More Differences Between Writing with the Dominant and Nondominant Hand by Normal Geriatric Subjects: Eight Perceptual and Eight Computerized Measures on a Sentence Dictation Task

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In 1986, Hansen and McNeil presented a series of tasks and a series of perceptual and computer-assisted evaluative procedures for the differential diagnosis of acquired dysgraphia. The motivation for the development of this test battery was to provide systematicity to a differential diagnostic dysgraphia literature that varies from study to study in stimuli, tasks, and analysis procedures. Hansen and McNeil (1986) argued that the writing produced by an individual with a known lesion could not be ascribed to the effects of the lesion because data are currently unavailable for normal subjects using the same stimuli, tasks and evaluation procedures. They further argued that the writing produced with the nondominant hand complicated the assessment and diagnosis of dysgraphia because there were no data on normal nondominant handwriting. Therefore, graphic ability in a person with a known lesion could not be ascribed to the effects of the lesion, nor to the fact that the writing was produced with the nondominant hand. In the Hansen and McNeil (1986) study, contrary to predictions, there were no significant (reliable) differences on 20 perceptual and computerized measures of spontaneous writing produced with the dominant and nondominant hands in 50 normal geriatric subjects. While their data are interesting and encouraging relative to the confidence one can place in the attribution of pathological writing characteristics to the pathology and not to possible differences between dominant and nondominant hand performance, spontaneous writing does not cover the scope of tasks from which pathological writing is judged. The present study sought to expand this scope by analyzing the interhand writing characteristics of those same 50 normal geriatric subjects on a sentence dictation writing task from the same neurodysgraphia battery, using 16 of the same perceptual and computerized measures.

METHOD

Fifty neurologically normal individuals served as subjects for this study. "Normal" was determined by a self-reported benign neurological history, and performance within normal limits on a vision and hearing screening, the Word Fluency Measure (Borkowski, Benton, and Spreen, 1967), the Revised Token Test (McNeil and Prescott, 1978), and Raven's Coloured Progressive Matrices (Raven, 1967). Twenty-five male and 25 female individuals were selected. Forty-six were right-handed and 4 were left-handed. Subjects were educated, with a mean of 4.4 years post high school. They were between 50-70 years of age, with a mean age of 59.5 years.

While only the data from the sentence dictation task will be discussed in this report, all subjects were given all subtests of the experimental battery. This battery consisted of a copying task which required subjects to copy 5 different graphemes, 20 words and 5 sentences; a task in which the subjects wrote the identical 5 graphemes, 20 words and 5 sentences from dictation; an automatic task of writing their name and address; and a spontaneous task in which subjects wrote a description of the Cookie Theft Picture from the Boston Diagnostic Aphasia Examination (Goodglass and Kaplan, 1983). Word stimuli were selected based on their frequency of occurrence and their orthographic regularity. Sentence stimuli were selected from the Minnesota Test for the Differential Diagnosis of Aphasia (Schuell, 1965).

The test protocol was completed twice by each subject in counterbalanced order; once with the preferred hand, and once with the nonpreferred hand. Subjects were allowed to print, use cursive, or use a combination of the two. Subjects were instructed to write all responses within a 7½ inch square drawn on each response sheet (identical to that used in the Porch Index of Communicative Ability; Porch, 1967). The test protocol was always administered in the same sequence with spontaneous writing first, automatic writing second, writing to dictation third, and copying last. Twenty features of the subjects' writing samples were coded for the purposes of these analyses (see Table 1).

Table 1. Perceptual and computer-assisted graphic features analyzed in the neurodysgraphia battery for 50 normal geriatric subjects using their dominant and nondominant hands.

PERCEPTUAL FEATURE	COMPUTER ASSISTED FEATURE
% Grapheme Formulation Errors	* Left Margin Width
* % Graphemes Capitalized	* Top Margin Distance
* % Grapheme Errors Detected	Right Margin Width
* % Grapheme Errors Corrected	* Grapheme Height
* % Word Formulation Errors	* Intergraphemic Distance
* % Word Omissions	* Interword Distance
* % Word Additions	* Slope
* % Word Substitutions	* % Graphemes Deviating From Slope
* % Illegible Words	* # of Graphemes per Deviation From Slope
# of Words per Sentence	
# of Graphemes per Word	

* = Measurements utilized in the present investigation.

Sixteen features were coded for the analysis reported in this portion of the investigation (marked with asterisks in Table 1). The features chosen for analysis were those features identified by previous investigators to be associated with acute confusional states (Chedru and Geshwind, 1972), aphasia (Leischner, 1969; Marcie and Hecaen, 1979), neuromotor speech disorders (Rosenbek, McNeil, Teetson, Odell and Collins, 1981), apraxia (Geschwind, 1973) and nondominant hemisphere lesions (Hecaen and Marcie, 1974). The first 8 features were judged perceptually, and the last 8 features were measured with a graphics tablet and programs written for the Harris Computer. High interjudge and intrajudge reliability was obtained for all measures included in this investigation.

RESULTS AND DISCUSSION

Eight perceptual and 8 computer-assisted measurements were made on the samples produced with the dominant and with the nondominant hand from the sentence dictation task. Means for each subject were used to compute a oneway analysis of variance for each measure. An alpha level of .01 was chosen since the ANOVA's were computed from data derived from the same subject population. The results obtained from statistical analysis of the perceptual and computer measures are presented in Table 2.

Table 2. Results of statistical analysis of the writing features produced with the dominant and nondominant hand by 50 normal geriatric subjects on a sentence dictation writing task.

Perceptual Measure	df	F	Computer Measures	df	F
% Word Formulation Errors	1,98	5.50	Left Margin Width	1,98	2.46
% Graphemes Capitalized	1,98	0.52	Top Margin Distance	1,98	0.06
% Grapheme Errors Detected	1,98	11.33*	Writing Slope	1,98	2.07
% Word Omissions	1,98	0.09	% Graphemes Deviated From Slope	1,98	17.34*
% Word Additions	1,98	0.98	# of Graphemes Per Deviation	1,98	9.17*
% Illegible Words	1,98	4.74	Grapheme Height	1,98	39.35*
% Word Substitutions	1,98	0.57	Intergraphemic Distance	1,98	14.41*
% Grapheme Errors Detected and Corrected	——	——	Interword Distance	1,98	5.11

* Significant at the .01 level.

In addition to the test of mean differences provided with the ANOVA's, Pearson Product Moment correlation coefficients were computed in order to determine the degree of predictability for each measure from the nondominant to the dominant hand (see Table 3).

Of the 8 perceptual measures, only 1, the percentage of grapheme errors detected, was significantly different between the writing produced with the dominant and nondominant hands. A grapheme error was considered detected if it was crossed out, written over, or changed after initial production. There were significantly more graphemic errors detected with the nondominant hand. This finding might be explained by the amount of effort and attention allocated to nondominant handwriting compared with writing produced with the dominant hand. The subjects voiced concern with how writing produced with the nondominant hand appeared. Subjects may have brought the nondominant handwriting task under greater controlled processing and hence detected those errors more readily than errors produced with the dominant hand.

Four of the computer-assisted measures were greater for the nondominant hand. There was a higher percentage of graphemes deviating from the slope, more graphemes in each deviation from the slope, greater grapheme height, and a greater distance between the graphemes for the nondominant hand. All of these findings appear to be attributable to reduced motoric control with the nondominant hand. It remains speculative as to whether this explanation or one attributable to perceptual or cognitive differences offers a more accurate and parsimonious explanation for the findings.

Table 3. Correlation coefficients and standard deviations for each of the 8 perceptually judged and 8 computer-measured characteristics of a sentence dictation writing task for 50 normal geriatric subjects with the dominant and nondominant hands.

MEASURE	R	DOMINANT HAND MEAN	SD	NONDOMINANT HAND MEAN	SD
PERCEPTUAL					
% Word Formulation Errors	.27	.36	.88	1.86	4.43
% Graphemes Capitalized	.67	4.59	12.05	6.85	18.41
% Grapheme Errors Detected	.07	.09	.24	.42	.64
% Word Omissions	.39	10.00	30.30	8.25	17.39
% Word Additions	.05	2.00	14.14	5.35	19.30
% Illegible Words	---*	0.00	0.00	7.50	24.35
% Word Substitutions	.02	4.00	19.79	7.40	24.81
% Grapheme Errors Corrected	1.00	100.00	0.00	100.00	0.00
COMPUTER					
Left Margin Width (mm)	.52	15.21	10.40	12.63	5.20
Top Margin Distance (mm)	.44	6.09	4.02	5.89	4.08
Slope (mm)	.07	.02	.02	.03	.05
% Graphemes Deviating From Slope	.04	14.98	18.80	33.24	24.65
# of Graphemes per Deviation	0.00	1.63	2.04	3.21	3.08
Grapheme Height (mm)	.53	2.34	.73	3.51	1.10
Intergraphemic Distance	.28	1.24	1.02	1.97	.88
Interword Distance	.47	2.70	1.70	3.42	1.49

* Correlation coefficient was not computed because of the number of zero entries.

Low interhand correlation coefficients were obtained for each measure, with the exception of the percentage of grapheme errors corrected. One hundred percent of the grapheme errors detected were corrected for both the dominant and nondominant hands. The graphic features produced with the dominant hand of these subjects do not reliably predict how the subjects will perform with the nondominant hand (and vice-versa). This may indicate the presence of a contaminant of nondominant handwriting in individuals with neuropathology. Since there is no predictable relationship between our measures of nondominant handwriting and dominant handwriting, it would be unwise to attribute the behaviors produced with the nondominant hand in pathological populations to the effects of the pathology. In other words, there is an intervening variable in addition to the pathology to which one could attribute the writing behavior.

The variables measured for this investigation were selected because they have been attributed to persons with neurological etiologies for their graphic disturbances. However, it is clear from these results that great caution must be exercised in the attribution of a neuropathological substrate for these behaviors. It appears that these behaviors are also present in neurologically normal individuals and might be attributable to variability of normal writing or to writing produced with the nondominant hand, and not to the lesion or other cognitive, perceptual, or motoric deficits that the person may bring to the testing situation.

Finally, it is interesting that no interhand differences were found in the Hansen and McNeil (1986) study on a spontaneous writing task with these same subjects using the same data analysis procedures. These findings might be explained by the nature of the writing tasks at hand. The subjects were indirectly placed under time constraints for both tasks. For the spontaneous task, they were instructed to "take two minutes to write as much as (they) could about the Cookie Theft Picture. For the dictation task, subjects were allowed only one repetition of the sentence stimuli. A primary difference between the two tasks is the length of responses required of the subject. For the dictation task, the entire sentence was needed in order for the task to be complete. However, for the spontaneous writing task, no criteria were given for the length of the required response. Therefore, subjects may have produced their spontaneous responses at a slower rate, allowing for greater motoric control, and hence fewer noted differences between dominant and nondominant hand productions. However, this time-controlled explanation does not appear to be consistent with the fact that the subjects detected more errors with the nondominant hand in the presence of a higher percentage of graphemes deviating from the slope, more graphemes in each deviation from the slope, greater grapheme height, and a greater distance between graphemes.

Further studies are needed which describe the performance of various neuropathologically impaired populations on the same protocol with the same analysis procedures. These studies are mandatory in order to provide data useful in differentiating normal variability in writing from writing disorders which have neuropathologically predictable substrates. These findings echo the cautions of Dr. Rosenbek, that everything pathological subjects do on diagnostic and treatment procedures is not attributable to their pathology.

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