Neurolinguistic Characteristics of Language Production in Huntington's Disease: A Preliminary Report

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Samples of spontaneous and descriptive speech were obtained from 12 patients with Huntington's disease (HD) and 24 at risk (AR) controls. The data were assessed according to a neurolinguistic protocol. HD was identified with a significant reduction in number of words produced, a diminished level of syntactic complexity, reductions of melodic line, phrase length, articulatory agility, and grammatical form, and increases in paraphasic errors and word-finding difficulty. The data were interpreted in support of the hypothesis that neostriatal pathology affects linguistic processing. © 1987 Academic Press, Inc.

Huntington's disease (HD), transmitted as autosomal dominant, is a progressive neurologic disorder. The symptoms of HD, which typically occur in midlife, include disturbances of movement, psychiatric symptoms, and dementia. Neuropathologic studies indicate a distinct pattern of neuronal degeneration in HD that affects many areas of the brain but consistently and initially involves the neostriatum, particularly the medial aspect of the head of the caudate nucleus (Forno & Jose, 1973) and subsequently, the putamen, globus pallidus, and cerebral cortex. PET scan studies with F-fluorodeoxyglucose and computed tomographic scan

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have revealed that the dementia in HD initially correlates with hypo-metabolic changes in the head of the caudate rather than atrophy or hypometabolic changes in the cerebral cortex (Kuhl et al., 1982). These findings present a paradox. Although deficits of cognition have been classically identified with disturbance of the cerebral cortex, HD produces intellectual deficits, at least initially, with predominantly subcortical pathology.

Although mechanisms underlying language have traditionally been re-garded as corticocortical, some investigators, such as Pierre Marie (1906; also discussed in Cole, 1968) have proposed corticosubcortical mechanisms. In contemporary works, Pribram (1976) theorized the importance of neo-striatal systems for language processing. Kornhuber (1977) reported that striatal pathology in combination with cortical lesions produces global aphasia. Aphasia with predominantly neostriatal lesions has been identified by Hier, Davis, Richardson, and Mohr (1977), Alexander and LoVerme (1980), Naeser et al. (1982), and Damasio, Damasio, Rizzo, Varney, and Gersh (1982). A. Damasio and colleagues proposed that damage to the anterior limb of the internal capsule or anterior caudate was identified with deficits of movement and language. In a case study, Cambier, Elghozi, and Strube (1979) cited a patient with infarction limited to the left head of the caudate who exhibited incoherence of speech and other features of Huntington's disease. Caudate hypometabolism has been documented with PET scans in patients with aphasia-producing lesions without direct pathology of the caudate. This finding provides further support for the thesis that the neostriatum provides an essential aspect of language pro-cessing (Metter et al., 1984).

The concept that neostriatal mechanisms subserve cognitive functions remains controversial (see Stuss & Benson, 1986). Nevertheless, these findings suggest to us that corticostriatal projections are critically involved in cognitive processes, some of which are likely to be either necessary or sufficient for adequate linguistic processing.

Until recently, the accepted topographic schema of the projections to neostriatum arising from various areas of association cortex was that of an anterior–posterior mapping, but more recent studies (Selemon & Goldman-Rakic, 1985) have demonstrated a mediolateral organization of corticoneostriatal projections. In theory, therefore, it is now possible to predict the form of neuropsychological deficit likely to arise from circumscribed damage to the caudate or putamen by reference to the predominance of its cortical inputs from either hemisphere. For example, the most anterior and medial part of the head of the caudate receives projections exclusively from the dorsolateral frontal cortex, whereas in more posterior portions of the head of the caudate, posterior parietal and superior temporal projections are encountered. Therefore, as HD progresses by producing degeneration of the neostriatum from anterior

to posterior sectors of the caudate-putamen, the symptoms should parallel the disconnection of the corresponding cortical inputs.

This model, additionally, predicts that the first symptoms of HD would involve cognitive disorders of the anterior frontal lobe. As superior–anterior putamenal regions are involved, which receive projections from premotor and motor cortical fields, the presence of articulatory defects should be identified. As damage involves the head and tail of the caudate head and portions of the putamen, there should arise certain symptoms of Wernicke's aphasia; these portions of the neostriatum receive direct projections from the superior temporal gyri. The present investigation was designed to examine these possibilities.

METHOD

Subjects. Twelve patients with Huntington's disease and 24 at-risk controls from New Zealand were studied with regard to features of language production and evaluated by a neurolinguistic protocol to be described below (Illes, 1983). From an initial sample of 16 HD patients, four subjects with advanced HD were excluded from the analysis as the result of poor intelligibility of speech production. The AR were selected to provide a conservative baseline for analysis of HD pathology. The mean age of the 12 HD patients was 57 years and they were, on the average, 4 years postdiagnosis. The AR controls had a mean age of 48 years.

Speech transcription. Samples of spontaneous and descriptive speech were obtained from each subject. Four minutes of speech, recorded on magnetic tape, were transcribed in extenso for analysis. Two minutes of descriptive speech samples were obtained from the Boston Diagnostic Aphasia Examination (BDAE) (Goodglass & Kaplan, 1983) "cookie theft" picture and 2 min of spontaneous speech were based upon an account of travel. The International Phonetic Alphabet was used whenever phonological deviations occurred. The identity of the subjects in the two groups was not known at the time the neurolinguistic analyses were performed.

Five types of hesitations were studied: (a) silent hesitations in speech production exceeding 150 ms, (b) filled pauses (such as "uh"), (c) phonemic prolongations (prolongation of a vowel occurring at any position in a word), (d) verbal repetitions (such as the duplication of an article or a preposition preceding the production of a noun corresponding to target), and (e) context-related comments or "modalizations" (such as "do you understand?") and interjections, such as "okay" (Nespoulous, 1981). Hesitations were analyzed for frequency and for syntactic location. The number of silent hesitations which occurred between clauses and between phrases was counted (Goldman-Eisler, 1964).

Overall syntactic complexity of verbal utterances was determined according to an hierarchical method of Lazare (1976). The 10 levels of syntactic complexity illustrated are as follows:

(1) Nominal syntagm (e.g., in response to a question such as "Where were you born and raised?" "*Auckland.*").

(2) Presentative nominal syntagm (e.g., "*It was in Auckland.*").

(3) Syntagms without subjects (e.g., "*about 15 miles from Auckland*").

(4) Nominal syntagm with a predicate syntagm (e.g., "*Auckland thrives.*").

(5) Nominal syntagms with a predicate syntagm requiring a complement (e.g., "*Auckland is beautiful.*").

(6) Nominal syntagm with a predicate syntagm, plus a completive (e.g., "*I think that Auckland is beautiful.*")
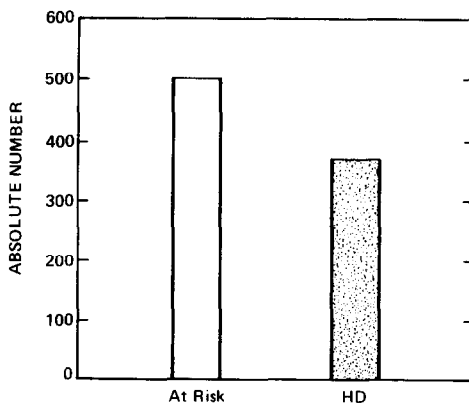
Fig. 1.   Number of words produced (4 min.).

(7) Sentences containing a spatial or temporal syntagm, (e.g., "*I have lived in Auckland for 30 years.*").

(8) Sentences in which the second proposition is in causal, temporal, or final relation with the first proposition (e.g., "*I have lived in Auckland because it is beautiful.*").

(9) Sentences with three or more propositions (e.g., "*I have lived in Auckland for 30 years because I think it is beautiful.*").

(10) Sentences containing a relative clause (e.g., "*Auckland is the city in which I lived all my life.*").

Paraphasic errors were identified according to whether they were semantic (replacement of a target word by a semantically related one) or phonemic (the addition or subtraction, substitution, or displacement of a phoneme in a word) (Lecours & Rouillon, 1976) and open class (content words such as nouns, verbs, and some adverbs) or closed class lexical categories (pronouns and indefinite pronouns).

RESULTS

The findings were analyzed by Multivariate Analyses of Variance (MANOVA) (BMDP-7DP). Bonferroni's test was used to correct for multiple comparisons of all pairs of means. Levene's test for equal variances was applied. Comparisons were performed between AR and HD patients. Results were combined collapsed between spontaneous and descriptive speech samples as no significant differences were identified between them.

Lexical Production

Figure 1 shows the number of words produced during the 4 min speech samples by the AR and HD groups. The HD subjects are indicated in this and all subsequent figures by shaded bars. The mean of 358 words/4 min (89.1 words/min) for the HD is significantly diminished as contrasted with a mean of 492 words (120.5/min) for the AR group. The result, as computed by the MANOVA, was significant ($F = 9.07$, $1/35$, $p = .0048$). The AR subjects were within the range of normal adults (Howes, 1964).
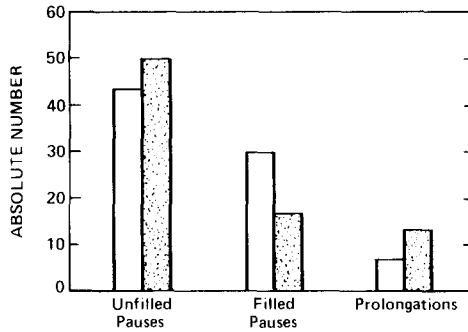
FIG. 2. Mean number of unfilled pauses, filled pauses, and prolongations occurring in 4 min.

Distribution of Unfilled and Filled Hesitations

The mean number of unfilled pauses longer than 5 sec (for 4 min of speech) for the AR group was .48 and the mean number for the HD group was 2.98. These results were highly significant (F = 16.78, 1/35, p < .001). The patterns of unfilled pauses and various types of filled hesitations are shown in Figure 2 and Table 1. This table indicates the total frequency and percentage of occurrence of hesitations per number of words for the HD and AR groups. HD subjects tended to be silent rather than to produce filled pauses; by contrast, the AR subjects (and normal speakers) tend to fill their hesitation time. These trends, however, did not attain statistical significance (p > .05).

Syntactic Complexity

The mean syntactic complexity of utterances produced by the HD group was 5.52 and that of the AR group was 6.67 (F = 6.92, 1/35,

TABLE 1
TOTAL FREQUENCY OF PAUSES

	HD	AR
1. Silent hesitations	49.08 (14.4)	45.33 (9.21)
2. Filled hesitations		
a. Filled pauses	12.00 (3.70)	17.95 (3.58)
b. Prolongations	5.00 (0.04)	3.62 (0.01)
c. Repetitions	10.91 (3.00)	11.60 (2.70)
d. Modalizations	3.41 (0.09)	5.37 (1.34)
e. Interjections	2.83 (0.06)	4.58 (0.07)
3. Aborted utterances	3.58 (1.00)	2.79 (0.01)

Note. The numbers not in parentheses refer to the total frequencies of occurrence; numbers in parentheses refer to percentages of occurrence per total number of words.
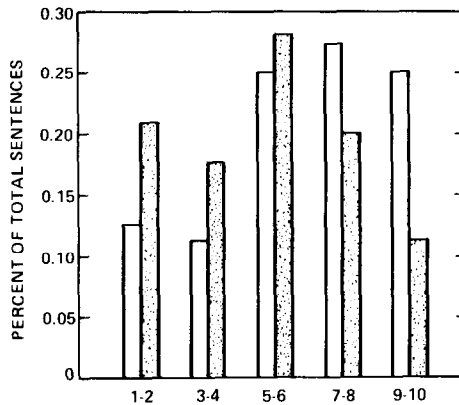
FIG. 3.   Distribution: syntactic complexity.

p = .0126). These results, presented for 10 categories, are shown in Fig. 3 with the categories reduced to five for clarity of illustration. Note that as syntactic complexity increased, the percentage of total sentences is progressively reduced for the HD subjects.

Paraphasic Errors

Analysis of the semantic paraphasias per number of words revealed that the HD group produced more paraphasic errors (.58%) than the AR group (.0017%). The HD subjects tended to produce substantially higher percentages of mumbled words (5.7%) than the AR subjects (.33%). These results approached but did not reach statistical significance. In the HD group there were 53 occurrences of semantic paraphasic errors, of which 62% were closed class. This contrasts with the usual preponderance of open class paraphasic substitutions recorded in jargon-aphasics (Lecours & Rouillon, 1976).

BDAE Speech Profile Ratings

A separate MANOVA was performed to analyze the results of this set of the BDAE scales, and the results are indicated in Table 2 and in Fig. 4.

On all six scales, the HD patients produced speech samples which were significantly different than the AR controls. Melodic line, phrase length, articulatory agility, and grammatical form were significantly reduced ($p < .01$). Paraphasic errors and word-finding difficulty were increased.

DISCUSSION

The results indicate that there is a disturbance of language production in HD. These patients evidence a significant reduction in the number of

TABLE 2
BDAE MANOVA Data

Scale Type	Mean of HD	Mean of AR	F	p
Mel. line	3.42	1.80	15.96	.0003
Phr. length	3.82	6.45	15.80	.0003
Art. agil.	2.93	6.17	7.85	.008
Gram. form	4.50	6.66	13.57	.0007
Paraphasias	5.28	6.79	6.34	.0161
Wd. finding	2.71	3.66	7.23	.0106

words produced, a diminished level of syntactic complexity, reductions of melodic line, phrase length, articulatory agility, and grammatical form, and increases in paraphasic errors and word-finding difficulty.

Word-finding difficulty and paucity of speech are characteristic of the patient with transcortical motor aphasia; the reduction of syntactic complexity, the impairment of articulatory agility, and poverty of grammatical form have qualities in common with a mild case of Broca's aphasia, and the semantic paraphasic errors give the impression of qualities identified with Wernicke's aphasia. The word-finding difficulty occurs in all aphasic syndromes. Overall, there are aspects of various aphasic syndromes represented by the speech production of HD patients.
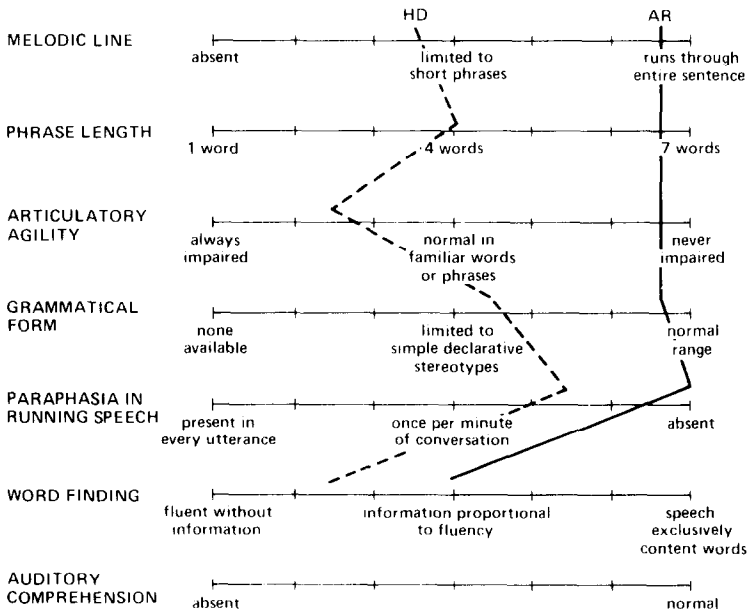

Fig. 4.   Speech profile ratings for persons with Huntington's disease and persons at risk.

The aphasiclike defects occurring in HD may be attributed to the following hypotheses:

(1) degenerative processes involving cerebral cortex;

(2) mechanical processes involving respiratory or articulatory mechanisms, or both;

(3) disconnection of cortical–neostriatal pathways that are ordinarily utilized in language.

With regard to the first hypothesis, it is well known that many cortical fields are impaired in advanced HD. However, initially in the disorder, the dementia is correlated with hypometabolic changes occurring only in the head of the caudate on PET scans. CT scans reveal focal pathology of the caudate. In the present investigation, patients with early onset of HD (less than 2 years) were not significantly different in their BDAE speech sample scores from patients with more advanced HD. Note that the most advanced cases were excluded from the analysis. In a recently completed study, early and late onset patients were not significantly different from each other in syntactic complexity (Illes, 1987) and were significantly more impaired as compared with early onset in Parkinson's patients (Illes et al., 1986). These data suggest that widespread degenerative processes involving the cerebral cortex are not necessary to produce the dementia and language impairments reported.

A defect of respiration, as occurs in some patients with choreaform movement, might produce a greater variability in the production of viable utterances and an increase the number of brief pauses. It does not follow that such an impairment would account for the wide range of linguistic disorders (i.e., word finding, syntactic simplicity, semantic paraphasic utterances) that coexist with HD. Similarly, a defect of articulation does not seem to be sufficient to produce all of these symptoms.

In our view (Gordon, 1985), the most plausible interpretation is that degeneration of the caudate and putamen is sufficient to produce the cognitive and linguistic defects occurring in HD. We hypothesize that

(a) earliest in the syndrome, when the anterior frontal head of caudate connections is involved, a transcortical motor aphasialike symptomatology will prevail;

(b) subsequently, as projections to the anterosuperior putamen are affected, which receive cortical projections from premotor cortex, a defect of articulation is predicted, and

(c) thereafter, as projections from the superior temporal gyrus to the head of the caudate are affected, features of Wernicke's aphasia will exist, that is, there will be a greater tendency for HD patients to produce semantic paraphasias.

There are several limitations of this preliminary investigation. We lack correlative neuropathological, CT scan, or PET scan information which would help to verify or refute our hypothesis. Only the characteristics

of oral production were studied; that is, auditory comprehension was not directly assessed. Further, the duration of the speech samples was relatively brief. Additional significant dissociations might emerge in a more extensive investigation, for example, between various forms of pauses.

These limitations notwithstanding, the results of the neurolinguistic analysis of HD patients reveal disorders consistent with a disturbance of linguistic processes. Further studies are in progress concerning language production in other dementing disorders (Illes, 1987). Whether some of the neural substrates of language are impaired in HD or whether the languagelike impairments are the consequence of strategies used to express viable speech remains an open question. In either case, we believe these findings add to the list of studies that demonstrate impairments of languagelike processes produced by neostriatal pathology.

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