# Agraphia in Left and Right Hemisphere Stroke and Alzheimer Dementia Patients

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Marce (1856) was the first to describe writing disorders following cortical lesions, for which Ogle (1869) introduced the term *agraphia* (Marcie and Hecaen, 1979). Several aphasias, apraxias, and pure agraphias associated with left hemisphere lesions have been described (Bub and Kertesz, 1982; Kaplan and Goodglass, 1981; Kinsbourne and Rosenfield, 1974; Mesulam, 1985; Pick, 1900; Roeltgen and Heilman, 1983; Shallice, 1981; Ulatowska, Hildebrand and Haynes, 1978; Vignolo, 1983). In addition, "spatial agraphia" associated with right hemisphere lesions is now recognized (Benson, 1979; Hecaen and Marcie, 1974; Metzler and Jelinek, 1977). Chedru and Geschwind (1972) studied agraphia in acute confusional states, and several authors, including Alzheimer (1907) recognized agraphia to be a common finding in dementia (Appell, Kertesz and Fisman, 1982; Bayles and Kaszniak, 1987; Cummings, Benson, Hill and Read, 1985; Horner, 1985; Kaszniak, Wilson, Fox and Stebbins, 1987; Obler and Albert, 1981).

Benson and Cummings' comprehensive taxonomy of the agraphias identifies nine aphasic agraphias and four nonaphasic agraphias (1985). Despite our growing appreciation for the complexity of writing (Ellis, 1982) and the manifestations of neurogenic writing disorders, the correlation of type of agraphia with etiology remains unclear. The value of writing disturbance to differential diagnosis among stroke syndromes and the dementias has not been addressed.

The purpose of this study was to explore whether the presence, severity or pattern of writing disturbance could distinguish patients with right or left hemisphere stroke from patients with dementia of the Alzheimer type. Narrative writing samples were analyzed using the *Western Aphasia Battery* (Kertesz, 1979, 1982) scoring approach and a novel multicomponent rating procedure, the *Writing Proficiency Scales* (Horner, Heyman and Dawson, 1986). Three null hypotheses were: (1) There will be no quantitative differences in narrative writing ability using the *Western Aphasia Battery* scoring approach or the *Writing Proficiency Scales*. (2) There will be no quantitative differences among groups as measured by the five subcomponents of the *Writing Proficiency Scales*. (3) There will be no quantitative differences in narrative writing ability sufficient to classify patients correctly in their true etiologic groups.

## METHOD

*Subjects*. This was a retrospective study of patient files from Duke University Medical Center. Selection criteria included: 1) single, unilateral stroke or 2) putative diagnosis of dementia of the Alzheimer type

(McKhann, Drachman, Folstein et al., 1984); 3) right hand dominance; and, 4) literacy. Exclusion criteria included positive history of 1) neurologic disease, 2) psychiatric disease, 3) speech, language or learning disorder, and 4) alcoholism. Patients were matched by age and education.

Twenty-eight patients met these criteria. Group I (N=10; 5 males, 5 females) had aphasia subsequent to left hemisphere stroke; Group II (N=8; 6 males, 2 females) had sustained right hemisphere stroke; Group III (N=10; 3 males, 7 females) had Alzheimer dementia. Education for Groups I, II, and III was 13.4 years, 11.8 years, and 14.0 years, respectively. Duration of illness was 14.8 months, 2.5 months, and 29.6 months, respectively.

Subjects' visual status was described as "no deficit," homonymous hemianopsia, or hemispatial neglect. Most left hemisphere stroke patients showed no acquired visual defect, while 2 showed a right homonymous hemianopsia and 1, a right neglect. The right hemisphere stroke group showed no deficit in 2 patients, left homonymous hemianopsia in 1, and is notable for the presence of left hemispatial neglect in 5 of 8 patients. In contrast, none of the Alzheimer patients showed any visual deficit.

All patients were premorbidly right-handed. Despite right-sided weakness in 9 of 10 left hemisphere stroke patients, 6 of 10 used their preferred hand for writing. All 8 right hemisphere stroke patients showed left-sided weakness, and all 8 used their preferred hand. Alzheimer patients were non-hemiparetic, and all 10 used their preferred hand.

All patients had performed a narrative writing task, either in response to the "picnic scene" from the Western Aphasia Battery or to the "cookie theft" from the Boston Diagnostic Aphasia Examination (Goodglass and Kaplan, 1972). Of 28 total samples, 14 were in response to the "picnic scene," and 14 in response to the "cookie theft" picture. In order to be entered into this study, the preestablished minimum sample of writing was five words.

Writing samples were scored using two approaches. The first was based on the Western Aphasia Battery (WAB) subtest VIB "Written Output." This approach awards points for grammatical completeness, number of correct words used, and correct spelling up to a maximum of 34.0 points. To minimize intertester differences we clarified these scoring guidelines (see Appendix).

The second scoring approach involved a multicomponent analysis, using the experimental version of the Writing Proficiency Scales (WPS). The composite WPS (maximum 25.0) was the sum of the following scales, each rated from 1 (representing severe deficiency) to 5 (representing normal performance):

1. The organization scale rates overall organization, relevance, and flow of ideas expressed in writing. It takes into consideration repetition of ideas, intrusions, tangentiality, and inappropriate, concrete, or self-referential statements.
2. The vocabulary completeness scale rates repertoire and accuracy of word usage. It accounts for completeness (accurate mention of at least 14 major people, objects or events) as well as related and unrelated semantic errors.
3. The grammatical completeness scale rates accuracy, completeness, and quality of sentence structure. It takes into account errors of inflection as well as the misuse of prepositions and other functors.
4. The spelling scale rates accuracy of spelling of all written words, regardless of the patient's level of education.

5. The mechanics scale rates spatial-constructional form, accuracy, and agility of writing. This scale considers awkwardness in construction of letters, spatial misalignment, and overall readability.

Samples were randomized and scored independently by coauthors (DLL, AMF). Using the WAB scoring approach, they agreed within plus-or-minus 2 points on 23 of 28 samples, for an agreement rating of 82%. On the WPS point-for-point reliability was 100 of 140 scores for an overall agreement of 71%. Following their scoring of the 28 samples and prior to statistical analyses author JH served as the third judge to resolve all points of disagreement.

## RESULTS

Spearman rank correlational analyses showed no significant correlation of sex, age, educational level or disease duration with the writing measures.

The Writing Proficiency Scales (WPS) showed a significant positive correlation with the Western Aphasia Battery (WAB) narrative writing score ($p < .0001$), lending content validity to this novel multicomponent approach.

The effect of pictures was analyzed and found to be significant for the WAB scoring approach but not for the WPS, with performance in response to the picnic scene being superior to the cookie theft picture. This picture effect was statistically adjusted in all relevant analyses.

The distributions of scores for our 3 groups were compared using the Wilcoxon Rank Sum Test (Table 1). As reflected in the median values, the group of left hemisphere stroke patients performed less well than either the right hemisphere stroke or Alzheimer dementia patients. However, the ranges were large within groups, and the scores were overlapping across all three groups. As a result, the Wilcoxon test found no significant differences among groups for either the WAB or WPS.

Table 1. Differences among median scores for left hemisphere stroke (LHS), right hemisphere stroke (RHS), and Alzheimer dementia (AD) patients.

| Scoring Approach | LHS (N=10) | RHS (N=8) | AD (N=10) |
|---|---|---|---|
| WAB[1] | 12.8 | 21.8 | 18.8 |
| WPS[2] | 16.0 | 17.0 | 18.5 |

[1] Western Aphasia Battery, subtest VI.B., "Written Output," maximum 34.0 points.
[2] Writing Proficiency Scales, maximum 25.0 points.

The fifth analysis involved tests of association between WPS subcomponent scores and diagnostic category (Table 2), using Exact Significance Probabilities and Ridit analyses for nominal and ordinal associations, respectively.

The ordinal analysis showed a statistically significant difference among groups on the grammatical scale, with the left hemisphere group showing significantly poorer performance than the right hemisphere and dementia groups. By design the scales on the WPS were not considered nominal scales, but the nominal analysis was done in an exploratory spirit. This analysis showed a significant difference among groups on the mechanics scale, with the right hemisphere group showing significantly poorer performance than the left hemisphere and dementia groups.

Table 2. Tests of association among Writing Proficiency Scales subcomponent scores and etiologic groups, expressed as p-values.

| Subcomponent | Significance Probabilities* Ordinal | Nominal |
|---|---|---|
| Organization | .01 | .25 |
| Vocabulary | .01 | .03 |
| Grammar | .008 | .11 |
| Spelling | .18 | .01 |
| Mechanics | .02 | .001 |

*None are significant at overall 5% level after adjustment for multiple comparisons.

Finally, discriminant function analyses were done. Using the WAB scoring approach for written output as a single discriminant (Table 3), the statistic predicted true classification of 7 of 10 left hemisphere stroke patients; 5 of 8 right hemisphere stroke patients; and 2 of 10 Alzheimer dementia patients. Overall correct classification was 14 of 28, or 50%

Table 3. Discriminant function analysis using the Western Aphasia Battery, Subtest VI.B, "Written Output" for left hemisphere stroke (LHS), right hemisphere stroke (RHS), and Alzheimer dementia (AD) patients.

| True | Predicted LHS | RHS | AD |
|---|---|---|---|
| LHS (N=10) | 7 | 3 | 0 |
| RHS (N=8) | 3 | 5 | 0 |
| AD (N=10) | 3 | 5 | 2 |

Using the overall WPS as a single discriminant (Table 4), the statistic predicted true classification of 4 of 10 left hemisphere stroke patients, 3 of 8 right hemisphere stroke patients, and 7 of 10 Alzheimer dementia patients. Fourteen of 28 or 50% of patients were correctly classified.

Thus, following analyses of narrative writing by left hemisphere stroke, right hemisphere stroke, and Alzheimer dementia patients, the null hypotheses were addressed. The first null hypotheses was accepted. Using either scoring approach, no significant differences in narrative writing

Table 4. Discriminant function analysis using the Writing Proficiency Scales composite score for left hemisphere stroke (LHS), right hemisphere stroke (RHS), and Alzheimer dementia (AD) patients.

| True | Predicted | | |
|---|---|---|---|
| | LHS | RHS | AD |
| LHS (N=10) | 4 | 4 | 2 |
| RHS (N=8) | 1 | 3 | 4 |
| AD (N=10) | 2 | 1 | 7 |

ability were found among the three etiologic groups. The second null hypotheses was tentatively accepted. The data suggested that the grammatical and mechanics scales might be sensitive to intergroup differences. The third null hypotheses was accepted. Neither the WAB scoring approach nor the WPS, when used in a discriminant function analysis, was able to classify patients into their true etiologic groups.

## DISCUSSION

The presence, severity, and pattern of agraphia did not reliably differentiate among left hemisphere stroke, right hemisphere stroke, and Alzheimer dementia patients in this study.

Narrative writing involves the integration of motor, practic, visuospatial, and linguistic abilities, as well as nonlinguistic cognitive abilities (e.g., memory, interpretive ability, and knowledge of written discourse rules). As such, the fact that agraphia is a frequent finding not only in left hemisphere stroke patients but also in other neurobehavioral syndromes is not surprising. Among our 28 patients (who represented three small etiologic groups), heterogeneity in written performance was the rule. This, too, was not surprising.

Despite the largely suggestive rather than definitive findings in the present study, clinical experience and intuition suggest, nevertheless, that writing probably has value in the differential diagnosis of stroke and dementia syndromes. The major issues of future research will be to pursue this initial effort to identify the salient features of writing necessary for differential diagnosis and to quantify these abnormal features appropriately.

Several recommendations for further study are appropriate. First, the multicomponent analysis should be refined. Bayles and Kaszniak (1987) stated that it is the relation of linguistic performance to nonlinguistic performance that enables the clinician to make the differential diagnosis between focal aphasia and dementia (p. 196). The importance of considering both nonlinguistic and linguistic features of writing motivated both the development and the design of the Writing Proficiency Scales. However, less than satisfactory levels of intertester reliability using the experimental WPS were obtained. Possible reasons for scoring discrepancies include the novelty of the procedure, the lack of sufficient increments on each subcomponent or scale, and the diversity of features considered within each scale. Refinements of this particular measure are necessary. Second, in order to discern patterns of writing impairment, the severity of writing should be controlled (e.g., limited to writing samples representing "moderate" overall impairment). Third, subtypes of patients within broad etiologic groupings should be distinguished. For example, subcategories of stroke patients might include fluent versus nonfluent aphasia following left hemisphere stroke, or presence or absence of neglect following right hemisphere stroke. Among Alzheimer patients, subtyping by prominent memory, visuospatial, and language impairments might be useful (Albert and Moss, 1984; Foster, Chase, Fedio, et al., 1983).

Type of agraphia has diagnostic implications in cognitive disorders and motoric disabilities, but the "analysis of writing disorders (agraphia) is difficult and inexact" (Benson and Cummings, 1985, p. 469). This study explored the differential features of writing with negative results. With refinement in subject selection and measurement, it may be possible to analyze narrative writing performance objectively to enhance differential diagnosis.

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## DISCUSSION

Q: Would you speak to the merits of using an analysis of handwriting in differential diagnosis of these disorders versus in understanding problems that these patients have when they are already diagnosed as having the disorders?

A: In many cases at Duke Medical Center patients are referred to us from the Memory Disorders Clinic and Alzheimer's Research Center in whom the diagnosis has not been made. The questions oftentimes are some of those that Joe Duffy addressed in his paper regarding early progressive aphasia; sometimes there is a question of stroke versus dementia in these patients. And it is largely through those types of experiences that we have become interested in analyzing writing. I think that both spontaneous speech and writing can be sensitive to aphasia and other deficits, and therefore valuable in differential diagnosis.

[Additional note: Furthermore, these types of analyses have merit with regard to the question: What are the neuropsychological processes governing not only aphasic and nonaphasic agraphias but also normal writing? (Ellis, 1982).]

Q: First, a comment. If I were going to do this I certainly wouldn't group them by fluent or nonfluent type of aphasia, because there isn't any construct validity for that construct, even with speech.

Second, a question. Regarding the Western Aphasia Battery scoring system, what is the validity of subtracting 1 point or 1/2 point? Has that in any way been validated, taking 1/2 point off for one thing versus 1 point off for something else, then can it be all pulled back together so that we can make sense out of the overall score?

A: No, it has not been validated, not to my knowledge. However, I think our clarification of scoring guidelines for Subtest VI.B. "Written Output" is consistent with what Kertesz has told us to do on that particular subtest. We attempted to take this established measure and clarify it in order, first, to give the patient as much credit as we could, and second, to minimize inter-tester differences.

Q: I wonder what your feeling is about differential diagnosis of a single piece of information (i.e., writing) versus input from multiple modalities given the historical difficulty that we've had with differential diagnosis across populations.

A: One of my thoughts is that we do an awful lot of testing with our patients -- I'm going with the assumption that differential diagnosis is the issue, whether it is these three groups, or it is confused language, or anything else -- that we do an awful lot of testing that is not geared to differential diagnosis. There is a great expenditure of time and effort. In contrast, if we select functions, abilities, performances that we believe clinically are sensitive, such as spontaneous speech or spontaneous writing, and understand them, then we can go through this process more quickly.

Q: I agree. Where will you go from here? Will you take speech samples and do the same thing, or will you add speech samples to your writing samples until you end up with an efficient differential diagnostic package?

A: In some of my work with Alzheimer's dementia, I have looked at narrative speech and narrative writing with scales similar to these, and I continue to think that speech and writing are among the most sensitive tasks. Now, particularly in dementia, perhaps writing to dictation is more sensitive and perhaps that is what we should use.

Q: I'm not sure that top-down, or bottom-up is better to use in terms of taking a number of different behaviors and trying to pare those down into an efficient package for differential diagnosis or building on a single modality, or samples such as writing. My bias is that if we start small and work up as you're doing, we may get somewhere. I'm not sure, I was just wondering what your opinion is.

A: I think there's value in starting with discrete tasks. One of my problems with aphasia batteries in general (e.g. the Western Aphasia Battery) is that really we have just a series of tasks, and none of them, in my opinion, really gets at processes underlying the performance. The best that we do is fluency versus content of spontaneous speech, and it's clear that the scoring approach for writing is quite global. So that "task approach" to differential diagnosis troubles me, and I would rather analyze one or two things in more depth.

Q: When using the Western Aphasia Battery scoring procedure, in eliciting these samples, did you abide by the time constraint, or did you just allow the patient to write?

A: We didn't time it exactly, but I think it's fair to say that these were roughly 1 to 3 minute samples of writing.

Q: I have a lot of trouble with the fact that there are those time constraints. I think you can look at a lot of other information instead of what they can produce when you put time constraints on.

A: I think it certainly would have made a difference in total number of words. I have done some repeated measures on Alzheimer's patients over days, and have timed them. Words per minute is highly variable across subjects, and within subjects across days. So I think that it's a good idea to let it be open-ended, and then time the sample for words, or sentences per minute. But I do not think (restricting or not restricting the sample by a time constraint) really alters the quality of response.

C: Yes, I agree with you. I am happy to hear that you just let them write so that we can look at linguistic adequacy. I think that if you had put a time constraint on, it might have been diagnostically distinguishing, but on some other basis, not on the one you were studying.

Q: You used the overall Writing Proficiency score for looking at the sensitivity among the groups?

A: Yes.

Q: I wonder if one thing that might tease out some differences is if you looked at each of the dimensions of scoring, and if maybe you have not diluted the sensitivity of the five dimensions by grouping them together and using an overall score. I think you might wash out the sensitivity of a single dimension to differences by lumping it within the variations created by the other dimensions.

A: Yes, I appreciate that point. When we did look at the subcomponents in more detail, however, we were disappointed to see trends just in terms of the grammatical scale and the mechanics scale. Had we seen differences among those scores, I think then it might have made sense in this small sample to go ahead and look at subcomponents per se. I'm not sure we had a justification for doing that at this point. I might be wrong.

Q: I think you mentioned making some revisions in the scoring. Can you tell us your thoughts about what revisions you might make?

A: I think we did confound our ordinal scale with nominal differences within each subcomponent -- the characteristics are buried in the scale in an effort to make them comprehensive. And also the five level increment may not be enough; each level may be, as a result, too broad. Those are two things. Perhaps we should have an ordinal scale that looks at overall adequacy within the dimension, but separately do a nominal analysis.

Q: First, a comment about your use of the term narrative. I'm finding it increasingly hard to justify defining the sorts of samples we get from pictures like the cookie theft as "narratives."

A: Perhaps you could clarify for us what you would term this type of performance, if not narrative.

C: "Picture description." In my work, it tends to elicit more labelling behaviors than actual narrative, or anything that is more akin to normal writing skills such as writing a letter, or "give me a description of what you've been doing today," or more functional writing. I've found that in both verbal and written work that picture description, especially in response to the cookie theft and similar pictures, are not really giving us a true flavor of what written expression really is, or verbal expression.

C: We'll be presenting a paper tomorrow in which we looked at single picture descriptions versus sequences of picture descriptions and found no significant differences in a number of behaviors, including labelling. We did another study in which we looked at 3 standard pictures, the cookie theft, the Minnesota picture, and the Western Aphasia Battery picture and found significant differences, with the Cookie Theft being the best of the three.

Q: Yes, I agree that it may not be a narrative, however I would caution throwing out the baby with the bath water. The idea of it is not necessarily to see narrative writing, but rather to get something to differentially diagnose one group from the other, and it may be perfectly valid for that purpose, or maybe not; we don't know that. But just because it's an elicited writing task doesn't automatically make it bad.

## APPENDIX

### Western Aphasia Battery: Clarification of Scoring Guidelines for Narrative Writing (Subtest VI.B. "Written Output")

1. General approach: Score sentence-by-sentence, or "score isolated words to a maximum of 10 points."
2. Complete sentences: For sentences of 6 words or more, award 8 points. Subtract for errors as follows:
   a. Semantic errors:
      i. Subtract 1 point for any erroneous word (content or function) that is unrelated to the picture.
      ii. Subtract 1/2 point for any erroneous word (content or function) that is related to the picture.
   b. Grammatical errors:
      i. Subtract 1/2 point for an error of word order (e.g., "the boy big"/the big boy).
      ii. Subtract 1/2 point for omission of articles.
      iii. Subtract 1/2 point for omission or substitution of a grammatical morpheme (e.g., "wash"/washing).
      iv. Subtract 1 point for omission of copula "is, are" (e.g., "the lady pouring").
   c. Spelling errors:
      i. Subtract 1/2 point per word for spelling error, except:
      ii. Subtract 1 point per word if the word is unrecognizable (e.g., "tntain").
      iii. For ambiguous responses, judge the word in the context of the task (e.g., "a lady is pouring a sadd"/soda). In this example, subtract 1/2 point for spelling error.
3. Incomplete sentence or short sentence: 1 point for each word; then subtract for semantic, grammatical, and spelling errors.
4. Ignore errors or omissions of punctuation, capitalization, spatial misalignment, or widened left margin.
5. Constructional errors: Though the Western Aphasia Battery does not provide a guideline for constructional errors, subtract 1/2 point per word for constructional error (e.g., omission of feature, perseveration of feature; letter crunched, distorted, or untranscribable).