years later Stanovich (1982) emphasized their importance among sources of individual differences in reading. Virtually every current comprehensive theory of reading assumes that decoding skills are essential to learning to read new words (Just & Carpenter, 1980, 1987, pp. 43-57, 93-100; Stanovich, 1984).

As Coltheart (1984) points out, "many models [of] the normal reading of English ... incorporate dual routes for reading aloud," namely "recognizing a letter string as a familiar visual entity" and "using a system of ... relationships between letters (or letter clusters) and their corresponding pronunciations" (p. 68). These dual routes can account for the ability to read words with irregular spelling and nonwords, respectively. However, Besner, Davelaar, Alcott, & Parry (1984, p. 132) conclude that "there is no convincing evidence that readers of alphabetic

English can treat their print as though it is not composed of letters" (p. 132). That is, letter recognition is a necessary step in word recognition; letter recognition is not decoding, but it is a necessary part in decoding.

In addition, a stream of recent research indicates that a disability in decoding underlies some children's crucial difficulties in learning to read (Blachman, 1983; Bradley & Bryant, 1983; Golinkoff, 1978; Katz, Shankweiler, & Liberman, 1981; Lundberg, Olofsson, & Wall, 1980; Mann, 1984; Mann & Liberman, 1984; Perin 1983; Stanovich, 1982). Such children have particular difficulty in reading or spelling unfamiliar words; typically, they guess at the identity of an unfamiliar word on the basis of context, initial letter, and word length. Such guesses are often wrong; as a result, the set of words that a poor reader can accurately recognize grows slowly.

Related studies have found poor short-term memory for spoken words in children who are poor readers (Liberman, Shankweiler, Liberman, Fowler, & Fischer, 1977; Mann, Liberman, & Shankweiler, 1980; Shankweiler, Liberman, Mark, Fowler, & Fischer, 1979). This disability affects only language; memory for items which cannot easily be named (e.g., squiggly line drawings) is unaffected (Katz, Shankweiler, & Liberman, 1981). Kamhi & Catts (1986) found that reading disabled children (ages six to eight) differed from normals on tasks that require memory for phonological representations of words.

Our research. We extended this research to adults, studying poor readers among men in prison (Read & Ruyter, 1985). Our goal was to describe more precisely the psycholinguistic skills that adult poor readers lack, focusing on their ability to use sound-spelling correspondences, as opposed to word-specific information (e.g., whole-word visual patterns). The men were selected on a standard test of reading comprehension; almost all scored below the fifth-grade level. We expected to find that they were poor readers in various ways; many of them had had poor educational backgrounds, and the social and psychological pathology that eventually led them to prison also interfered with their performance in school, in many cases. In fact, however, the men were surprisingly uniform in their poor decoding/encoding skills and poor ability to identify and locate speech sounds within syllables. This ability, known as "segmentation," appears to be necessary for learning to read and spell alphabetically (Liberman, Shankweiler, Liberman, Fowler, & Fischer, 1977).

Our adult subjects were at third- to fifth-grade levels in reading comprehension, and we compared them with children in those grades who had performed the same tasks in previous studies (Baron, 1979; Treiman, 1984; Richardson, DiBenedetto, and Adler, 1982). The adults performed like the poor readers among the children, except that they were slightly better on words of exceptional spelling, for which experience helps, and significantly worse on unfamiliar words, which can be read and spelled only with a knowledge of sound-spelling correspondences. Despite their cognitive maturity and greater experience with language, adult poor readers evidently use strategies like those of child poor readers, and they experience similar difficulties.

Although our subjects were surprisingly uniform in their strategies and difficulties, we could reliably distinguish among them, by comparing their reading and spelling of exceptional words with that of nonwords. (The former require the use of word-specific information, while the latter require the use of sound-spelling correspondences.) Those who were poorest in using sound-spelling knowledge had significantly greater difficulty on segmentation tasks, such as locating speech sounds within syllables, especially in noninitial position. Adults' segmentation skills predict their reading and spelling strategies, at all levels of overall performance in our sample.

We also observed a link between reading/spelling and short-term memory (STM) for spoken syllables. Our subjects were nearly normal in performance IQ, measured by Block Design and Picture Completion subtests of the WAIS-R, but they were more than one standard deviation below normal in STM, measured by the Digit Span subtest. Digit Span scores were significantly correlated (~.50) with measures of segmentation. Again, this basic disability fit with the reading and spelling strategies of individuals: men who were poorest in using sound-spelling knowledge differed from those who were best at doing so in the types and locations of their errors on the Digit Span subtest, but not in total score.

Thus reading and spelling strategies correspond to both segmentation skill and short-term memory for spoken language. These correspondences make sense if segmentation and short-term memory are necessary for acquiring and using a knowledge of sound-spelling correspondences. That is, one must hold an auditory representation of a spoken word in memory while segmenting it into phonemes in order to learn the correspondences between phonemes and spellings.

This account is consistent with both theory and data on the role of short-term memory in reading. Perfetti and Lesgold (1977) argued that speed and efficiency of coding information in short-term memory is a major locus of differences between good and poor comprehenders -- not general STM capacity or the ability to exploit the structure of discourse. Baddeley, Logie, Nimmo-Smith, and Brereton (1985) found "working memory span" for verbal material to be the best of several predictors of reading comprehension in adult normal readers. In different ways these two studies both emphasize the functioning of STM rather than its capacity.

The background for our speech perception study is Brady, Shankweiler, & Mann (1983), showing that third-grade poor readers are also poorer at perceiving speech, but not nonspeech sounds, when perception is made difficult by noise. The children's errors revealed faulty phonetic encoding of words in memory, from both reading and listening. Perhaps as a result, reading-disabled children are poorer at repeating verbatim what they have heard (Kamhi & Catts, 1986). Such a perceptual disability may be the real cause of their short-term memory deficit: one cannot accurately remember what one has inaccurately perceived. Thus a perceptual disability might underlie both poor STM and poor decoding skill. We tested this hypothesis with adults.

Design

Foreground variables. Two main descriptive goals of this research were:

> to describe short-term memory, decoding skills, and reading comprehension in samples of adult good and poor readers, and to describe the predictive (correlational) relations among these three.

This part of the study was a partial replication of Read & Ruyter (1985), with better control over several subject variables and with good readers as well as poor.

Another goal was:

> to determine whether adult poor readers are also poorer in the perception of speech under certain conditions.

With the same subjects, we replicated Brady et al.'s (1983) study of speech perception, but with adult good and poor readers to compare with their third-graders. We presented words against clear and noisy backgrounds, comparing the effect of noise on good versus poor readers. We also examined the relations between speech perception and the reading variables.

Background variables. We measured nonverbal cognitive performance and listening vocabulary, two factors which are not direct predictors of reading in our model of STM and decoding. From prison files we obtained information on three facts of personal history: age, last grade completed in school, and history of alcohol and drug abuse, a nearly universal problem among prisoners which may affect short-term memory.

Method

Subjects. From the men at one minimum-security prison, we selected native speakers of English who did not have a severe hearing loss. [Those excluded had a hearing level worse than -40 dB in both ears between 500 and 4000 Hz]. All of the men had been judged (in the courts and the prison intake evaluations) to be of normal intelligence. None had any severe abnormality in speech. We further selected men who were unlikely to be released during our testing and who were emotionally stable enough to take part; on these two criteria we accepted the judgment of each man's prison social worker. The language and hearing constraints excluded only a few men; our samples seemed to the social workers to be representative of men in Wisconsin prisons.

Initially we distinguished between good and poor readers with the reading comprehension subtest of the Stanford Achievement Test, administered to groups of men upon entry to the prison system. For men who had been in prison for a long time (or more than once), these scores were years old, so we later administered another test of reading comprehension (below). Poor readers (n = 50) were those who scored below the sixth-grade level on the Stanford subtest. That test does not measure below the third-grade level, so our poor readers had a narrow range of scores: 3.0 to 5.9 in grade levels. Good readers (n = 38) were those who scored between the seventh and twelfth grades. Even our "good" readers, therefore, are not like college readers, but their reading was commensurate with their schooling: on average they had completed 9.8 years of school, and their mean reading comprehension grade level was 9.4. The poor readers had also completed nine years of school on average, but their mean reading level was 4.5. Table One summarizes these data:

	n	school grade	mean age	Stanford	Woodcock	GEDs earned
Poor Readers	30	9.2	31.5	4.5	15.1	20%
Good Readers	38	9.8	28.4	9.4	20.4	39%
Difference		6%	-11%	52%	26%	

Table One: Subject Data

Key:
- school grade: mean grade completed in school
- Stanford: reading comprehension subtest of Stanford Achievement
- Woodcock: passage comprehension subtest of Woodcock-Johnson
- GEDs earned: percent of Ss who earned GED while in prison

Our good and poor readers were by no means matched, but they were similar in background while different in reading comprehension.

Fifty-five percent of our subjects were black, 42% were white, and 3% were Hispanic. We have not labeled our poor readers as "dyslexic" or "reading-impaired" because they were not diagnosed as such. These terms have so many meanings that in the absence of a stipulative definition, they add nothing to "poor reader."

Measures. Table Two lists the measures we used for each variable:

Foreground variables

Short-term memory
- Digit Span subtest (scaled score) of WAIS-R
- Working memory test (based on Baddeley et al., 1985)

Decoding Skill: The Decoding Skills Test
- I: familiar words
- II-R: real but less frequent words
- II-N: nonwords

Reading Comprehension
- Passage Comprehension subtest of Woodcock-Johnson
- Reading Comprehension subtest of Stanford Achievement

Speech Perception (replicates Brady et al., 1983)
- Speech in clear
- Speech in noise
- Non-speech sounds in clear
- Non-speech sounds in noise

Background variables

Performance IQ: nonverbal tasks
- Block Design subtest (scaled score) of WAIS-R
- Picture Completion subtest (scaled score) of WAIS-R
- Mathematics subtest of the Stanford Achievement

Listening Vocabulary
- Peabody Picture Vocabulary Test (raw score)

Age
Last grade completed
Race
History of Alcohol & Drug Abuse
Hearing (Pure-tone audiometry)
} Prison files

Table Two: Measures

Trained testers administered all tests to subjects individually in quiet offices at the prison. The working memory test was based on that of Baddeley et al. (1985, p. 123). The subject listened to a group of 3 or 4 sentences, checked "true" or "false" for each, and then was asked to recall either the "people" or the "things". After practice items, there were 5 groups of 3 and 5 groups of 4, for 35 sentences in all. Unlike the Digit Span test, this one requires comprehension and memory for meaningful material. All of the other cognitive and reading tests are published.

The tests of listening perception were of two kinds: *speech* (48 words, half of high frequency) and *nonspeech sounds* (24 items such as knocking on a door, dialing a telephone, an automobile starting, an organ playing, and a baby crying). The subject listened to each item and then named the word or the sound. Both speech and nonspeech were presented once in noise and once in the clear (in that order) with one week between the two presentations. The noise had a wide frequency spectrum that varied in amplitude with the recorded sound; that is, at the loudest part of a syllable (e.g., a vowel) the noise was also at its loudest. Overall signal-to-noise ratio was about 0 dB. The recorded stimuli were those used by Brady et al. (1983, expts. 2 & 3), for which the words were selected "to control for syllable pattern, phonetic composition, and word frequency" (p. 355).

Under normal conditions, listening perception is so effective that there are few individual differences among people with normal hearing. The design of this test is to make perception difficult (by removing context and adding noise) so that one can compare good and poor readers.

Results

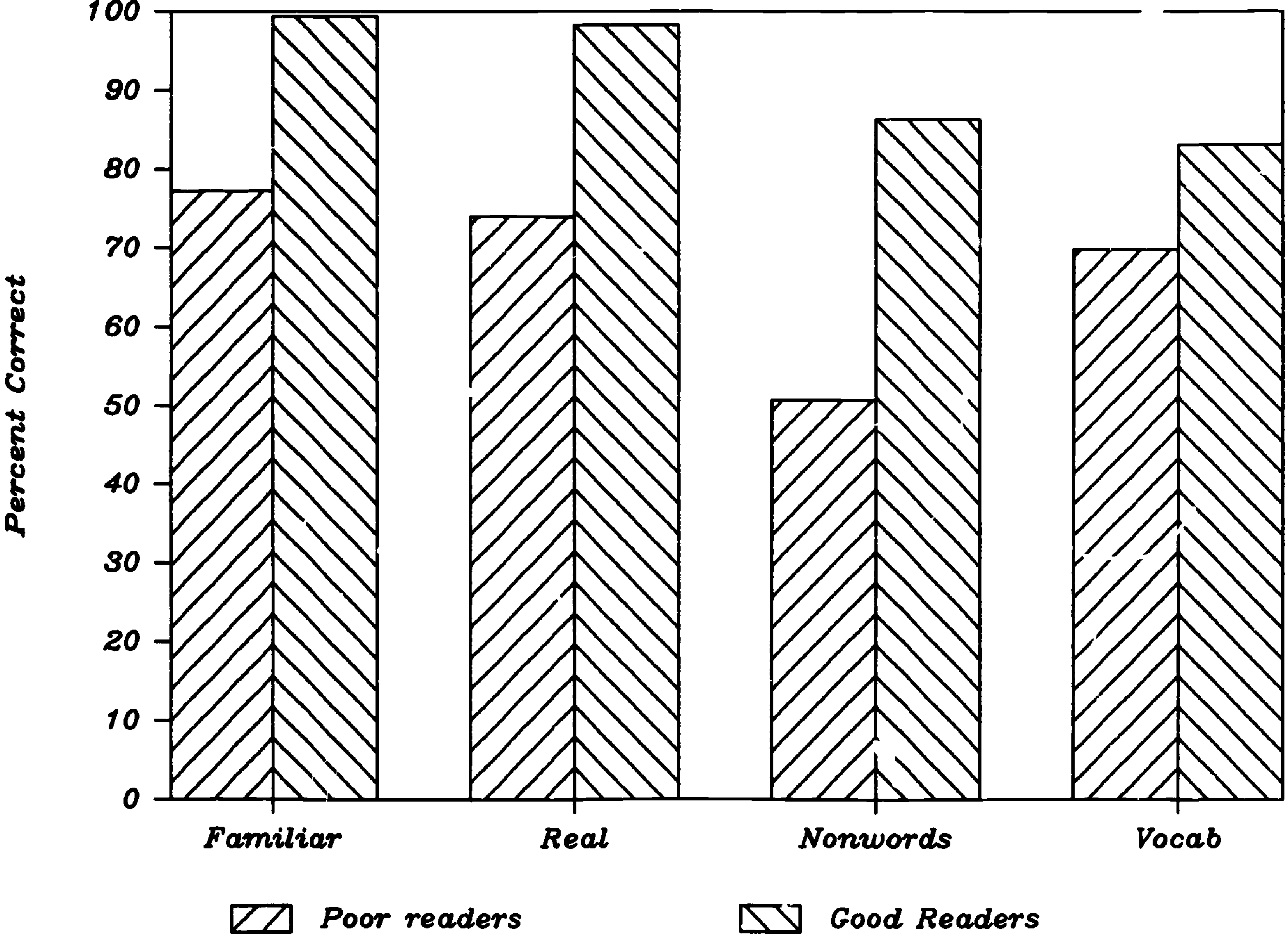
Reading comprehension. As shown in Table One, good and poor readers differ substantially on both reading comprehension tests: on the subtest of the Stanford Achievement Test because they were grouped on that basis, but al: , on the passage comprehension subtest of the Woodcock-Johnson Psycho-Educational Battery. These two comprehension scores are correlated at only $r = .51$, and the two groups differ only half as much on the Woodcock-Johnson as on the Stanford. These differences may reflect unreliability in the Stanford scores, differences between the two tests, and unequal learning while in the prison system such that poor readers improved more. We will use both tests as targets to be predicted by measures of other skills.

Decoding skills. Good and poor readers differ substantially in decoding skill; they differ most in reading nonwords, as shown in Figure One.

Insert Figure One about here

Nonwords can be read only by decoding, not by using familiar word-specific features (such as shape); thus it seems that our good and poor readers differ most in decoding. However, the good readers approached 100% correct on real words (parts I and IIR of the Decoding Skills Test), so the true difference on real words may be greater. The two groups differ least on listening vocabulary

Decoding Skills
and Vocabulary



(PPVT), which does not require reading, although it predicts comprehension.

Table Three displays the mean scores on reading comprehension, decoding, and vocabulary, along with measures of variability.

	Poor Readers			Good Readers		
	x	s.d.	range	x	s.d.	range
Stanford	4.5	1.0	2.3 - 5.9	9.4	1.4	7.1 - 12.4
Woodcock	15.1	5.1	0 - 24	20.4	2.0	16 - 24
DST I	84.9	30.5	4 - 110	109.3	1.0	106 - 110
DST II-R	44.4	18.5	0 - 60	59.0	2.0	49 - 60
DST II-N	30.4	21.2	0 - 60	51.8	10.2	9 - 60
PPVT	122	15.4	92 - 153	146	10.7	121 - 166

Table Three: Reading and Vocabulary Scores

The wide variation among poor readers on all comprehension and decoding scores results in part from about five men who could scarcely read at all. A histogram of scores on decoding nonwords (the DST II-N: Figure Two) shows that both groups included some good decoders, but virtually all the poor decoders were among the poor comprehenders, many of whom could not read nonwords at all.

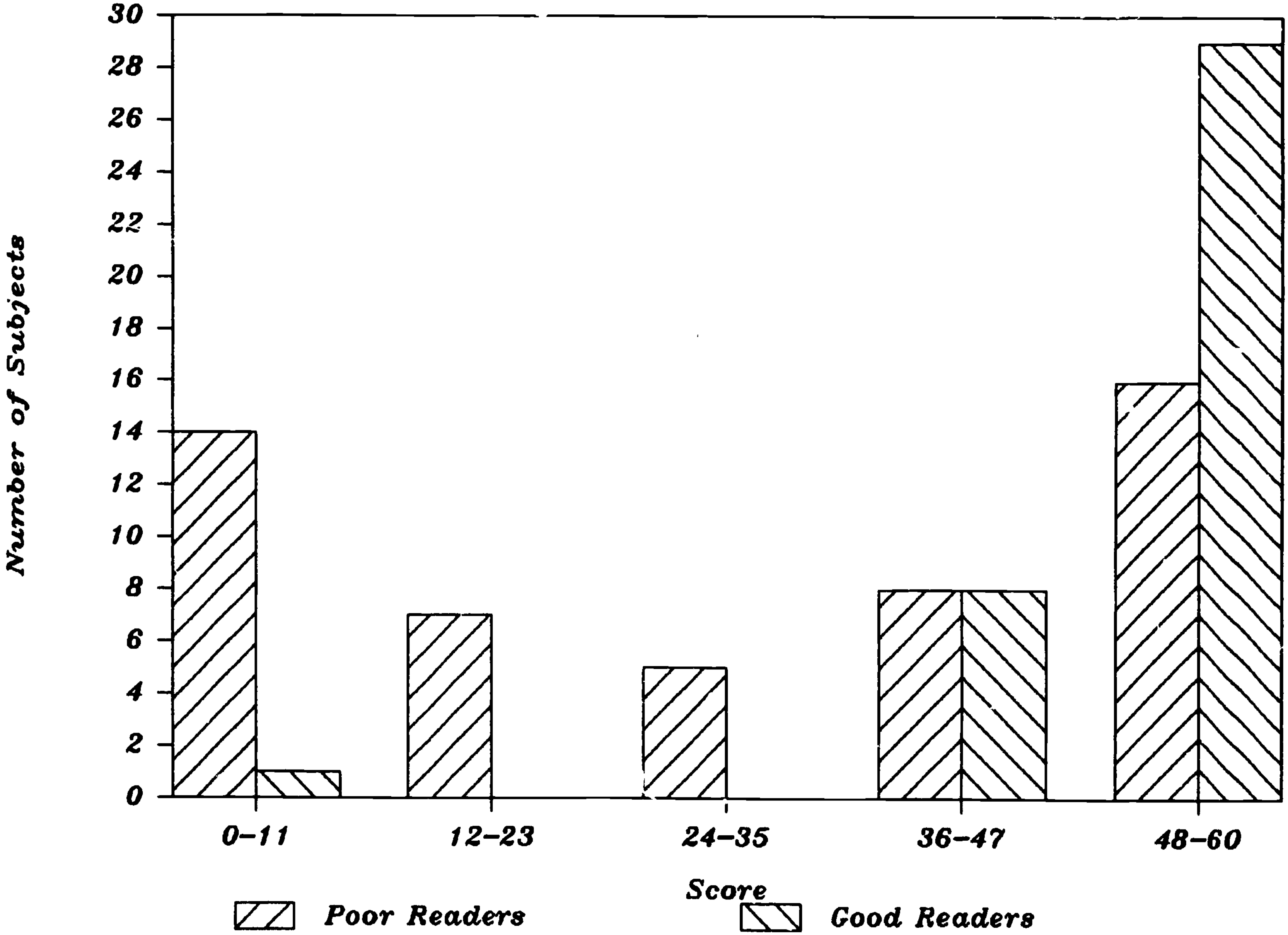
Insert Figure Two about here

Nonverbal abilities. Our good and poor readers differ also in nonverbal skills, as measured by the Block Design and Picture Completion subtests of the WAIS-R (Figure Three).

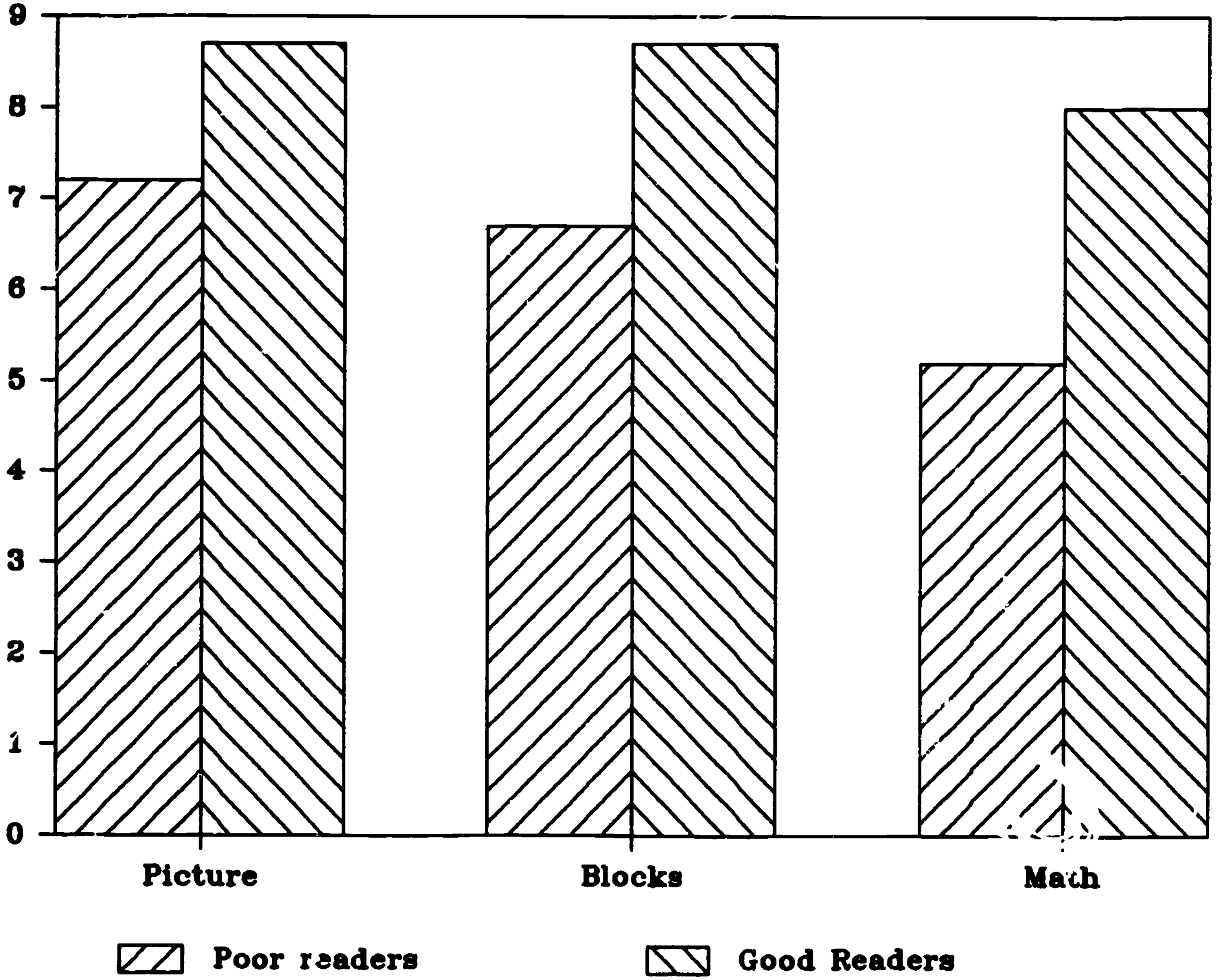
Insert Figure Three about here

Decoding Nonwords

DST II-N



Nonverbal Skills



The poor readers are approximately one s.d. (3) below the population mean (10) on both tests. Our poor readers lack skills specific to reading and language, but they differ significantly from the good readers nonverbally as well. Table Four presents the summary data.

	Poor Readers			Good Readers		
	x	s.d.	range	x	s.d.	range
Block	6.7	2.4	2 - 12	8.7	2.5	5 - 14
Picture	7.2	2.4	4 - 12	8.7	2.9	2 - 14
Math	5.2	1.8	2.1 - 10.5	8.0	2.0	3.6 - 13.0

Table Four: Nonverbal Abilities

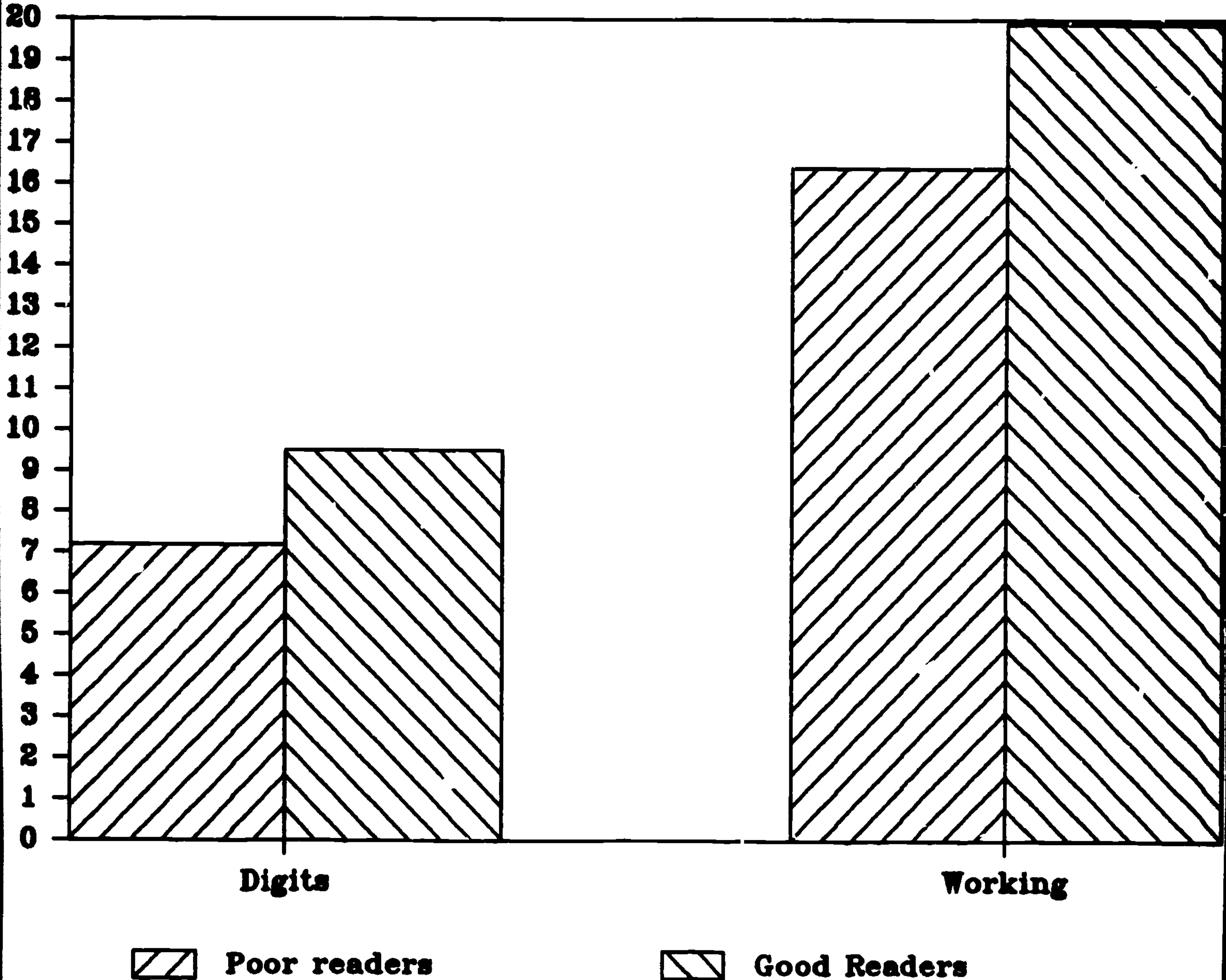
The mathematics subtest requires reading, so understandably our groups differ more on it than on the other two tests. Our results on Block Design and Picture Completion are different from those of Kender, Greenwood, & Conard (1985), who administered the WAIS-R to more than 500 adults in prison. Their "adequate readers" performed like our good readers, but their "underachieving readers" did much better than our poor readers; in fact, they did nonsignificantly better than the adequate readers on Picture Completion.

Short-term memory. Good and poor readers differ substantially on both measures of short-term memory, as shown in Figure Four.

Insert Figure Four about here

On the Digit Span subtest of the WAIS-R, the poor readers are again about one standard deviation below the population mean. The

Short-Term Memory



groups differ somewhat more, proportionally, on Digit Span than on Working Memory, even though the latter was designed to measure skills that are more directly relevant to reading, namely simultaneous comprehension and memory. Table Five presents the data; for the Digit Span test, Table Five includes results from Kender et al. (1985) below those from our subjects.

	Poor Readers			Good Readers		
	x	s.d.	range	x	s.d.	range
Digits	7.2	2.7	2 - 13	9.5	2.8	4 - 16
Kender	8.2	2.8	unknown	8.5	2 3	unknown
Working	16.4	4.6	2 - 26	19.9	3.7	11 - 26

Table Five: Short-term Memory

Kender et al. (1985) found a much smaller (and nonsignificant) difference in the same direction as ours.

Effects of alcohol and drug abuse. Any report on short-term memory among prisoners must take into account that most of these men have abused alcohol or other drugs, which may cause short-term memory damage. Differences in short-term memory related to reading are important regardless of what caused those differences, but we would like to know, for instance, whether the poor STMs are likely to have developed after the school years.

Each man's prison file contains information on drug abuse, based on interviews with the prisoner and in most cases, his family and other members of the community. Because these evaluations indicate what treatment is needed, they tend to use a few consistent terms, such as "severe," "moderate," and "not significant." We classified each man's drug abuse history into one of three levels accordingly. There is no difference between good and poor readers on this measure: on a scale of 1 to 3, both groups have a mean of 2.1 with s.d.'s of .78 and .C7 respectively. The drug scale is not a significant predictor of reading comprehension, either by itself or with the background or foreground variables as covariates. It is also not a good predictor of short-term memory; ANOVAs of Digit Span and Working Memory by drug use both have F-ratios less than 1.0. We conclude that while drug abuse may well account for some short-term memory loss in this population, it does not differentiate between our good and poor readers; the substantial difference in STM between them is not attributable to drug use.

Summary. Our good and poor readers differ significantly on every measure of reading comprehension, decoding, short-term memory, vocabulary, and even nonverbal skills ($p < .001$ in each case, by both a two-sample t-test and a Mann-Whitney two-sample rank test). They differ most (41%) in reading nonwords, which requires decoding skill. They do not differ on grade completed in school or drug use ($p > .1$ in each case, again by either test).

Prediction of Reading Ability

Poor readers. Of the several variables on which our good and poor readers differ, which ones predict reading ability? For poor readers, comprehension, decoding, and short-term memory are highly correlated with each other, as shown in Table Six:

	Reading	Passage	Digit Span
Passage	.58		
Decoding familiar	.62	.88	.67
Decoding real	.37	.86	.66
Decoding nonwords	.52	.[illegible]7	.65
Digit Span	.44	.59	

Table Six: Correlation Coefficients, Poor Readers

Of 136 correlation coefficients among 17 variables in our data (excluding grade in school and math), these 12 are the only ones greater than .50, except for those between subtests of the same test or between subtest and total.

Both measures of reading comprehension are significantly predicted by each of the following: decoding of real words (DST1 + DST2-R), decoding of nonwords (DST2-N), and the Digit Span subtest. In a multiple regression, the sum of all three decoding scores predicts comprehension (both measures, $p < .001$ for each) better than digit span. In fact, no measure adds significantly to the predictive value of the summed decoding scores. As suggested in Table Six, total decoding predicts Passage Comprehension much better than it predicts Reading Comprehension (78% and 33% of variance, respectively). We attribute this difference to the limited range of the Stanford reading comprehension scores among poor readers and the fact that the test was given to groups at prison intake.

In turn, the best predictor of total decoding score (other than comprehension) is the Digit Span test (r = .68). By itself Digit Span predicts 46% of the variance in decoding, and with PPVT, the only other significant predictor, it predicts 56%. In short, for poor readers, the best predictor of comprehension is decoding, and the best predictor of decoding, other than comprehension, is short-term memory. This result fits a model in which decoding is an essential skill in reading, and STM is a critical factor in decoding, at least for poor readers.

Good readers. The situation for good readers is quite different. For them, decoding and short-term memory are not so highly correlated with comprehension, as shown in Table Seven:

	Reading	Passage	Digit Span
Passage	.56		
Decoding familiar	.03	.23	.21
Decoding real	.25	.11	.09
Decoding nonwords	.40	.26	.29
Digit Span	-.12	.18	

Table Seven: Correlation Coefficients, Good Readers

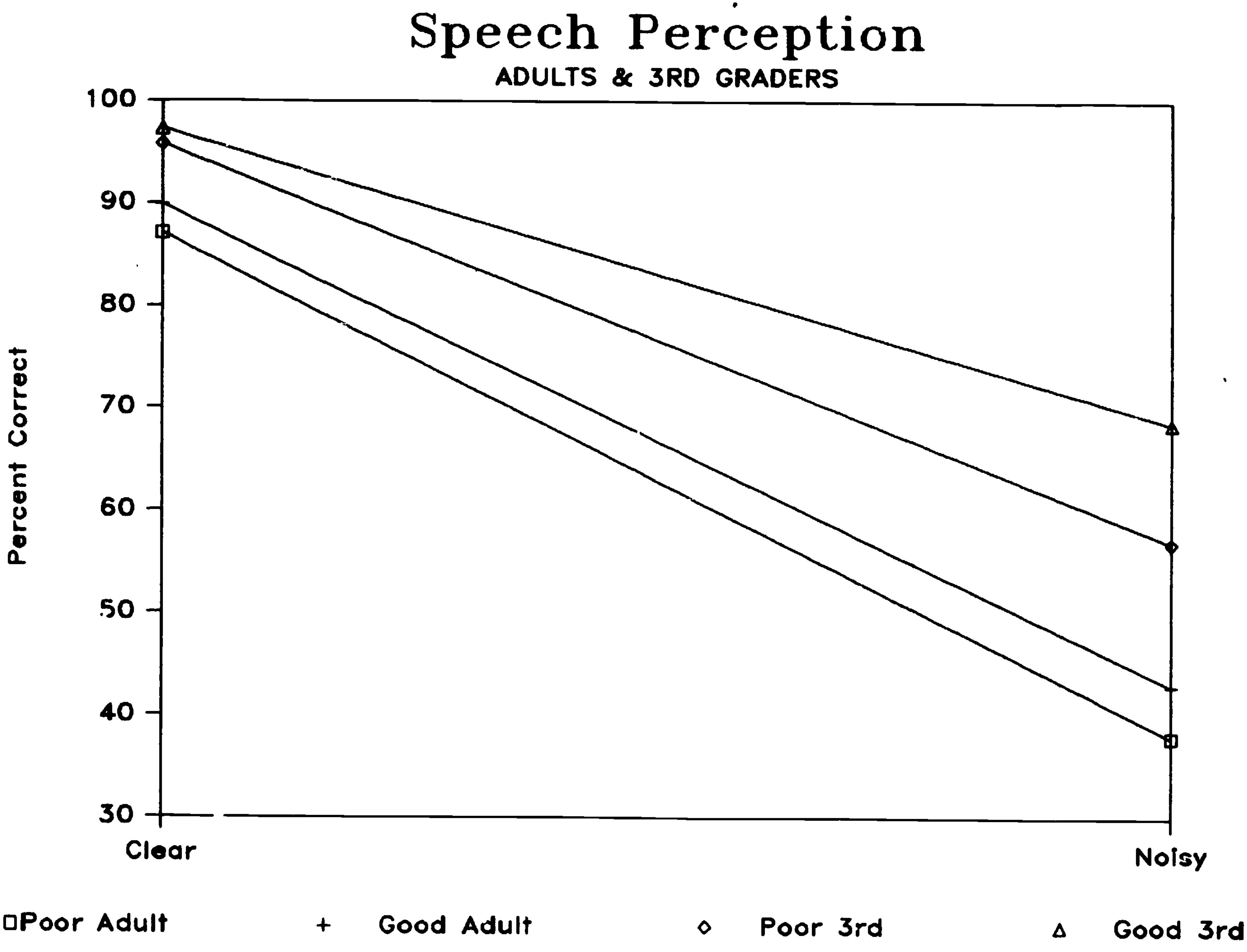
The two measures of comprehension are still moderately related to each other, but the variables which predicted comprehension among poor readers no longer do so. In multiple regressions, the only significant predictors of comprehension among good readers are Block Design for the passage test (r = .54) and the decoding of nonwords for the Stanford test (r = .40). Among good readers there is less variance in comprehension, decoding, and STM in relation to the means, so the associations among these factors are bound to be weaker. In practical terms, because good readers have at least adequate STM and decoding skill, these do not constitute the major differences among individuals.

Speech Perception

As noted above, Brady et al. (1983) showed that in third grade, poor readers are also poorer in perceiving speech. This result suggests that the short-term memory and decoding deficits may originate in perception, not memory, and in spoken language, not written. If confirmed, this inference would have major implications for our understanding and treatment of reading disabilities. For example, teaching decoding skills to people with unreliable perception of speech would be futile. Accordingly, we replicated the Brady et al. study with our adults. Figure Five displays the overall results.

Insert Figure Five about here

The top pair of lines in Figure Five shows the effect found by Brady et al.: poor readers (marked with a diamond) are more affected by noise than good readers (marked with a triangle). This interaction was significant: $F(1, 28) = 15.8$, $p < .001$. The bottom pair of lines shows the same comparison among our adults; the overall difference between good and poor readers is small [$F(1,83) = 3.0$, $p < .09$], and the interaction with noise is not significant [$F(1, 83) = 1.8$]. Our adults perceived the recorded speech less well overall than Brady's third graders, but we cannot


Speech Perception
ADULTS & 3RD GRADERS
100
90
80
70
60
50
40
30
Percent Correct
Clear
Noisy
Poor Adult
Good Adult
Poor 3rd
Good 3rd

directly compare them overall because we may not have duplicated the listening conditions precisely (in sound level, for instance).

The stimuli that we and Brady et al. used consisted of 24 high-frequency and 24 low-frequency words, matched for syllabic pattern. Because the differences in frequency were large (e.g., door, team, road vs. bale, din, lobe) and because our poor readers have limited listening vocabularies, a more valid comparison may be for the high-frequency words only, which our good and poor readers should be able to recognize equally well. Figure Six shows the effect of noise on our subjects' perception of all words (bottom pair of lines [same as in Figure Five]) and of high-frequency words only (top pair of lines).

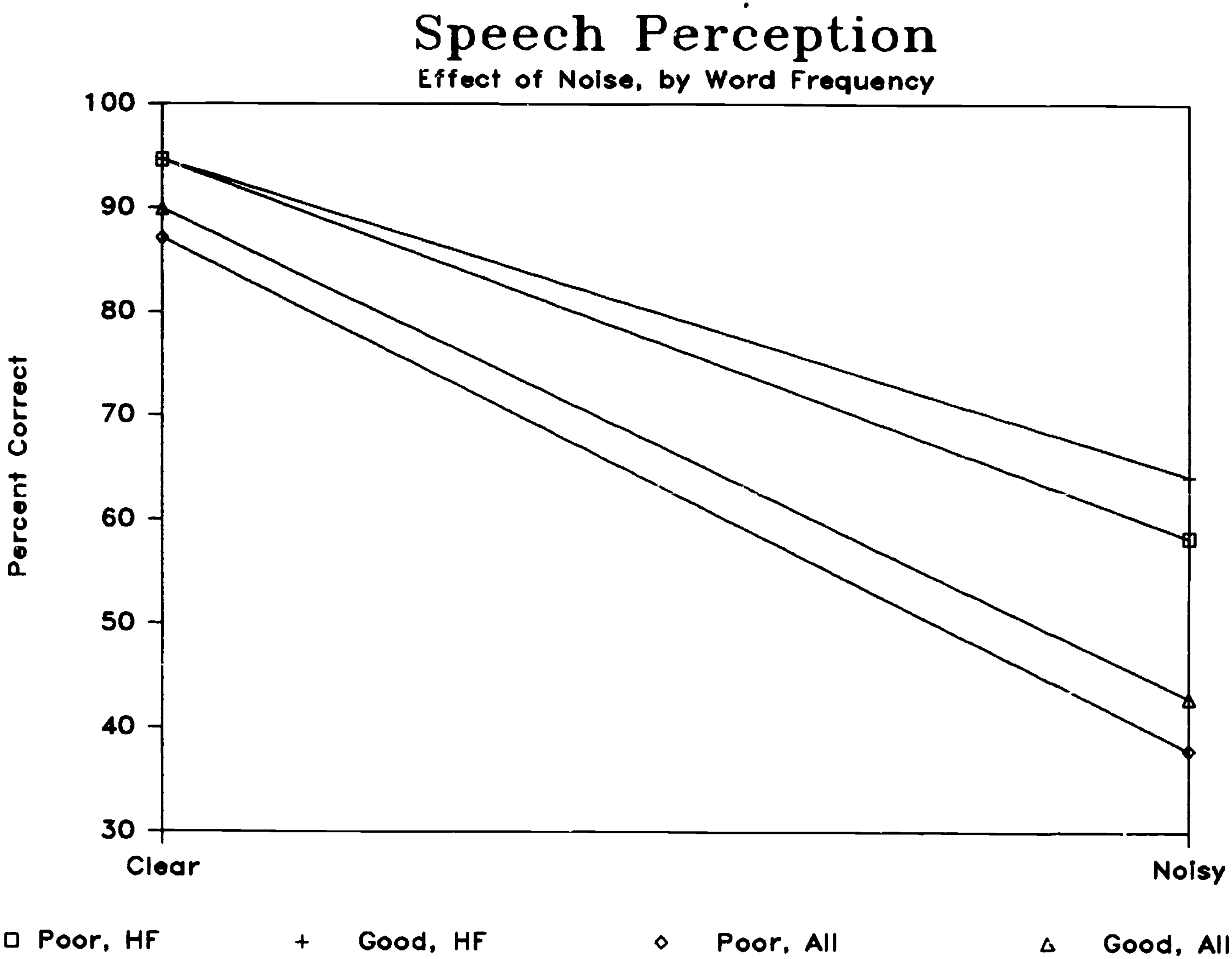
Insert Figure Six about here

In this case, the overall difference between good and poor readers is again not significant [$F(1, 83) = 1.2$, $p < .3$], but the interaction is significant [$F(1,83) = 5.7$, $p. < .02$]. That is, noise has a significantly greater effect on poor readers' perception of familiar spoken words.

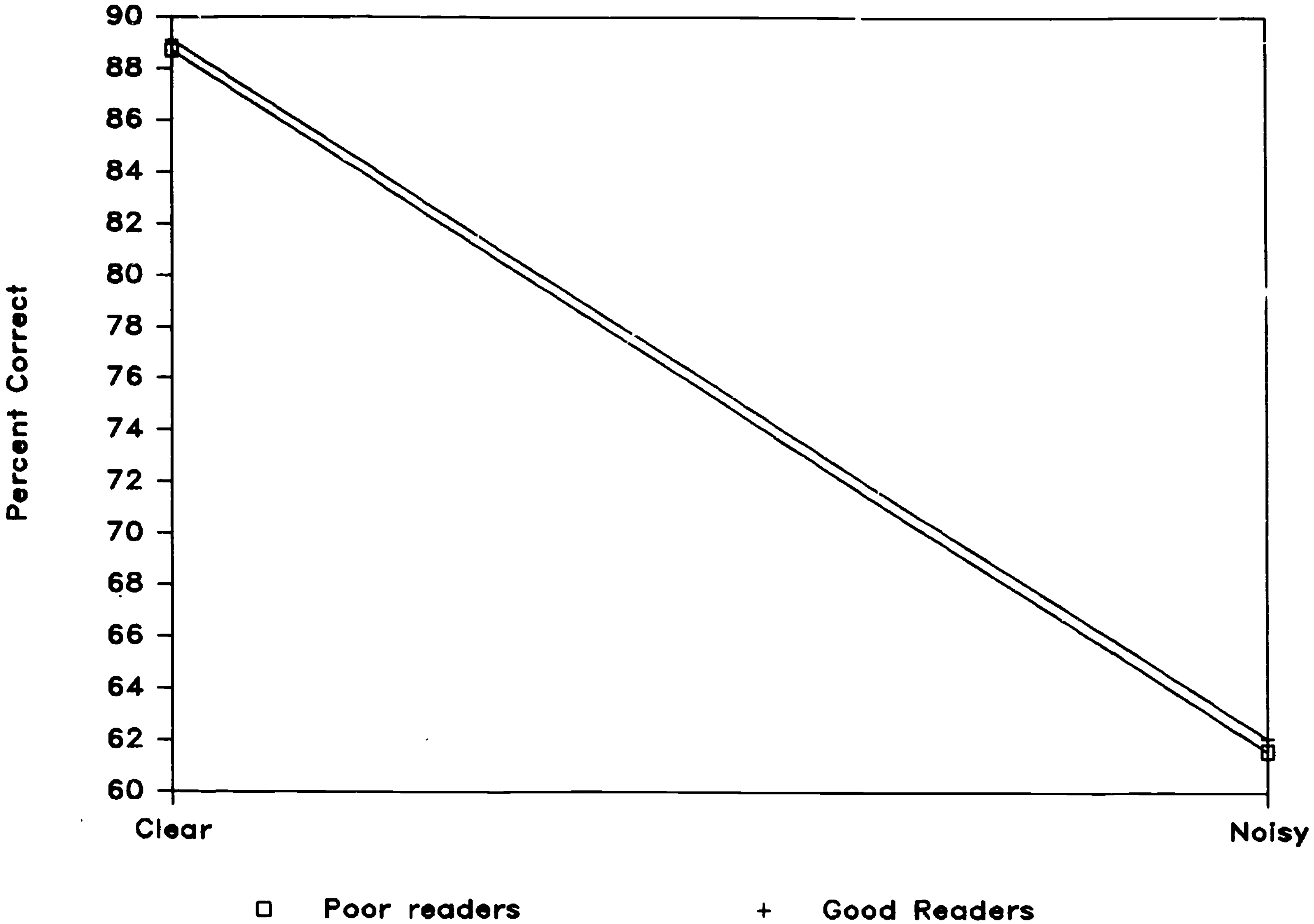
Finally, a crucial feature of the Brady et al. results is that the differential effect of noise was for speech only; there was no such effect for a set of 24 "environmental sounds." Figure Seven displays our adults' perceptions of these sounds in noise and in the clear.

Insert Figure Seven about here

Obviously, there is no difference between good and poor readers and no differential effect of noise [$F(1,83) < 1$ for both]. Thus


Speech Perception
Effect of Noise, by Word Frequency
100
90
80
70
60
50
40
30
Percent Correct
Clear
Noisy
Poor, HF
Good, HF
Poor, All
Good, All

Sound Perception



as in Brady et al., the difference between good and poor readers in perception is limited to <u>speech</u>.

<u>Relation to other variables</u>. The perception of speech (in noise or clear) is not highly correlated with any other measures. The <u>difference</u> in perception of speech (clear minus noise) is also not highly correlated with any other measures, for all words or for high-frequency words only. The largest such correlation is -.28 (8% of variance in common), between (a) reading comprehension and (b) the difference between high-frequency words in clear and in noise for poor readers. That is while there is a significant difference between good and poor readers in the effect of noise on speech perception, neither that effect nor speech perception itself strongly predicts reading comprehension or any of the related factors we have measured.

<u>Relation to temporal perception</u>. Tallal (1980) and others have found that many poor readers are impaired in perceiving rapidly-changing stimuli, even nonspeech. For example, in Tallal (1980) reading-impaired children were significantly worse than normal readers in perceiving tones, <u>only</u> when the tones changed rapidly. Errors on this task were highly correlated (rs = .81) with errors in reading nonwords. Our comparison between speech and other sounds is confounded with rapidity of stimulus change. Our subjects' tasks were to identify the spoken words (and thus the rapidly-changing sounds within them), but to identify only the <u>nature</u> of nonspeech sounds, even those that changed rapidly, such as music. Thus the differences between good and poor readers on

these tasks are consistent with Tallal's hypothesis but are not crucial evidence for it.

Conclusions

We undertook this research expecting to find that adult poor readers read poorly in many different ways and that any predictive relationships are concealed within that variation. These men are indeed quite varied; for example, a few never attended school, while a few others went as far as the twelfth grade [with fourth-grade reading comprehension and vocabulary!]. Moreover, their difficulties are by no means limited to language; most are far below average on nonverbal tasks; the poor readers are quite different from the good ones in that respect. However, within all the variation and nonverbal deficits, there are clear predictive relationships: short-term memory, decoding, and reading comprehension strongly predict each other. These relationships are much stronger than those involving vocabulary and nonverbal tasks, not to mention age, schooling, or drug abuse.

Of course, from such associations one cannot infer causation. At most, these results are consistent with a model of reading in which short-term memory is needed to learn and to use sound-spelling relationships, and decoding skill is in turn necessary for comprehension. The strength of these associations for poor readers and not for those who read above an elementary-school level suggests, but does not prove, that short-term memory and decoding are a large part of the barrier that poor readers have encountered. Only research which combines correlation with manipulation can claim to have found causation, as did Bradley & Bryant (1983), for example. However, the consistency of these results with those of our previous study of adults and with the substantial literature on children does yield a consistent picture of poor readers: they have poor immediate memory for language, both spoken and written, and they cannot effectively relate spellings to sounds, the principle of alphabetic writing. As a result, they are at a loss to read unfamiliar words, and their reading vocabularies grow slowly. Adult cognition does not alter this pattern; in STM and decoding, our poor readers in prison look like those in elementary school (Mann & Liberman, 1984; Stanovich, 1982; Mann, Liberman, & Shankweiler, 1980). Recognizing words is only part of reading, but decoding and short-term memory predict most of the variance in comprehension among poor readers.

There is an even deeper level of difference between good and poor readers, that of speech perception. On words that were well within their limited listening vocabularies, our poor readers were more affected by noise than comparable good readers. In this respect, too, our adults resemble elementary schoolers in one study (Brady et al., 1983), and this difficulty affects language only, not other sounds. This additional link attaches to our chain:

- One cannot comprehend written language unless one can recognize the words in it. Decoding is essential to

^his recognition, and is a critical skill for elementary readers.

- In turn, decoding and learning to decode depend upon holding a representation of a spoken word in memory.
- That representation must come from an accurate percept.

Poor readers may have difficulty at any links in this chain: decoding, memory, and perception. The predictive value of speech perception is small compared with that of the other two factors, but the difference between good and poor readers is significant. That difference appears to be attenuated in adults, perhaps because they develop some compensatory strategies. One study of children and one of adults cannot provide a full picture of the relation of speech perception to reading; for now, we conclude that good and poor readers differ somewhat in speech perception, the most basic language ability of all, but that difference does not underlie the substantial differences in short-term memory for language which are strongly related to reading comprehension.

Implications

What do these results tell us about identifying and teaching adults who read at a primary-school level, recognizing that such people make up a large fraction of the population of our prisons? Assuming that our samples are representative, we conclude:

1) Those who read at an elementary-school level are substantially different from those who read a few grade-levels higher, on several basic measures of language and cognition. That is, the differences are not just differences in schooling,

although they may have been enhanced or preserved by schooling. The nature and size of these differences may not be revealed by reading tests given at prison intake, and they may not correspond to enrollment in particular programs. In our samples, both good and poor readers had been assigned to "exceptional education" (13% and 20% respectively), and men from both groups were enrolled in GEd programs.

2) **The poor readers are characterized by poor short-term memory for language and poor decoding skills.** What they evidently cannot do is to hold in memory a representation of a spoken word and relate that representation to the word's written form. These skills strongly predict reading comprehension. There is more to good reading than word recognition, but these skills constitute a crux for readers at this level.

3) **The poor readers may also have a subtle disability in perceiving speech, which becomes apparent only under difficult perceptual conditions, such as noise.** If so, this disability is not a predictor of reading comprehension, but it may contribute to the differences between good and poor readers, e.g., in listening vocabulary.

In the light of this research, the following appear to be key questions for teaching:

- to what extent can we improve short-term memory and decoding skills in adult poor readers?
- by what methods?

- what happens to reading comprehension if we do improve those skills?

Obviously, this research was not designed to answer these questions, but it does indicate their importance.

Most basically, this research says that low literacy among adults is associated with fundamental psycholinguistic processes, namely short-term memory and speech perception. That is not to say that such adults cannot be taught to read better; it is to say that while their special weakness is typically in decoding, training in decoding alone is not enough. If poor readers' perception of and memory for speech is unreliable, then learning to analyze and represent that inaccurate image will be frustrating for both teacher and student. Such readers need help in learning to perceive and to remember spoken words at the level of detail necessary for learning to decode. Such help is part of several approaches to teaching adults to read better, including the Orton-Gillingham materials.

Society recognizes the importance of literacy for participation and especially for employment; "no read, no release" policies reflect that recognition ("Virginia governor earmarks $1 million for reading program," 1986). These and other educational policies depend upon an accurate picture of the reading skills and disabilities of the adults that they affect.

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