CHAPTER

9

Differences Between Writing with the Dominant and Nondominant Hands by Normal Geriatric Subjects on a Word-Dictation Task

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Hansen and McNeil (1986) and Hansen, McNeil, and Vetter (1987) studied the performance of normal geriatric subjects' preferred and nonpreferred hand performance on a spontaneous writing task and on a sentence-dictation task using a variety of perceptual and computerized measures for the quantification of linguistic, visual-spatial, and sensorimotor features of the handwriting. These studies were motivated by the hypothesis that all features of writing described in pathologic subjects are not necessarily attributable to the effects of the pathology per se but, rather, might be accounted for by use of the nonpreferred hand or the range of normal performance.

The Hansen and McNeil (1986) study, examining performance on a spontaneous writing task, reported only chance differences in performance between writing produced with the preferred and nonpreferred writing hands in their 50 normal subjects. The Hansen, McNeil, and Vetter (1987) study, reporting performance by these same subjects on a sentence-dictation task, found statistically significant interhand differences on the percentage of grapheme errors detected, percentage of graphemes deviating from the slope, number of graphemes per deviation, grapheme height, and intragraphemic distance. Given the disparity between results of these two previous studies, further information on which tasks produce interhand differences was sought by examining the same measures on another subtest of the Experimental Neurogenic Dysgraphia Battery (Hansen and McNeil, 1986).

The present study examined the interhand differences in writing characteristics on a word-dictation task. Seventeen perceptual and eight computerized measures were used for this analysis.

METHODS AND PROCEDURES

Fifty neurologically normal adults, 25 male and 25 female, served as subjects for this study. They ranged in age from 50 to 70 years, with a mean of 59.5 years, and education ranged from 12 to 20.5 years, with a mean of 16.4 years. Forty-six subjects preferred to write with the right hand, and 4 preferred the left hand. Subjects were judged normal on the basis of a self-reported benign neurologic history and performance within the normal range on hearing and vision screening, the Word Fluency Measure (Borkowski, Benton, and Spreen, 1967), the Revised Token Test (McNeil and Prescott, 1978), and the Raven Coloured Progressive Matrices (Raven, 1962).

Each subject completed the entire test battery, in the following order: spontaneous writing, automatic writing, sentences from dictation,

TABLE 9-1. MEASURES USED IN ANALYSIS OF WORDS FROM DICTATION IN NORMAL SUBJECTS

1. Grapheme substitution (P)
2. Grapheme addition (P)
3. Grapheme omission (P)
4. Transposition (P)
5. Illegible graphemes (P)
6. Attempted T-crossing (P)
7. Overlapped graphemes (P)
8. Added grapheme segment (P)
9. Omitted grapheme segment (P)
10. Grapheme errors detected (P)
11. Grapheme errors corrected (P)
12. Total grapheme errors (P)
13. Word errors detected (P)
14. Word errors corrected (P)
15. Added capitalization (P)
16. Detached affixes (P)
17. Correct spelling (P)
18. Left margin size (C)
19. Top margin size (C)
20. Mean grapheme height (C)
21. Mean grapheme width (C)
22. Mean intergraphemic distance (C)
23. Slope (C)
24. Percent graphemes off slope (C)
25. Number of deviations from slope (C)

Note: P = perceptual measure; C = computerized measure.

words from dictation, graphemes from dictation, sentence copying, word copying, and grapheme copying. Each subject completed the battery first with one hand and then with the other. The order of hand used was counterbalanced across subjects. Subjects were instructed to write in the way that was most comfortable for them. That is, they could either print, use cursive, or combine the two. All responses were written within an 8 by 9 inch area drawn on an 8½ by 11 inch page, similar to the response sheets used for the Porch Index of Communicative Ability (Porch, 1981). While each subject completed the entire test battery, only words from dictation were analyzed for this report.

The features coded for analysis were selected because they have been reported to occur in neurologically damaged populations or because they have been observed in the performance of neurologically impaired subjects on this test battery. Twenty-five measures were selected for interhand analysis in this investigation. The measures used are listed in Table 9-1. A number of other measures also were calculated for these subjects; however, they were *not* included in this study because they were not observed in the performance of any of these normal subjects, using either hand.

Interhand differences were assessed using t-tests (Dixon et al., 1985), with the alpha level set at .002. This alpha level was determined by dividing the chosen .05 level by the number of measures (25), because the independence of these measures could not be established. The relation between the writing of preferred and nonpreferred hand was examined

by calculating the correlation coefficients (Dixon et al., 1985) across hands for each measure. Finally, the accuracy of these measures for differentiating between preferred and nonpreferred handwriting was evaluated in two ways. First, the classifiability of the preferred and nonpreferred handwriting was evaluated using discriminant analysis (Dixon et al., 1985). The results of the discriminant analysis were compared to the ability of five speech-language pathologists to classify the writing samples correctly by visual inspection.

RESULTS AND DISCUSSION

Results of t-tests and correlations are summarized in Table 9-2. Of the 25 measures, six statistically significant differences were found. These were the total number of word errors detected (preferred hand = P > nonpreferred hand = N), total number of word errors corrected (P > N), number of attempted T-crossings (P > N), the number of omitted grapheme segments (N > P), number of transpositions (N > P), and the number of illegible graphemes (N > P).

Correlation coefficients, computed for each measure between the preferred and nonpreferred hand, were low and accounted for less than 50 percent of the variance for each measure, with the single exception of the number of added grapheme segments (r = .89). Interpreted, these data suggest that performance with one hand on any measure (with the single exception of added grapheme segments) does not predict the performance on the same task with the other hand.

The discriminant analysis, computed at the .05 confidence level, revealed that the 25 measures included in this analysis were not particularly effective in differentiating between the preferred and nonpreferred hand on this particular task. Overall, only 40 percent of the writing samples were correctly identified as having been generated with the preferred or nonpreferred hand. Of the remaining 60 percent of the samples, 59 percent were unclassifiable (not clearly associated with the performance profiles shown by either hand) and only 1 percent was misclassified. While slightly more samples produced with the nonpreferred hand (42%) were correctly classified than with the preferred hand (38%), 2 percent of the nonpreferred hand cases were misclassified, as opposed to 0 percent misclassified for the preferred hand. It is important to remember that the number correctly classified may be inflated, owing to statistical shrinkage (Fletcher, Rice, and Ray, 1978); however, a conservative alpha level of .05 allowed an unclassifiable category and made the correct classification category a reasonable and conservative estimate of group membership.

TABLE 9-2. CORRELATION COEFFICIENTS AND STANDARD DEVIATIONS FOR EACH OF THE MEASURED CHARACTERISTICS ON THE WORD-DICTATION TASK WITH THE PREFERRED AND NONPREFERRED HANDS

	Preferred			*Nonpreferred*	
Measure	MEAN	SD	*R*	MEAN	SD
Perceptual:					
Grapheme substitutions	2.25	2.08	.34	3.36	2.02
Grapheme additions	0.69	0.87	.18	1.06	1.36
Grapheme omissions	1.96	2.25	.30	2.26	1.96
Transpositions	0.04	0.20	−.09	0.16	0.37
Illegible graphemes	0.90	1.47	−.18	3.67	3.42
Attempted T-crossings	0.73	1.29	.59	0.26	0.78
Overlapped graphemes	0.10	0.51	−.05	0.18	0.77
Added grapheme segments	0.35	1.32	.89	0.38	0.92
Omitted grapheme segments	0.12	0.33	.09	0.62	1.09
Grapheme errors detected	0.41	0.67	−.17	0.38	0.53
Grapheme errors corrected	0.35	0.52	−.10	0.36	0.53
Total grapheme errors	7.12	5.22	.25	11.54	4.31
Word errors detected	0.22	0.59	.05	0.06	0.24
Word errors corrected	0.16	0.47	.15	0.04	0.20
Added capitalization	0.61	1.55	.70	1.46	3.31
Detached affixes	0.21	0.40	.38	0.28	0.45
Correct spelling	16.90	2.42	.38	15.56	1.97
Computerized:					
Left margin size	19.18	13.15	.56	14.64	10.46
Top margin size	14.20	4.71	.19	13.33	4.26
Grapheme height	2.41	1.04	.22	2.73	1.40
Grapheme width	3.64	1.01	.38	3.33	1.43
Intergraphemic distance	0.87	0.67	.47	1.19	0.73
Slope	−0.13	0.39	.41	−0.10	0.50
Percent of graphemes off slope	31.72	8.51	.46	30.57	10.60
Number of deviations from slope	20.67	3.03	.26	19.38	5.13

Finally, we had five speech-language pathologists sort the 100 productions of the task, presented in a randomized order, into those which they judged to be produced with the preferred or nonpreferred hand. The average correct classification rate was 97 percent, ranging from 93 to 99 percent. That is, the speech-language pathologists were very suc-

cessful at judging the words produced with the preferred and nonpreferred hands. All errors involved misclassification of writing produced by the nonpreferred hand. Writing produced with the preferred hand was never mistaken for writing produced with the nonpreferred hand.

Taken together, these four very different analyses lead to several perhaps different and opposing conclusions. First, the test of mean differences leads to the conclusion that there are a few variables that are produced differentially and reliably with the two hands. The results of the correlation analyses suggest that the features produced with one hand do not predict the magnitude or frequency with which that feature will be produced with another. The results of the discriminant analysis suggest that less than half the transcripts can be correctly classified, although few are misclassified. Finally, the finding from the perceptual judgments, that nearly all preferred and nonpreferred hand productions are somehow correctly classified, leads to the conclusion that differences do exist between writing produced with the preferred and nonpreferred hands, but these differences were not effectively captured by those measures utilized in this investigation. This finding is important from a test construction/psychometric perspective. Although a number of the variables that have been reported as being associated with various neurogenic dysgraphias were produced with both the preferred and nonpreferred hands, they do *not* appear to be differentially produced with the use of the preferred and nonpreferred hands, at least on this word-dictation task.

None of the variables that showed interhand differences on this word-dictation task are the ones that were found to be statistically significantly different in the 1987 study that presented results from the sentence-dictation task. Further, only one common measure appears on both the sentence-dictation task and the discriminant analysis from the word-dictation study (intergraphemic distance). There are a number of possible explanations for this. Several of the variables selected on the sentence-dictation task related to the slope of the line of writing. While these slope-related measures were included in this study as well, the slope of a single word is not likely to show as much variability as the slope of an entire line of text. Likewise, the detection of word and grapheme errors might make it more likely that the entire word will be rewritten in a word-level production, but that only the incorrect portion of the word will be rewritten in a sentence-level production. Thus word-level error detection and correction differed between hands on the word-level task, but not on the sentence-level task. The number of grapheme errors detected differed between hands on the sentence task, but not on the word task. All words on the sentence task are common words, and the majority are orthographically regular. In contrast, 50

percent of the words in the word-dictation task are unfamiliar, and 50 percent are orthographically *ir*regular. It is possible that these factors differentially influenced error detection and correction. Finally, three of the variables used in the word-dictation study (attempted T-crossing, detached affix, correct spelling) were not defined at the time of the earlier studies and so were not included in the earlier analyses. Further, two of the measures (transposition and illegible graphemes) were redefined since the previous studies.

A final issue is why interhand differences were found with both dictation tasks, but *not* found on a spontaneous discourse writing task. The spontaneous writing task differs from the other two in that it requires formulation of the text, as well as the actual production. The two dictation tasks impose short-term memory requirements, as well as the coding of auditory input into written output. The spontaneous writing task (written picture description) makes essentially no demands on the storage of auditory information. In contrast, the storage and coding operations involved in both the word- and sentence-dictation tasks, combined with the use of the nonpreferred hand, may create a greater demand on the storage and coding of linguistic information before it is relayed to the right hemisphere in preparation for the execution of the writing with the nonpreferred hand. Perhaps a degradation of the auditory stimulus was produced by the memory load plus the interhemispheric transfer of information for motor programming and execution. While an appeal to a neuropsychological construct for the explanation of the differences found across experimental tasks is clearly speculative, the phenomenon is theoretically interesting and clinically *very* important for the valid interpretation of neurogenic dysgraphias.

In summary, these data support the conclusions of previous work with this experimental test battery. That is, the presence of certain features in the writing of a person with a neurologic deficit is not easily attributed to the neurologic deficit. Our normal subjects produced an impressive array of graphic features that have been reported to define and differentiate neurogenic dysgraphias. Likewise, extreme caution must be given to the pathologic assignment of writing produced with the nonpreferred hand. We do not yet know enough about writing produced with the two hands and how neuropsychological variables interact with psycholinguistic and communicative variables to feel confident about the detection of pathologic writing or the assignment of pathologic features to handwriting. As always, great caution in our clinical activities and further research are recommended. Until considerably more data from neurologically normal and neurologically impaired individuals have been collected on the same set of tasks and analyzed using the same measurement procedures, great caution in our clinical activities involving the dysgraphias is recommended.

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