BRAIN AND LANGUAGE 33, 146–160 (1988)

Language Production in Parkinson's Disease: Acoustic and Linguistic Considerations

J. ILLES

Department of Hearing and Speech Sciences and Neuropsychology Laboratory, Stanford University School of Medicine

AND

E. J. METTER, W. R. HANSON, AND S. IRITANI

UCLA School of Medicine and Veterans Administration Medical Center

The hypokinetic dysarthria of Parkinson's disease (PD) has been described extensively. In contrast, patterns of hesitation and the language structure in spontaneous speech of the PD patient have not been investigated, although several studies have shown language-related abnormalities in word naming, word generation, and verbal recall. In the present study, 10 male Parkinson's patients and 10 normal male speakers were compared in a reading and spontaneous speaking paradigm for acoustic and linguistic features. Among acoustic measures, fundamental frequency and relative intensity differentiated PD from control subjects, consistent with reported features of hypokinetic dysarthria. The striking observations among linguistic measures differentiating PD from control subjects were an increase in the number of (a) silent hesitations per minute, (b) abnormally long silent hesitations, (c) words per silent hesitation, (d) open class phrases, and (e) optional open phrases per speech sample, and a decrease in the number of modalizations and interjections. An increase in the number of filled hesitations occurring per minute, as well as a decrease in syntactic complexity separated moderate from mild Parkinson's patients. Our interpretation of the data favors the hypothesis that changes in the structure of spontaneous language production with increasing severity of dysarthria reflect PD patients' *adaptation* to their disease. © 1988 Academic Press, Inc.

INTRODUCTION

Parkinson's Disease (PD), a neurodegenerative disease identified by damage to the nigrostriatal dopaminergic bundle, has generated substantial

The authors acknowledge the contributions of K. H. Pribram and H. F. M. Van der Loos to this manuscript. Reprint requests should be sent to Judy Illes, Ph.D., EEG Systems Laboratory, 1855 Folsom Street, San Francisco, CA 94103.

0093-934X/88 $3.00

controversy surrounding presumed changes in mental status. Most early reports of PD concentrated on the motor disturbance, tremor at rest, stooped posture, rigidity and bradykinesia apparent with this disorder. In fact, when James Parkinson first described PD, he denied the presence of any associated mental changes. On the other hand, Charcot believed that the intellect was impaired in PD and that cognition and memory deteriorated as the disease advances. Recent fluorodeoxyglucose PET studies of patients with PD have shown mild cortical hypometabolism, a finding consistent with the diffuse nature of the disease (Kuhl, Metter, & Riege, 1984; Metter, Riege, Kameyama, Kuhl, and Phelps, 1984), and one which could explain a generalized cognitive-intellectual decline. Cognitive decline has been found to affect 30–80% of the PD population, and is characterized by a compromise in a number of mental functions, such as cognition, memory, visuospatial skills, and personality (Benson, 1984). Albert (1978) has suggested that the pattern of cognitive change in PD is similar to the behavioral syndrome seen in patients with frontal lobe damage (e.g., Luria, 1966; Teuber & Proctor, 1964).

Despite reports of cognitive decline in PD, Pirozzolo and his colleagues (1982) have reported that vocabulary and information-processing abilities are preserved in PD patients. However, several other researchers have demonstrated language-related abnormalities and have suggested that PD patients may indeed have difficulty with speech planning and with lexical access. For example, on the naming section of the Boston Diagnostic Aphasia Examination (BDAE; Goodglass & Kaplan, 1972), PD patients produced significantly fewer words than matched controls (Obler, Mildworf, & Albert, 1977). In contrast, when tested for written descriptive ability (Cookie Theft Picture; BDAE), PD patients used a greater number of words to describe the same number of themes described by normal control subjects. PD patients also tended to use full sentences in contrast to the abbreviated style preferred by the normals. On tests of serial speech, such as naming the months of the year, the majority of the PD patients in the study were unable to stop at the end of the series. This finding is consistent with a study by Bowen, Kamienny, Burns, and Yahr (1975), in which PD patients were shown to have difficulty shifting sets and completing concepts.

Tweedy, Langer, and McDowell (1982) have demonstrated verbal recall and recognition deficits in PD subjects relative both to matched normal controls and to right hemisphere stroke patients. Semantic cues were not found to be effective in facilitating recall for the PD group. Scholz and Sastry (1985) have also documented language-related difficulties in PD in terms of patients' inability to cluster verbal material to facilitate recall (reductive encoding). In contrast to Tweedy's findings, however, these authors did demonstrate positive, facilitative semantic cue effects. Bayles and Boone (1982), Bayles and Tomoeda (1983), and Bayles (1984) have reported that perseveration is characteristic of all neurodegenerative groups, including PD, at least when patients are confronted with the task of describing simple objects. Bayles and her colleagues have also described patient's difficulty in peforming tests of lexical disambiguation, sentence disambiguation, confrontation naming, generative naming, and syntactic judgments.

Although each of these studies has contributed to our understanding of cognitive-intellectual and language-related changes associated with PD, they have not allowed for the separation of motoric from cognitive-intellectual components of the specific behaviors. Motoric components most associated with language have been described as a hypokinetic dysarthria and have been well documented (Darley, Aronson, & Brown, 1975; Metter, 1985). Specific features, however, are variable from subject to subject (Metter & Hanson, 1986). Evidence for changes in the dynamic quality of *spontaneous* language production, i.e., daily communicative ability, has been limited to anecdotal observation. In the study reported here, two principal questions were asked:

1. Does spontaneous language production of PD patients differ from that of normal speakers as determined by changes in sentence planning, formulation, and lexical search?

2. If PD does give rise to changes in spontaneous language production, what is the relationship between these changes and the motoric features of the disease as measured using an acoustic analysis of speech?

METHODS

Subjects

Ten male PD patients and 10 male age-matched controls were recruited from the community for study. All subjects were right-handed, literate, and native speakers of the English language. Each PD patient was rated on the Webster 30-point scale of Parkinsonian disability. Five PD patients with a Webster score of 1–10 were classified as mild. five PD patients with a Webster score of 11–20 were classified as moderate. The mean number of years postonset of the disease was 4.6 for the mild group and 10 years for the moderate group. All PD subjects were medicated with levodopa. Neither patients nor significant others reported any major change in cognitive ability.

Speech Samples

Speech samples were tape-recorded with the patient seated in a sound-treated test room (IAC, Model 403) directly in front of a microphone (Electrovoice, Model RE-15) coupled to an Ampex tape recorder (AG-600) located in an adjacent test room. The mouth-to-microphone distance was 8 in. Subjects were asked to read the "Grandfather" passage, and to produce several minutes of spontaneous speech to questions about where they were born and raised, their occupation, and travel. Samples of the "Grandfather" passage were analyzed by a microprocessor controlled speech analyzer (PM 301, Voice Identification, Inc.) which gave measures of duration, voicing, fundamental frequency, pausing, relative intensity, and variations of these measures.

Spontaneous Speech Transcriptions

Samples of the spontaneous speech were transcribed in extenso. Following the procedure of Ford and Holmes (1978), the speech was first segmented into sentences. The word *and* was considered redundant when used as a conjunction between completely independent clauses. The words *so* and *then* were also considered redundant in cases where, if omitted, the utterances preceding and following them were still meaningful.

The International Phonetic Alphabet was applied to transcribe repetitions (successive approximations; Joanette, Keller, and Lecours, 1980) and verbal deviations (phonemic paraphasias, verbal paraphasias and neologisms; Lecours, Lhermitte, & Bryans, 1983). Repetitions were further denoted with an arrow (↓). For example,

I was the first child *of* ↓ *of* the family.

Aborted segments were denoted by a double down-arrow (⇊). For example.

I had ⇊ It was nine April.

Silent hesitations were denoted with a square (□) and filled hesitations unrelated to context (e.g., *umm, hmm*) were transcribed as *euh*. Analyses of these phenomena are discussed in greater detail below.

NEUROLINGUISTIC ANALYSIS

1. Production Rate

a. Word rate. A count was made of the number of words produced during a given sample with respect to the total duration of the sample. Contractions (e.g., *I'm, wasn't*) were counted as two words.

b. Verbal rate. Verbal rate was calculated according to the equation given by Illes (1986). It is

$$\text{verbal rate} = \frac{(\text{total number of words})}{(\text{duration of speech sample}) - (\text{total duration of silent hesitations})}.$$

2. Temporal Variables

Interruptions of the temporogrammatical stream of speech were defined operationally as temporal variables which included silent hesitations, filled hesitations, interjections and modalizations, repetitions, and aborted utterances.

Silent hesitations. It is known from the literature on speech production in normal populations that the amount and location of silence in speech can be a reliable indicator of the kinds of underlying processes the speaker is engaging. It has been shown, for example, that the occurrence of many silent hesitations is associated with the word selection process and that accessing items from the mental lexicon can produce a measurable delay in output (e.g., Goldman-Eisler, 1964; Butterworth, 1979). A similar relationship between silent hesitations, sentence formulation, and sentence planning has also been demonstrated (e.g., Ford, 1978; Ford & Holmes, 1978).

In the present study, any silent rupture in speech that exceeded 200 msec (Ford & Holmes, 1978) was considered to be a silent hesitation. This cutoff was selected on the basis of careful consideration of previous studies on hesitation patterns in *all* types of speaking situations (e.g., Boomer, 1965; Ford & Holmes, 1978; Grosjean & Deschamps, 1972; Henderson, Goldman-Eisler, & Skarbek, 1966; O'Connell, Kowal, & Hormann, 1970). This limit is considered sufficiently long to breathe in order to restore subglottal pressure for articulation and also long enough to produce one stop consonant after another. The duration of silent hesitations was determined using a Bruel & Kjaer Level Recorder. Silent hesitations were studied as follows:

a.1 Number of words per silent hesitation. The number of words per silent hesitation was established for each speech sample. This gives an indication of the average chunk of speech uninterrupted by a silent hesitation.

a.2 Linguistic environment of silent hesitations. The linguistic environment of silent hesitations was evaluated as to the proportion and duration of silent interclausal hesitations (e.g., □ *And we have lots of fun*) versus interphrasal hesitations (e.g., *And we have* □ *lots of fun*) and versus intraphrasal hesitations (e.g., *So we have a big house and two* □ *good children*). Silent hesitations occurring at intraclausal positions generally are considered to reflect search for an upcoming lexical target. Taking into account only those silent hesitations that occurred *within phrases* (intraphrasal) provided a highly conservative but certain estimate of the degree of word finding difficulty during spontaneous language production.

To study processes presumed to be related to the planning of clauses (Ford & Holmes, 1978), the proportion and duration of silent hesitations occurring at the beginning of sentences, before embedded clauses (e.g., *I'm kind of disappointed* □ *that I didn't think earlier about taking some pictures*), between mandatory phrases, and between mandatory phrases and optional phrases was determined. Optional phrases were defined as those which could be removed from the principal clause without changing the meaning of the utterance (cf. below).

b. Filled hesitations. Miscellaneous vocal noises unrelated to context and devoid of semantic value (e.g., *euh, um*) were considered to be filled hesitations. The number of filled hesitations occurring per minute of each speech sample was counted.

c. Interjections and modalizations. Using the definitions provided by Nespoulous (1979), interjections were identified as the exclamatory phrases that are interjected during speech, such as *Oh, Ah,* and *Okay*. Modalizations, on the other hand, were identified as comments made by a speaker that bear on his own verbal behavior, such as *you know*. They may take the form of highly routinized set phrases or of verbalized predicates used to qualify the propositional content of a speaker's message (Austin, 1962; Searle, 1977). For example,

That's what it was called, *I guess*.

The number of interjections and modalizations occurring per minute was counted.

d.1 Repetition of syllables (successive approximations; Joanette et al., 1978). For example,

– */recei/* ↓ */receive/* ↓ */receiving/*

shows two successive approximations to the target word *receiving*. The number of phonemic approximations occurring per minute was determined.

d.2 Repetitions of words, phrases or parts of phrases. For example,

... and *sell* ↓ *sell* the other one.

Phrases were defined as one or more words, arranged in a grammatical construction, which act as a meaningful unit in a sentence. Interruptions of phrases were only considered to be repetitions if there was an obvious effort by the speaker to reach the initiated target word or phrase. This is generally consistent with Levelt's (1981) definition of *self-correction*. Otherwise, the interrupted segment was considered to be aborted. The number of repetitions per minute was assessed.

e. Aborted phrases. The number of false starts or aborted phrases per minute was assessed.

3. Syntactic Complexity

A scale for syntactic complexity was developed by Illes and Ford (1984, unpublished) that fits well into the framework of lexical functional grammar (LFG; Bresnan, 1982). LFG does not attempt to describe deleted aspects of a sentence occurring in fragmented utterances, as would transformational grammar (Chomsky, 1966), and thus provides a good framework to guide the analysis of syntactic structure of spontaneous language production.

Syntactic complexity of the verbal output was determined by applying a score of complexity for each and every clause produced. The underlying premise of this analysis is that the principal planning unit for spontaneous language production is the basic clause (subject + predicate). Embedded clauses reflect a higher degree of planning than nonembedded clauses (Ford, 1978). Complexity scores were applied to clauses only, therefore, and not to sentences as a whole. All modalizations except for stock phrases such as *you know* were scored for complexity.

A mean degree of syntactic complexity was established for each speech sample. The scale used is given below. For nonembedded clauses, the category number (e.g., **1** = clauses without a subject) corresponds to the score applied to the clause presented in italics. For embedded clauses, the sum of the numbers in parentheses corresponds to the score applied to the italicized clause in that category.

a. Nonembedded clauses

1. Clauses without a subject. These usually occur in response to a question such as: Tell me about where you were born and raised; e.g., *Hawaii.*

2. Clauses with one argument (monadic predicate): e.g., (S)—*We moved.*

3. Clauses with two arguments (dyadic predicate): e.g., (S)(O)—*I like hard work.*

4. Clauses with three arguments (triadic predicate): e.g., (S)(O)(O2)—*We put that ferry on a flat car.*

5. Clauses with a complement which itself contains a verb: e.g., (S)(O complex)—*I think* they had a good time.

b. Embedded clauses. Embedded clauses were scored according to the above scale (1–5) and a weight was applied according to degree of complexity (Ford & Holmes, 1978) as follows:

Coordinated clauses: + 1

Leave the kids at home *and take off to Europe.* (2 + 1)

Complements and adverbials: +2

e.g., (S)(O complex)—I think *that Australia is good.* (3 + 2)

e.g., I didn't fly *because by vision was too bad.* (3 + 2)

Relatives: + 3

We had a few *that were a little bit unhappy.* (2 + 3)

Weights were applied according to level of embedding. For example,

I'm trying (5) *to get the children* (5 + 2) *to get their situation* (2 + 2 + 5) *the way it should be* (3 + 3 + 2 + 2).

The analysis of syntactic complexity did not take into account the presence or absence of optional phrases. The occurrence of optional phrases was considered in detail, however, in the analysis of lexical form.

4. Lexical Form

a. Verbal deviations. The number, type, and—where appropriate—grammatical class of verbal and phonemic deviations produced in a given sample were determined. Additionally, the number of deviations occurring per minute in each speech sample was assessed. Paraphasias were classified according to the definitions provided by Lecours et al. (1983):

semantic paraphasias, i.e., substitutions of a target word by another dictionary word on the basis of formal kinship (e.g., retired → */resigned/*), or the replacement of a target word by a semantically related one (e.g., home → *front*).

phonemic deviations, i.e., deletions (e.g., asked → *aked*), additions (e.g., hiking → *hikiking*), transpositions (e.g., Mazatlan → */Maztalan/*)

neologisms, i.e., nondictionary words (new words) or words that are so severely deviant (such as compounded semantic and phonemic paraphasias) that their target is no longer identifiable.

b. Open versus closed class phrases. The distinction between open and closed class vocabularies corresponds to the distinction in linguistics between lexical and grammatical items (Kolk & Blomert, 1985). The former refer to content words such as nouns, verbs, and some of the adverbs. The latter refer to functional words (articles and prepositions), pronouns, and indefinite pronouns. The designations *open* and *closed* are used to refer to the fact that the content words belong to an open set of items with unrestricted, indeterminately large membership, and the function words to a closed set of typically small membership (Bradley, 1978).

Each speech sample was analyzed for the occurrence of open class subject phrases (e.g., *My son*), closed class subject phrases (e.g., *It*), open class predicate phrases (all predicates except *to be* and *to have*), closed class predicate phrase (*to be* and *to have*), mandatory or complement open class phrases (e.g., This has been *some life;* or I went *to Chicago*), and closed class mandatory or complement phrases (e.g., That's *about it*). In addition, optional phrases were tabulated and classified according to whether they were open class (e.g., Went to the University of California *in Berkeley, in a pre med course.*), or closed class (e.g., I thought I was going to burn up *over there*).

As per convention (e.g., Lecours et al., 1983), all phrases composed of generic words such as *thing* or *stuff* were classified as belonging to the open class. All optional phrases concerning time (e.g., *now*) were classified as belonging to the closed class inventory. All optional adverbial phrases ending in——*ly* such as *simply* or *seriously* were classified as belonging to the open class. All optional adverbial phrases which did not end in ——*ly* such as *too much* were classified as belonging to the closed class. The proportions of open class and closed class subject phrases, object phrases, and optional phrases per speech sample were determined by dividing their number by the total number of phrases.

RESULTS

Student *t* tests were calculated between the PD and control subjects (NC) on all acoustic measures. Of the acoustic measures analyzed from the reading passage, fundamental frequency (F_0) and intensity differentiated PD from control subjects (Table 1).

As an initial step in the linguistic analysis, word rate (words per speech sample) and verbal rate (number of words per minute of actual speaking time, i.e., with the total silent hesitation time subtracted out; Table 2) were compared in a two-way analysis of variance. A highly significant within-group effect ($F(1, 13) = 28.63, p < .0001$) and a significant interaction effect ($F(1, 13) = 6.34, p < .0252$) suggested that, as expected, the amount of silent hesitation time is an important factor in the spontaneous speech of PD patients. This was further confirmed by a series of Student

TABLE 1
MEANS AND *t* VALUES FOR ACOUSTIC MEASURES

	F_O	Intensity	CV/I	CV/freq	Pause	V/S
PD	140.80	35.71	20.76	14.42	22.40	48.17
SD	26.21	3.88	1.30	6.16	18.53	5.50
NC	116.40	38.93	19.77	18.60	12.62	79.70
SD	24.83	2.41	1.40	4.31	5.09	2.71
t	2.57**	−2.16*	1.65	−1.76	1.61	−.79

Note. CV/I: Coefficient of variability for intensity; CV/freq: Coefficient of variability for frequency; Pause: Pause time; V/S: Percentage of speech sample time that was voiced.
* $p < .05$.
** $p < .01$.

t tests which showed that the number of silent hesitations per minute, words per silent hesitation, and abnormally long hesitations (>2sec), were elevated in the PD speech samples. These data are provided in Table 3. The abnormally long silent hesitations were most prevalent at sentence initiation positions, and between mandatory and optional phrases.

Four other measures in the linguistic analysis significantly differentiated PD patients from controls at the $p = .05$ level unadjusted for the number of comparisons. The number of interjections and modalizations produced per minute was significantly decreased in PD speech samples. A breakdown of the occurrence of each type of phrase in the normal and PD samples is shown in Fig. 1. The proportions of open class phrases, and open class optional phrases per total number of phrases, were significantly elevated. The proportion of open class phrases was found to be highly correlated with the proportion of open optional phrases ($r = .94$). The means and *t* values for these data are also given in Table 3.

When comparing linguistic measures between mild and moderate PD subjects, the number of filled hesitations per minute and syntactic complexity separated the degree of illness. The mean number of filled hesitations

TABLE 2
MEANS AND STANDARD DEVIATIONS FOR WORD RATE (WORD/MIN) AND VERBAL RATE

	Word rate	Verbal rate
PD	112.30	169.10
SD	34.80	54.20
NC	132.00	154.50
SD	22.40	25.50
F value	28.63***	

*** $p < .0001$.

TABLE 3
MEANS AND *t* VALUES THAT DISTINGUISH NORMALS FROM PARKINSON'S DISEASE PATIENTS

	(SH > 2s)/min	(Mod + intj)/min	Open phr.	Open opt.
PD	1.41	0.57	72.8%	17.0%
NC	0.03	1.96	62.4%	10.0%
t	3.10**	−2.44*	3.26**	2.93*

Note. (SH > 2s)/min: Number of silent hesitations (exceeding 2 sec) per min; Mod + intj: Modalizations and interjections; Open phr.: proportions of open phrases per total number of phrases; Open opt.: proportion open optional phrases per total number phrases.
* $p < .05$.
** $p < .01$.

produced per minute in the mild PD speech samples was 6.8, and 2.4 in the moderate PD samples ($t = 2.28$, $p < .05$). The mean degree of syntactic complexity for the early PD speech samples was 4.37, and 3.59 for the moderate PD samples (Fig. 2). Because of the association of linguistic measures to PD identifications, the correlation of two linguistic measures (syntactic complexity and the proportion of open phrases) to measures of PD severity (duration of illness, dysarthria rating scale, and Webster PD disability score) was examined. Strong correlations were found between syntactic complexity, dysarthria severity, and the Webster scale.

To balance the linguistic and acoustic measures, a correlation matrix was computed and variables were identified that had extremely high correlations. For the sample of 20 subjects and across significant acoustic and linguistic variables, $r = .56$ ($p < .001$, uncorrected for the number

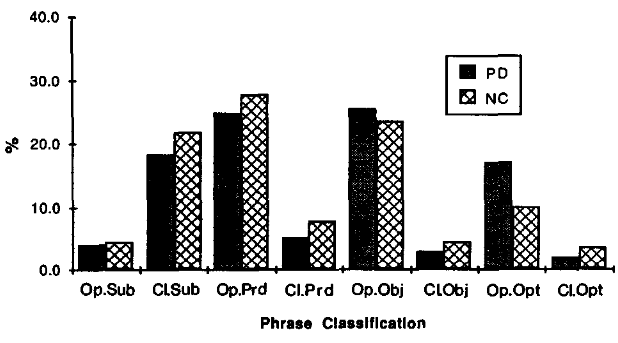

FIG. 1. Percentage occurance of open and closed class phrases per total number of phrases in the speech samples of the PD and control subjects. Op.Sub: open class subjects; Cl.Sub: closed class subjects; Op.Prd: open class predicates; Cl.Prd: closed class predicates; Op.Obj: open class objects; Cl.Obj: closed class objects; Op.Opt: open class phrases; Cl.Opt: closed class optional phrases.

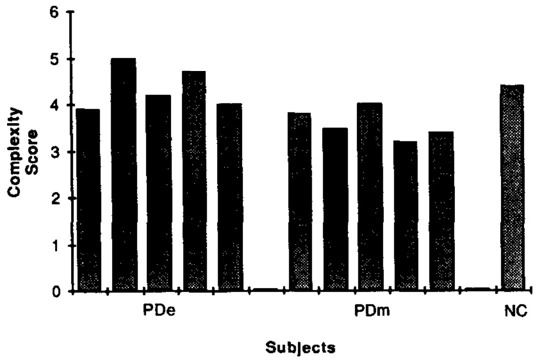

FIG. 2. Syntactic complexity scores for the five subjects in the early PD group (PDE) and for the five in the moderate PD group (PDM). The mean complexity score for the normal controls (NC) is shown in the last column for reference.

of calculations). Correlations were accepted as being extremely high for $r > .75$. From the high correlations, the number of variables was reduced to 14, including 7 acoustic and 7 linguistic measures. A stepwise discriminant analysis was done to examine which variables were most important in separating PD patients from controls. A function was identified which was significant ($p = .004$) and which correctly identified 18 of the 20 subjects. The remaining two PD subjects with very mild dysarthria were classified as controls. Four variables were found to be important: fundamental frequency, intensity, words/silent hesitation, and proportion of open optional phrases/total number of phrases.

DISCUSSION

The measures most important in discriminating the PD from the normal group included both acoustic and linguistic measures. The acoustic measure of fundamental frequency was shown to be elevated in the PD samples, while relative intensity was found to be reduced. These findings are consistent with previous studies of connected speech in PD (Ludlow & Bassich, 1983; Kent & Rosenbek, 1982), and with clinical impressions. The linguistic data, on the other hand, have not been previously reported. The linguistic measures of the number of words produced per silent hesitation and the proportion of open class optional phrases were found to be the key distinguishing elements of PD speech samples as compared with control samples. That is to say, the PD patients in this study generally produced shorter chunks of uninterrupted speech, but typically longer sentences. This latter phenomenon does not imply increased syntactic complexity, since this factor relates to the structured *sequences* of messages and not to their complexity. It appears, therefore, that PD patients produce many utterances in a *list* fashion, but not necessarily agrammatically or telegraphically. This phenomenon is illustrated in the following example,

I worked for thirty-two years for the ↓ the Department of Water and Power, first as a ↓ a /m↓/↓ /m↓/↓ mechanic, then a ↓ lead man, then finally as a /f↓/↓ /f↓/↓ foreman,

in which *for thirty-two years, for the Department of Water and Power, as a mechanic, as a lead man, finally,* and *as a foreman* are each open class, optional phrases which supplement the principal clause *I worked* with additional information. The following example, extracted from one of the normal speech samples, contains fewer optional phrases per sentence. They are in boldface type. All other phrases are governed by a verb:

I just finished scheduling some of the hearing aid patients. And that's ***always a bit*** *of a nuisance because it requires first looking and pulling the charts. There's always one that isn't there* ***for some reason.***

When comparing the two levels of severity of the PD group, a reduction in syntactic complexity and a relative increase in the production of filled hesitations in the moderate PD subgroup were the distinguishing factors.

We conceive of two possible interpretations for these combined acoustic and linguistic data. First, it may be suggested that the relative reduction in the number of words produced per silent hesitation, the change in semantic form, and the eventual decrease in syntactic complexity with increasing severity are evidence that the linguistic changes are an intrinsic part of the disease process. This hypothesis is supported by evidence for deficits of verbal generation and recall, and by cognitive studies showing deficits of concept formation and concept completion in PD. It may be further supported by the syntactic simplification observed in the speech samples of the moderate PD subgroup, a phenomenon which is also characteristic of the spontaneous language production of early Huntington's disease patients (Illes & Gordon, 1984; Illes, 1987).

That the PD patients in our study produced relatively more *open optional phrases* than the normal speakers, however, is not consistent with this hypothesis. Although the production of superfluous referential utterances such as open class optional phrases may be consistent with patients' inability to exit from their *cognitive loop,* it is in direct contradiction to any intrinsic deficit of lexical access; a significant increase in the production of nonreferential or automatic utterances such as interjections and modalizations would be the expected result. The contrary was found. Furthermore, the absence of any noteworthy aberrations in the occurrence of repetitions or aborted phrases is also evidence that, at least in the context of spontaneous language production, the divergence from normal patterns is not due to a primary deficit of lexical access or sentence planning and formulation in PD.

The occurrence of many open class optional phrases and the reduction in nonreferential utterances in the PD samples also describe a pattern of spontaneous language production that is divergent from the spontaneous language production of patients with other forms of neurodegenerative disease, such as Huntington's disease (HD) and Alzheimer's disease (AD). Both historical and contemporary reports have documented deficits of language in HD and AD (reviewed in Cummings & Benson, 1983). When tested on a neurolinguistic battery similar to the one described here, these patients produced significantly more closed class phrases and nonreferential utterances as compared with matched control subjects (Illes, 1987).

The second and alternative interpretation of the data presented here, therefore, favors the hypothesis that as the severity of the disease and dysarthria increase, PD patients adopt a strategy to convey as much information about a concept as possible, as compactly as possible, in a single sentence. PD patients appear to adapt to, or to compensate for, their mechanical difficulties by producing an increased number of open class optional phrases. The mechanical difficulties have been indexed by the acoustic measures and, in part, by the linguistic measures: relatively short chunks of uninterrupted speech and by silent hesitations occurring most frequently, and of longest duration, at the beginning of sentences. The relative reduction in modalizations and interjections also favors the adaptation hypothesis in that, because of their mechanical difficulty, it would be *inefficient* for PD patients to produce noninformative, extraneous speech.

The notion of *adaptation* is consistent with the distinction that Hughlings Jackson made in 1884 about positive and negative symptoms. Jackson suggested that negative symptoms result from the disease, and positive symptoms are the outcome of activity of the nervous system untouched by any pathological process. Therefore, while adaptive behaviors are abnormal in the statistical sense, they may be quite normal in the functional sense. It seems entirely reasonable to assume that PD patients attempt to remain functionally communicative within the constraints of their disease. This does not imply, however, that full awareness is a necessary condition for adaptation (i.e., that patients actually *intend* to produce a greater number of optional phrases), or that adaptation is necessarily a conscious process. As seen in both expressive (Goldstein, 1948; Heeschen, 1984; Kolk & Friederici, 1985) and receptive forms of aphasia (Butterworth, 1979; Illes, Nespoulous & Lecours, 1986), a wide variety of presumably unconscious strategies may be used by impaired speakers to cope with specific functional impairments in an endeavor to go on communicating through speech, and to react as well as possible to the demands imposed by the environment.

Whether the linguistic idiosyncracies demonstrated in the speech samples of PD patients in this study reflect an adaptive, compensatory mechanism to increasing speech-motor difficulty, or whether they are actually evidence of a language impairment intrinsic to the disease process remains an open question at this time. We are considering a number of studies designated to resolve these issues, including the assessment of the lexical frequency of words composing the open class optional phrases, applying the protocol to groups of female speakers, both normal and Parkinsonian, and comparing these data with samples of normal spontaneous speech of subjects under delayed auditory feedback. Other studies will follow naturally as the interplay between acoustic and linguistic variables in spontaneous language production become better understood.

REFERENCES

Albert, M. L. 1978. Subcortical dementia. In R. Katzman, R. D. Terry, & K. L. Bick (Eds.), *Alzheimer's disease: Senile dementia and related disorders,* New York: Raven, 173–180.

Austin, J. L. 1962. *How to do things with words.* Cambridge: Harvard University.

Bayles, K. 1984. Language deficits in Huntington's and Parkinson's disease. *Proceedings of the Academy of Aphasia,* Los Angeles.

Bayles, K., & Boone, D. R. 1982. The potential of language tasks for identifying senile dementia. *Journal of Speech and Hearing Disorders,* **47**, 210–217.

Bayles, K., & Tomoeda, C. K. 1983. Confirmation naming in dementia. *Brain and Language,* **19**, 98–114.

Benson, D. F. 1984. Parkinsonian dementia: cortical or subcortical? In R. G. Hassler & J. F. Christ (Eds.), *Advances in neurology.* New York: Raven. Vol. 40, pp. 235–240.

Boomer, D. S. 1965. Hesitation and grammatical encoding. *Language and Speech,* **8**, 148–158.

Bowen, F. P., Kamienny, R. S., Burns, M. M., & Yahr, M. D. 1975. Parkinsonism: Effect of levo-dopa treatment in concept formation. *Neurology,* **25**.

Bradley, D. C. 1978. *Computational distinctions of vocabulary type.* Cambridge, MA: Thesis. MIT.

Bresnan, J. 1982. *Mental representation of grammatical relations.* Cambridge, MA: MIT Press.

Butterworth, B. 1979. Hesitation and the production of verbal paraphasias and neologisms in jargon aphasia. *Brain and Language,* **8**, 133–161.

Chomsky, N. 1966. *Aspects of the theory of syntax.* Cambridge, MA: MIT Press.

Cummings, J. L., & Benson, D. F. 1983. *Dementia: A clinical approach.* London: Butterworths.

Darley, F. L., Aronson, A. E., & Brown, J. R. 1975. *Motor speech disorders.* Philadelphia: Saunders.

Ford, M. 1978. *Planning units and syntax in sentence production.* Ph.D. dissertation. MIT, Cambridge, MA.

Ford, M., & Holmes, V. 1978. Planning units and syntax in sentence production. *Cognition,* **6**, 35–53.

Goldman-Eisler, F. 1964. Hesitation, information and levels of speech production. In A. V. S. de Reuck & M. O'Connor (Eds.), *Disorders of Language.* London: Churchill. Pp. 96–111.

Goldstein, K. 1948. *Language and language disorders.* New York: Grune and Stratton.

Goodglass, H., & Kaplan, E. 1972. *The assessment of aphasia and related disorders.* Philadelphia: Lea & Febiger.

Grosjean, F., & Deschamps, A. 1975. Analyse contrastive des variables temporelles de l'anglais et de français: Vitesse de parole et variables composantes, phénomènes d'hésitation. *Phonetica*, **31**, 144–161.

Heeschen, C. 1980. Agrammatism in aphasia: An example of self-therapy in brain-damaged patients. *Proceedings on the Symposium of Mental Health: Choice or Fate*, Rotterdam.

Henderson, A., Goldman-Eisler, F., & Skarbek, A. 1966. Sequential temporal patterns in spontaneous speech. *Language and Speech*, **9**, 207–216.

Illes, J. 1987. *The structure of spontaneous language production in Alzheimer's, Huntington's and Parkinson's disease*. Ph.D. dissertation, Stanford University, Stanford.

Illes, J., & Gordon, W. P. 1984. Neurolinguistic defects of Huntington's disease. *Proceedings of the Academy of Aphasia*, Los Angeles.

Illes, J., Nespoulous, J. L., & Lecours, A. R. 1986. Hesitation patterns in neologistic jargonaphasia: A longitudinal study. *La Linguistique*, **2**, 75–93.

Jackson, H. J. 1884. The Croonian lectures on the evolution and dissolution of the nervous system. Reprinted in R. J. Herrnstein & E. G. Boring (Eds.), *A source book in the history of psychology*. Cambridge: Harvard University, 1965.

Joanette, Y., Keller, E., & Lecours, A. R. 1980. Sequences of phonemonic approximations in aphasia, *Brain and Language*, **11**, 30–44.

Kent, R. D., & Rosenbek, J. C. 1982. Prosodic disturbances and neurologic lesion. *Brain and Language*, **15**, 259–291.

Kolk, H. H. J., & Blomert, L. 1985. Word interference effect. *Brain and Language*, **26**, 94–05.

Kolk, H. H. J., & Friederici, A. 1985. Strategy and impairment in sentence understanding by Broca's and Wernicke's aphasics. *Cortex*, **21**, 47–67.

Kuhl, D. E., Metter, E. J., & Riege, W. H. 1984. Patterns of cerebral glucose utilization determined in Parkinson's disease by the (18F) fluorodeoxyglucose method. *Annals of Neurology*, **15**, 419–424.

Lecours, A. R., Lhermitte, F., & Bryans, B. 1983. *Aphasiology*. Sussex: Ballière Tindall.

Levelt, W. P. 1985. Lexical access in speech production. *Proceedings of the Workshop on Language Processing*. Center for the Study of Language and Information, Stanford University, Stanford.

Ludlow, C. L., & Bassich, C. J. 1983. The results of acoustic and perceptual assessment of two types of dysarthria. In W. R. Berry (Ed.), *Clinical dysarthria*. San Diego: College Hill Press.

Luria, R. 1966. *Higher cortical function in man*. New York: Basic Books.

Metter, E. J. 1985. *Speech disorders: Clinical evaluation and diagnosis*. New York: Spectrum.

Metter, E. J., & Hanson, W. R. 1986. Clinical and acoustical variability in patients with hypokinetic dysarthia. *Journal of Communication Disorders*, **19**, 347–366.

Metter, E. J., Riege, W. H., Kameyama, M., Kuhl, D. E., & Phelps, M. E. 1984. Cerebral metabolic relationships for selected brain regions in Alzheimer's, Huntington's and Parkinson's Diseases. *Journal of Cerebral Blood Flow and metabolism*, **4**, 500–506.

Nespoulous, J. L. 1979. De deux comportements verbaux de base: référentiel et modalisateur et leur dissociation dans le discours aphasique. *Société de Neuropsychologie de Language Français*, Paris.

Obler, L., & Albert, M. 1983. Language and aging: A neurobehavioral analysis. In D. S. Beasely & G. A. Davis (Eds.), *Communication processes and disorders*. New York: Grune & Stratton. Pp. 107–121.

Obler, L., Mildworf, B., & Albert, M. 1977. Writing style in the elderly. *Proceedings of the Academy of Aphasia*, Montreal.

O'Connell, D. C., Kowal, S., & Hormann, H. 1970. Semantic determinants of pauses. In G. B. F. d'Arcais & W. J. M. Levelt (Eds.), *Advances in psycholinguistics*. Elsevier: North-Holland. Pp. 218–223.

Pirozzolo, F. J., Hansch, E. C., Mortimer, J. A., Webster, D. D., & Kuskowski, M. A.

1982. Dementia in Parkinson disease: A neuropsychological analysis. *Brain and Cognition,* **1,** 71–83.

Scholz, O. B., & Sastry, M. 1985. Memory characteristics in Parkinson's disease. *Journal of Neuroscience,* **27,** 229–234.

Searle, J. R. 1977. *Speech Acts.* Cambridge: Cambridge University.

Teuber, H. L., & Proctor, F. 1964. Some effects of basal ganglia lesions in subhuman primates and man. *Neuropsychologia,* **2,** 85–93.

Tweedy, J. P., Langer, K. G., & McDowell, F. A. 1982. The effect of semantic relations on the memory deficit associated with Parkinson's disease. *Journal of Clinical Neuropsychology,* **4,** 235–247.

Webster, D. D. 1979. *Webster Rating Scale, Parkinson's disease patient evaluation.* New York: Endo Laboratories.