DIFFERENCES *between* GOOD *and* POOR SPELLERS *in* READING STYLE *and* SHORT-TERM MEMORY

Jeanne Ellis Ormrod
University of Northern Colorado

Three experiments were conducted to test Frith's (1980) hypothesis that good spellers read by full cues while poor spellers read by partial cues; a fourth experiment was conducted to investigate short-term memory differences between the two groups. Subjects for all four experiments were ten pairs of 9th- and 10th-grade students matched for sex and intelligence but differing in spelling ability. Good spellers were found to be faster readers than poor spellers (Experiment 1), contrary to Frith's prediction that poor spellers should read faster. Good spellers were found to be more accurate in identifying matches and mismatches in similarly spelled pairs of nonsense words (Experiment 2) and in spelling

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Author's address:
Department of Educational Psychology,
University of Northern Colorado, Greeley CO 80639

nonsense words they had just seen (Experiment 3). Experiments 2 and 3 both lend support to Frith's hypothesis regarding different reading styles in good and poor spellers; however, an alternative explanation, that of differences in short-term memory, must also be considered. Experiment 4 involved the comparison of good and poor spellers in short-term visual memory for digits, consonant-vowel strings, and consonants, under both simultaneous and sequential presentation methods. Good spellers were found to have better short-term memory for all three content types and both presentation methods.

In the process of learning to read it is logical to assume that one would also learn to spell (Ehri, 1980; Frith, 1980). In order to recognize a word one must have some sort of mental representation of that word, a representation which can then be employed in writing the word at a later time. Nevertheless, in a group of individuals of equal intelligence and/or reading ability, one will find wide variability in their spelling ability (Frith, 1978, 1980).

To account for the differences in the spelling ability of otherwise equally capable individuals, Frith (1980) has proposed that poor spellers and good spellers of equal reading ability differ in their reading style. More specifically, she has hypothesized that poor spellers take greater advantage of a passage's redundancy and overlook many letters in the process of reading for comprehension (i.e., they read by partial cues). Good spellers, on the other hand, attend to most, if not all, of the letters they see while reading (i.e., they read by full cues). Actually seeing the letters of the words one reads, rather than skipping over many letters not necessary for comprehension of what is read, should lead to greater knowledge of correct word spellings.

Frith has presented some evidence to support the partial cues hypothesis. For example, in two studies of 12-year-olds equated for reading achievement, poor spellers had greater difficulty than good spellers in reading aloud misspelled words, including their own misspellings (Frith, 1978, Experiments 1 and 2). This finding is consistent with the partial cues hypothesis, in that someone sampling only a portion of the letters of a word while reading (the poor speller) would be more easily misled by an incorrect letter than would someone looking at all the letters (the good speller).

In a third study (Frith, 1978, Experiment 3) good spellers performed better on a proofreading task; again, this would be expected if only the good spellers were attending to all the letters of the passage.

While the results of the above studies can be interpreted as supporting Frith's partial cues hypothesis, other interpretations of the results are also possible. For example, the poor speller's lower performance in reading misspelled words may simply have been due to weaker word attack skills. The poor performance of poor spellers in the proofreading task may have been due to other factors such as their lower spelling ability per se or possible differences in reading time used in completing the task. (In a study by Ormrod [1978], poor spellers were found to be inferior even in a proofreading task where highly familiar words such as *the* and *and* were misspelled; however, neither general ability nor reading time was controlled in that study.)

The studies described below were designed to investigate possible differences in the reading styles of good and poor spellers, particularly within the context of Frith's partial cues hypothesis. For reasons to be presented below, short-term memory spans of good and poor spellers were also assessed.

EXPERIMENT 1

One prediction that Frith (1980) has made is that good spellers, if they are attending to greater detail of what they read, should be slower readers. Poor spellers, in skipping many of the details of the written page, should be faster readers. While the personal testimonies of many of my own undergraduate students support Frith's prediction, a relationship between reading speed and spelling ability has not been systematically determined.

Experiment 1 was designed to measure the reading speed of good and poor spellers in reading passages of different degrees of predictability. According to psycholinguistic approaches to reading (e.g., Smith, 1971), the more predictable a reading passage is, the more an individual can use the redundancy inherent in the passage's predictability to skip letters and even words in the process of reading; thus, the individual can read very quickly. Conversely, in less predictable passages the reader needs to rely more heavily on the cues provided by the printed page and therefore has to slow down the reading rate. Since good spellers are hypothesized to depend heavily on the printed page in any case, they should not be greatly affected by a decrease in passage predictability. Poor spellers, who are taking advantage of the passage's redundancy, should slow down as predictability is decreased.

Method

Subjects. Subjects were selected from 9th- and 10th-grade students enrolled in art and humanities classes at a university laboratory school. The Otis-Lennon Mental Ability Test and the first 30 items of the Level II spelling test of the Wide Range Achievement Test (WRAT) were administered to 121 students by their classroom teachers. From these students ten matched pairs were selected, all consisting of students of average intelligence (Otis-

Lennon deviation-IQs ranged from 99 to 114). One student in each pair had high spelling ability (WRAT spelling score) $> = 25$, $M = 27.5$), and the other student had low spelling ability (WRAT score $< = 17$, $M = 15.2$). Pairs were matched for sex and for intelligence (Otis-Lennon scores differed by 4 points or less, with the mean IQs of the good spellers and the poor spellers being 106.1 and 106.0, respectively). Nine of the pairs were matched for grade; the tenth was composed of a 9th-grade good speller and a 10th-grade poor speller.

Materials. Two passages were taken from Norton Juster's *The Phantom Tollbooth* (1972) and were chosen for their apparent differences in predictability. The passages were estimated from Fry's (1977) readability graph as being at the 6th- to 7th-grade reading level. The first passage, 315 words taken from the beginning of the book, described the difficulties of a boy named Milo in understanding the worth of school and academic tasks. The second, a 304-word passage taken from the middle of the book, described a situation in which Milo attempted to restore sound to the world by dropping a small whisper into a cannon and shooting it toward a fortress containing all the world's sounds. This passage, when taken out of context, was judged to be more difficult to predict, as the events described seemed almost nonsensical without knowledge of the circumstances preceding them. The difference in predictability of the passages was confirmed with the use of the cloze procedure (e.g., Jongsma, 1980). The first sentence of each passage was kept intact; every fifth word of the following 275 words was replaced with a blank (55 blanks total for each passage). Four volunteers from an undergraduate class in developmental psychology read the passages and filled in their best guesses as to what words should be in the blanks. Mean predictability scores, consisting of the mean number of words correctly predicted, were 37.8 (69%) and 30.0 (55%) for Passages 1 and 2, respectively ($t[6] = 2.88, p < .05$).

Procedure. The passages were presented with the use of the WISE authoring program of the World Institute for Computer Assisted Teaching (WICAT) System 300. This system consists of a minicomputer with five megabytes in main memory and 474 megabytes in hard disc, plus 30 terminals on which lessons can be run independently.

Subjects were first given brief instructions in how to use the computer keyboard. Instructions regarding the task and a short practice passage were administered by means of the computer. Subjects were informed that the test would "measure your ability to read passages of text and learn from what you are reading," and that they would be given a short multiple-choice test over the passages after they had read both of them. In order to ascertain typical reading speed, subjects were not told that their reading speed would be measured.

After receiving feedback regarding their performance on the multiple-choice question for the practice passage, subjects read the test passages (identified as Part I and Part II). Both passages were divided into eight sections, with each section ending at a natural break (e.g., a period) in the passage. Sections of each passage were presented as successive frames; a subject who finished reading one frame pressed the return button on the keyboard to see the next frame. Reading speed for each passage was measured by the computer (to the nearest second) from the beginning of presentation of the first frame until the subject pressed the return button after completing the eighth frame. Following Passage 2, a six-item multiple-choice test was presented, with three items testing comprehension of each passage.

Results and Discussion

A three-way analysis of variance was conducted for the reading speed measures, with subject pairs and spelling ability as between-subjects variables and reading passage as the within-subject variable. The effect of spelling ability was significant ($F[1,9] = 14.71$, $p < .001$). However, the means were in the opposite direction from what was predicted: good spellers (M = 114.6 seconds) were faster readers than were poor spellers (M = 153.5 seconds). The effect due to reading passage ($F[1,9]$ = 0.73) and the interaction between spelling ability and passage ($F[1,9]$ = 0.19) were not significant at the .05 level. The hypotheses that subjects should read Passage 2 more slowly than Passage 1 because of Passage 2's lower predictability, and that spelling ability should interact with the predictability of the passage were not supported. Possibly the difference in predictability between the two passages was not great enough, or the confounding of passage and presentation order may have eliminated any effects.

Although the comprehension test was not central to the hypotheses, it should be pointed out that a parallel analysis of the comprehension test scores revealed no significant effects due to spelling ability ($F[1,9] = 0.07$, $p > .05$), passage ($F[1,9] = 0.69$, $p > .05$), or their interaction ($F[1,9] = 3.77$, $p > .05$). The mean comprehension score for the six items was 5.4.

Contrary to Frith's (1980) prediction, good spellers were actually found to be faster readers than poor spellers. One possible explanation for this unexpected finding is that, while Frith contrasted good and poor spellers of equal reading ability, the present study compared good and poor spellers of equal intelligence. While the similarity of comprehension scores for the two groups indicated similar reading abilities for the good and poor spellers, actual equivalence of the groups in this respect cannot be assured.

In any event, the faster reading speed of the good spellers does not rule out the partial cues hypothesis. It is possible that good spellers are more likely to attend to every letter despite their faster reading rate. Such a proposition would suggest a relatively inefficient reading style on the part of the poor spellers.

EXPERIMENT 2

If good spellers are more likely to attend to every letter of a word they read while poor spellers do not, then good spellers should perform better on a matching task where two words are spelled very similarly. Experiment 2 was designed to test this hypothesis. Pairs of nonsense words were presented on a computer screen, with the second word presented after the first had been erased. Half of the word pairs were spelled identically; the other half differed by one letter. The subject's task was to determine whether or not the words in each pair were spelled in the same way or differently.

Method

Subjects. The subjects from Experiment 1 also participated in Experiment 2.

Materials. A total of 40 nine-letter consonant-vowel strings (CVCVCVCVC) were constructed by a random selection of letters. For each of these nonsense words an alternate spelling was created by replacing one of the middle five letters with another letter.

Procedure. The instructions and stimulus words were presented with the use of the WICAT system described in Experiment 1. Instructions describing the task, two example items, and feedback were presented by the computer. These were followed by the test items.

The order of the test items was randomly determined and was the same for all subjects. For half of the items (randomly selected) the same word was presented both times (a "match"); for the other half the word and its alternate spelling were each presented once (a "mismatch").

All words were presented in lower-case letters. For presentation of the word pairs two boxes appeared on the screen, one box directly below the other. The first word of each pair was presented inside the upper box for one second, then disappeared. Following a one-second delay, the second word of the pair (either the same word as before or its similarly spelled alternate) was presented inside the lower box for one second. After the second word was erased, the subject was asked to indicate whether or not the two words were the same ("S") or different ("D"). Scores, the number of items correctly identified as being a match or a mismatch, were tabulated by the computer.

Results and Discussion

A two-way analysis of variance was conducted on the total scores, with subject pairs and spelling ability as the independent variables. A significant F-ratio ($F[1,9] = 5.61, p < .05$) indicated that good spellers ($M = 32.7$) performed better than did poor spellers ($M = 28.9$).

This finding does support the partial cues hypothesis: the better performance of the good spellers may be attributable to their attention to more letters. However, an alternative explanation must also be considered: the success of the good spellers may simply be due to differences in short-term memory capabilities. The latter possibility will be investigated in Experiment 4.

EXPERIMENT 3

Ultimately, good spelling involves the ability to reproduce a word one has previously seen in print. If learning to spell follows directly from learning to read, as Ehri (1980) and Frith (1980) have suggested, and if good spellers attend to more of the letters they see while reading, then good spellers should be more accurate in their reproductions of words they have read. Experiment 3 was designed to assess good and poor spellers' abilities to reproduce the letters of a word they had seen for a period of time similar to the time they might look at a word within the context of reading a passage.

Method

Subjects. Subjects were the ten pairs used in the previous experiments.

Materials. A total of 30 nonsense words were constructed, 6 each with four, five, six, seven, and eight letters. All words were constructed by a randon selection of consonants (Cs) and vowels (Vs), with the following formats for the different word lengths, respectively: CVCV, CVCVC, CVCVCC, CVCVCVC, and CVCVCCVC. Constraints on letters chosen were that none of the "words" be real English words, that all words be pronounceable, and that no letter be repeated within a given word. The order of presentation of the words was random, with each consecutive group of five words containing one word of each length. The word order was the same for all subjects.

Procedure. The task was presented by means of the WICAT system described in Experiment 1. Instructions and two examples were presented as part of the computer administration. Each example or test word was presented on the screen for approximately 400 milliseconds. Because of the time involved in displaying the word on the screen, with the display beginning on the left-hand side and moving right, the beginning of each word was presented for a longer period of time than was the end of the word; furthermore, this effect was more pronounced for longer words. Immediately after the word was erased from the screen, the subject was asked to type the word presented. Scores, consisting of the number of words correctly typed, were tabulated by the computer separately for each word length.

Results and Discussion

A three-way analysis of variance was conducted, with subject pairs and spelling ability as between-subjects variables and word length as a within-subjects variable. The effect of spelling ability was significant ($F[1,9] = 21.60, p < .0001$), with good spellers ($M = 4.52$) performing better than poor spellers ($M = 2.62$). The effect of word length was also significant ($F[4,9] = 48.65, p < .0001$), with mean number correct being 5.6, 5.0, 3.7, 2.2, and 1.5, for 4-, 5-, 6-, 7-, and 8-letter words, respectively.

Of greatest interest here is the interaction between spelling ability and word length ($F[4,9] = 5.59, p < .001$). Cell means for this interaction are displayed in Figure 1. As can be seen from this figure, both groups were able to recall 4-letter words with an equally high degree of accuracy. For words of 5 letters or more, good spellers performed significantly more accurately ($p < .05$) than did poor spellers. For 8-letter words, good spellers recalled about half of the words correctly ($M = 2.8$), while poor spellers recalled almost none of them ($M = 0.2$).

It appears, then, that good spellers are able to reproduce words they have just seen more accurately than poor spellers. This difference was observed for words as short as five letters in length. As was true for the results of Experiment 2, the results of Experiment 3 may be interpreted as indicating either that good spellers attend to more of the letters they see, or that they are able to remember those letters better over a short time period.

EXPERIMENT 4

The superiority of good spellers' performance in Experiments 2 and 3 may have been due to better short-term memory rather than to great attention to detail. Experiment 4 was designed to compare good and poor spellers as to their short-term memory spans for visual material.

Three types of content were used in the memory tasks. First, digit strings, being the most commonly employed content in tests of general intelligence and specific abilities, were used. Second, consonant-vowel strings (CVCV. . .) were used, as they more closely resembled a real-word memory situation. However, differences between the two ability groups for this type of content could be due to other factors aside from memory span. For example, good spellers might be more likely to convert these strings to auditorially coded "words," just as they appear to do for real words (Frith, 1978; Perin, 1983). Therefore, consonant strings, being non-pronounceable letter strings, were additionally employed.

Two presentation methods were used. A simultaneous presentation was used, where all elements of the string were presented at the same time. This presentation method was chosen because it is analogous to the way in which one sees a word on the printed page (i.e., all letters at once, side by side). However, with this presentation mode it is difficult to separate the two factors of short-term memory span for the items, on the one hand, from attention to all the items presented (full vs. partial cues), on the other. Therefore, a second presentation method was also employed, that of sequential presentation. With this method each item in a string was presented separately in order to increase the probability that attention would be directed toward all items.

Method

Subjects. Subjects were the same 10 pairs who participated in the previous three experiments.

Materials. Digit, consonant-vowel, and consonant strings were constructed by random selection of digits and letters. For each content type, six strings (three for each presentation method) were constructed for each of these string lengths: 3, 4, 5, 6, 7, 8, and 9 digits or letters ("items"). In addition, 10- and 11-item consonant-vowel strings were constructed, as this content was predicted to be easier due to its pronounceability.

Six tests were constructed from the strings, two presentation methods for each of the three content types. Each test included three strings of each length from 3 to 9 items, with consonant-vowel tests also including strings of 10 and 11 items.

Procedure. The tasks were presented with the use of the WICAT computer system described in Experiment 1. Each subject was administered all three tests of one presentation method on one day, and the three tests of the other presentation method on the following day. The order of the presentation methods and the order of the content types within presentation methods were random, and were different for each subject.

Each test was preceded by instructions and two three-item examples presented by the computer. Presentation times for the example and test strings were equal to one second for each item in the string. Strings in the simultaneous condition were presented as a unit for the full presentation time. In the sequential condition each item of a string was presented for one second, then erased; the succeeding item immediately appeared to the right of its antecedent. Individual digits or letters in the sequential condition appeared in positions identical to their equivalents in the simultaneous condition.

Subjects typed their responses on the computer keyboard. If a response was correct, the first string on the next length was presented. If a response was incorrect, the next string of the same length was presented. If responses to all three strings of a given length were incorrect, that task was terminated. Scores were tabulated directly by the computer and were equivalent to the length of the longest string that a subject was able to recall correctly.

Results and Discussion

A four-way analysis of variance was performed on recall scores, with two between-subjects variables (pairs and spelling ability) and two within-subjects variables (presentation method and type of content). The effect due to spelling ability was significant ($F[1,9] = 22.37$, $p < .0001$), with good spellers ($M = 7.72$) recalling longer strings than poor spellers ($M = 6.53$). The effect due to presentation method was also significant ($F[1,9] = 18.75$, $p < .0001$), with simultaneous presention ($M = 7.67$) leading to greater recall than sequential presentation ($M = 6.58$). Finally, the effect of content was significant ($F[2,9] = 30.05$, $p < .0001$), with consonant-vowel strings being easiest ($M = 8.30$), followed by digits ($M = 7.15$) and consonants ($M = 5.92$). No interactions among these factors were significant at the .05 level.

Based on these results it appears that good spellers do in fact have a better visual memory than poor spellers. Their superior performance under the sequential presentation method as well as under the simultaneous method rules out the possibility that differences in attentional strategies account for the better memory. Their superior performance on digit and consonant strings as well as on CVC strings reduces the possibility that their better performance is due to an auditory recoding of the strings into "words" rather than being due to visual memory per se.

GENERAL DISCUSSION

The results of Experiments 2 and 3 can be interpreted as supporting Frith's hypothesis that good spellers read by full cues while poor spellers read by partial cues. Good spellers are more accurate in identifying whether or not two very similarly spelled words are spelled differently (Experiment 2). They are also more accurate in reproducing new "words" seen a few seconds before (Experiment 3). However, an alternative explanation for these results is that good and poor spellers differ in short-term memory capabilities rather than in their initial attention to the letters. The results of Experiment 4, while not ruling out differences in attentional processes, indicate that good and poor spellers do indeed differ in their short-term memory abilities for visual material. This difference exists even when elements of a string are presented sequentially, so that attention to all items of the string is facilitated. Poor spellers, in recalling fewer letters from what they see, will undoubtedly be handicapped in forming accurate mental representations of the words they read.

Good spellers are not slower readers, as Frith (1980) has predicted; in Experiment 1 their reading speed was found to be significantly faster than that of poor spellers. It appears that good spellers may simply be more efficient readers, able to remember more physical detail of the printed page (or computer screen) in a given amount of time. Poor spellers, on the other hand, appear to be relatively inefficient at the reading task, taking longer to read a passage while remembering (or possibly even attending to) fewer of the details of what they see.

Two weaknesses of the studies described here must be pointed out. First, as indicated earlier, good and poor spellers were equated for intelligence but may have differed in reading ability. Reading comprehension scores for the two groups were not significantly different, indicating probable similarity in reading ability. However, subject pairs were not specifically matched for reading achievement, so differences observed between the two groups may have been partly a function of differences in reading ability.

Second, a possible confounding factor in Experiments 3 and 4 must be considered. Experimental tasks in both experiments required the typing of a series of letters or numbers on the computer keyboard. Differences in familiarity with the keyboard between the good and poor spellers may have been present, affecting the facility with which letter and number series could be accurately typed.

Despite these limitations the studies described here do provide evidence for differences between good and poor spellers in cognitive processing strategies and abilities (e.g., reading style, attention, short-term memory). The question as to which of these factors are most centrally involved in spelling ability must be addressed in future research.

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