SPEECH AND PROSODY CHARACTERISTICS OF ADULTS WITH MENTAL RETARDATION

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Audio-recorded continuous speech samples from forty 20-50-year-old noninstitutionalized persons with mental retardation were selected from a database of 192 samples. Descriptive data on segmental and suprasegmental characteristics were obtained using close phonetic transcription as input to linguistic analyses software. For this sample of adults with mental retardation, speech and prosody status were not statistically associated with gender or gross level of mental retardation, but were associated with estimated probability of independent living. Speech and prosody analyses and content analyses of transcribers' comments yielded diacritic-level profiles of these speakers' linguistic and paralinguistic behaviors in continuous speech. Additional analyses of the error data tested alternative sources of processing involvement within a four-stage speech production model. A cognitive capacity constraint, which limits the speaker's ability to allocate resources to phonological encoding, is proposed as a sufficient explanation for the obtained pattern of token-to-token inconsistency of articulation. An additional sociolinguistic constraint is hypothesized to account for reduced prosodic and paralinguistic competence in continuous discourse. Both constraints are amenable to intervention programming. Findings fail to support the view that the potential for long-term speech prosody competence in individuals with mental retardation is limited by speech-motor constraints. Discussion includes intervention considerations in the context of current trends in special education.

KEY WORDS: mental retardation, speech disorders, prosody disorders, vocational, deinstitutionalization

Over a decade ago in a discussion of deinstitutionalization and normalization, Swetlik and Brown (1977) concluded that impaired language and communication skills "constitute major impediments to the social, emotional, and vocational adjustment of retarded citizens" (p. 39). Since the Rehabilitation Act of 1975 (Education for all handicapped children, 1975) and subsequent deinstitutionalization, however, the contribution of speech and prosody characteristics to an individual's community integration has yet to be closely studied. Rather, the past two decades of research in the communicative disorders associated with mental retardation primarily has provided descriptions of early speech development, early and later cognitive and language development, and alternative communication modes and devices. The following survey of research findings in mental retardation is limited to studies of speech and prosody characteristics from linguistic and social-vocational perspectives.

Linguistic Studies

Studies of the speech of persons with mental retardation can be divided into prevalence surveys and smaller group descriptive studies. The prevalence studies differ greatly from one another in subject composition (age, gender, intelligence level, etiology, child rearing, and living arrangements) and methodological approaches (type of speech sample, level of phonetic transcription, type of linguistic or acoustic analysis). Most of the prevalence studies predate deinstitutionalization, with findings reflecting subject characteristics and speech analysis procedures associated with research paradigms prior to the 1970s (Blanchard, 1964; Karlin & Strazzulla, 1952; Klink, Gerstman, Raphael, Schlanger, & Newsome, 1986; Lenneberg, Nichols, & Rosenberger, 1964; Reynolds & Reynolds, 1979; Schlanger & Gottsleben, 1957; Strazzulla, 1953). Depending on the age and intelligence level of the target group and the definition of speech errors associated with measurement operations, deviant speech patterns have been reported for as low as 5% and as high as 94% of individuals with mental retardation (see reviews of the survey literature in Keane, 1972; Matthews, 1971). Although differences in subject characteristics and methodological approaches prohibit detailed cross-study comparisons, the speech data from these large studies are consistent in one important respect. The error patterns of persons with mental retardation appear to be similar to those of young children acquiring speech normally. Across all levels of age, etiology, and intellectual involvement, the two most common error sites are consonant clusters in all word positions (deletion, substitution, and distortion of member sounds) and word-final consonant deletions. Four other error types, described in phonological process terminology as weak syllable deletion, stopping, fronting, and liquid simplification, are also reported to occur at high rates.

A second body of literature includes studies of smaller numbers of subjects whose speech has been studied more intensively, with most studies including only persons with Down syndrome. As with the large group survey studies, the most frequent conclusions from these studies is that the speech development and error patterns of persons with mental retardation are not qualitatively different from those of younger children acquiring speech normally (Bleile, 1982; Bleile & Schwartz, 1984; Bodine, 1974; Dodd, 1972, 1975, 1976; MacKay & Hodson, 1982; Moran, Money, & Leonard, 1983; Oller, 1975; Oller & Seibert, 1988; Prater, 1981; Prater & Swift, 1982; Smith & Oller, 1981; Smith & Stoel-Gammon, 1983; Sommers,
Patterson, & Wildgren, 1988; Sommers, Reinhart, & Sistunk, 1988; Stoel-Gammon, 1980, 1981; Van Borsel, 1988). However, a frequently expressed second conclusion is that the trial-to-trial responses to articulatory tasks of children with Down syndrome are more variable (Rosin, Swift, Bless, & Vetter, 1988). It is important to note that in attempts to address sources for both of these conclusions, few studies have used well-developed narrow phonetic transcription systems, with the obvious benefits for diacritic-level phonological analyses. Moreover, even the more recent studies have continued to use single-word responses obtained spontaneously and by immediate or delayed imitation. Given that the short-term imitative skills of persons with at least some types of mental retardation may be considerably better than their long-term psychomotor programming ability (Dodd, 1975, 1976; Frith & Frith, 1974; Henderson, Morris, & Frith, 1981), such procedures may overestimate “typical” performance (Morrison & Shriberg, 1989).

Prosodic studies of persons with mental retardation, including prevalence studies and smaller-group descriptive studies, focus most often on children with Down syndrome (Cabanas, 1954; Hollien & Copeland, 1965; Kimelman, Swift, Rosin, & Bless, 1985; Michel & Carney, 1964; Montague & Hollien, 1973; Moran, 1986; Moran & Gilbert, 1978; Novak, 1972; Pentz, 1987; Pentz & Gilbert, 1983; Schlanger & Gottsleben, 1957; Weinberg & Zlatin, 1970; Willcox, 1988; Zisk & Bialer, 1987). Most of these studies, which include findings for fundamental frequency, perceived voice quality, and dysfluency, conclude that children and adults with Down syndrome differ from controls on these vocal and rhythm characteristics. Although well-controlled studies have demonstrated statistically significant differences on such acoustic variables as formant amplitudes of vowels in citation forms (e.g., Pentz, 1987), no database is available on the prosodic characteristics of adults during continuous spontaneous conversation.

Within the methodological constraints noted above, findings from nearly four decades of speech and prosody research in mental retardation can be summarized as follows. As a group: (a) persons with mental retardation are likely to have articulation errors, (b) the most frequent type of articulation error is likely to be deletions of consonants, (c) articulation errors are likely to be inconsistent, (d) the pattern of articulation errors is likely to be similar to that of very young children or children with “functional” articulation delays, and (e) at least in persons with Down syndrome, prosody and segment-length samples of voice quality are likely to be perceptually and acoustically distinct.

Speech-motor control issues. In the context of the considerable body of work on the neuromaturational substrates of Down syndrome (e.g., Elliot, Weeks, & Elliot, 1987; Lincoln, Courchesne, Kilman, & Galambos, 1985; Pueschel, Gallagher, Zartler, & Pezzullo, 1987; Tannock, Kershner, & Oliver, 1984) researchers have suspected speech-motor control deficits as an important contributor to the linguistic deficits associated with Down syndrome (e.g., Rosin et al., 1988). In comprehensive reviews of alternative research models, Miller (1987a; 1987b) illustrates how deficits in speech-motor control might result in asynchronies among comprehension and performance variables in early cognitive-linguistic development. Much of the inference in such proposals predicts different phonetic and phonologic results corresponding to deficits at several levels of proposed speech production models (e.g., Kohn, 1988; Odell, McNeil, Hunter, & Rosenbek, 1990). Two relevant aspects of such inference models in the present context are the possible assumptions that (a) distortion errors implicate deficits at motor control levels, whereas substitution and deletion errors implicate higher-level difficulties generally termed phonological, and (b) some errors are more “natural” than others among all three error types, with non-natural errors more likely to implicate deficits in structural, sensory, or motor function. Each of these two premises requires brief discussion for the study to follow.

Perhaps the most active research pursuing the notion of phonetic versus phonologic levels of involvements is evident in the literature on apraxia of speech. McNeil’s (1988) review, for example, considers the types of speech data that have been used to argue for lower-level speech-motor planning and/or execution involvements in adults with apraxia, including evidence for muscle co-contraction (Fromm, Abbs, McNeil, & Rosenbek, 1982), noncategorical voice onset times (e.g., Blumstein & Baum, 1987), coarticulatory irregularities, and other dependent variables discussed also in a review by Keller (1987). Whether measured by perceptual, acoustic, kinematic, or physiologic procedures, the inference that abnormal findings on such dependent variables reflect lower-level control problems requires the assumption that a speaker’s phonologic organization and articulatory function were at one time normal. That is, for speech sound distortions to reflect only speech-motor encoding imprecision, rather than higher-level formation, storage, or processing deficits, the onset of the disorder must occur after the developmental period (nominally, 0–11 years; Kent, 1976; Sharkey & Folkins, 1985) rather than any time before normal speech was acquired. Note that during the normal developmental period, any child can conclude that dentalized /s/ or even nasally emitted vowels are the correct allophones to use unrestrictply or in certain phonotactic contexts. Alternatively, children can correctly induce from the ambient community the correct spatial target for /s/ or front vowel allophones, but be unable to realize them due to structural or neuromotor constraints.

The position taken here regarding the second premise, concerning the proposal of both natural and non-natural phonological processes, is that the distinction is useful and defensible on both theoretical and empirical grounds. Extended discussion of the theoretical assumptions of the natural phonological process approach in comparison to other clinical implementations of the construct of phonological processes (i.e., Donegan & Stampe, 1979; Stampe, 1969) is available elsewhere (Edwards & Shriberg, 1983; Shriberg, 1983; Shriberg & Kwiatkowski, 1980). The explanatory status of Stampe’s construct when applied to models of speech acquisition and performance has been the subject of considerable debate. Representative issues concern procedures to de-
termine (a) whether underlying lexical representations are intact (Elbert, Dinnisen, & Weismer, 1984; Fey, in press; Gierut, 1986), (b) whether organizational rules and processes at suprasegmental tiers influence segment-level processes (e.g., Chiat, 1983, 1989; Klein & Specter, 1985) and (c) whether simplifications and performance variability are explained by appeal to phonetic substrates underlying such terms as phonetic motivation (e.g., Ohala & Jaeger, 1986) or psycholinguistic constructs such as limited processing capacity (e.g., Prelock & Panagos, 1989). On empirical grounds, the large number of reports describing essentially similar error patterns across a variety of speech disorders in children and adults argues for the utility of some type of universalist notion of natural speech errors.

Later discussion will assume that the occurrence of natural surface-level deletions or substitutions is sufficiently explained by the construct of a cognitive processing constraint affecting speech acquisition and/or performance. Conversely, occurrences of non-natural (non-dialectal) deletions and substitutions are viewed as evidence for long-term or transitory structural, sensory-motor, or affective involvement.

Social-Vocational Studies

Training needs. The second body of relevant literature in the present context includes studies assessing the contribution of communication variables to the social adjustment and vocational success of adults with mental retardation. As described in several position papers (Greenspan, 1981; Landesman, 1986; Luftig, 1988), deinstitutionalization and mainstreaming of these individuals did not, by itself, eliminate their loneliness and other adverse effects of social isolation. Rather, it created a new set of social and vocational needs, such as those studied by Lovett and Harris (1987). These latter authors studied the self-perceived needs of 48 adults with mild to moderate mental retardation living in group and private homes. Respondents rated the need for competent vocational skills highest among vocational, social, personal, academic, and leisure skills. Social skills were rated second in importance; among the four social skills, “answering the telephone” and “good table manners” were rated as a more important need than “speaking clearly.”

Essentially similar findings in other studies (e.g., Foss & Bostwick, 1981; Greenspan & Shoultz, 1981) indicate that skills associated with finding and keeping a good job are foremost among the self-perceived needs of adults with mental retardation. Studies of such variables as communication skills and clear speech have treated these domains as macrovariables, referencing only global self-perceptions of speech, language, prosody, or interpersonal style. Metalinguistic awareness of differences in articulatory and prosodic variables is evidently an unstudied variable in these individuals. The result is that few data are available on the self-perceived role of speech and prosody in social-vocational communication.

With unemployment rates among adults with mental retardation four to five times the national average (Shafer, Hill, Seyfarth, & Wehman, 1987), many employer satisfaction studies have been undertaken to determine specific training needs. From the employer’s perspective the value of communication skills appears also to play a less important role in job retention than skills more directly related to productivity and reliability of performance (Bullis & Foss, 1986; Hill, Wehman, Hill, & Goodall, 1986; Salzberg, Lignugaris/Kraft, & McCuller, 1988). Because many jobs require only minimum verbal skills, reliable work habits and stable emotional behavior rank higher as more closely related to vocational success. Studies indicate that attractive appearance and apparent intelligence are associated with more frequent attention from staff members in group homes (Dailey, Allen, Chinsky, & Veit, 1974; Felce et al., 1987), but no data are available on possible associations among speech and prosody characteristics, perceived attractiveness, and social-vocational competence.

Gender issues. A perspective on some potential interactions of gender with social-vocational issues requires, first, some background on gender issues and speech development.

Speech acquisition studies have suggested that girls mature faster than boys in speech sound articulation (e.g., Davis, 1947; Templin, 1957). Following a recent metaanalysis of 165 studies not involving subjects with mental retardation, Shibbey-Hyde and Linn (1988) conclude that gender differences in verbal ability no longer exist in studies after 1973, with the possible exception of studies of speech acquisition. In a collaborative study of almost 20,000 three-year-old children, Darley and Fay (1980) report that boys had more difficulty than girls with tongue protrusion and lateralization tasks and Kenny, Prather, Mooney, and Jeruzal (1984) found that boys made more distortion and substitution errors than girls, while making equivalent percentages of deletion errors. Findings from the latter two studies have been interpreted as evidence that boys have slower neuromotor development, suggesting that gender differences may be due to different rates of phonetic, rather than phonologic development. However, in a test of this hypothesis with 58 children developing speech normally, Schwartz (1987) found no differences between girls’ and boys’ error rates for distortions of /s/, /r/, and /l/. Although none of the mean differences were statistically significant, all boys consistently had more distortions, deletions, and substitutions, which agrees with clinical data indicating a consistent 3:1 ratio of boys to girls enrolled for speech therapy (Shriberg, Kwiatkowski, Best, Hengst, & Terselic-Weber, 1986).

Returning to the mental retardation literature, gender differences for speech proficiency have not been reported with equivalent data on the relative importance of speech skills for gender-related social and vocational integration. Lovett and Harris (1987) found no significant differences between men’s and women’s perceptions of the relative importance of different kinds of skills, including communication skills. However, Richardson, Koller, and Katz...
(1988) found that significantly more females than males had jobs requiring interpersonal and verbal skills. There is some suggestion that speech skills may be particularly important for vocational opportunities available to adult females with mental retardation. As with adults without mental retardation, however, it may be the case that gender is no longer an important moderating variable for theoretical or applied issues in social-vocational functions.

Study Questions

The goal of this study is to provide in some detail a profile of the segmental and suprasegmental speech characteristics of a sample of noninstitutionalized adults with mild to moderate levels of mental retardation. The explanatory goals are to use these data as a base from which to consider both theoretical issues in accounting for any observed speech and prosody findings, and clinical issues relating findings to social-vocational function and intervention. Results will be organized in relation to three questions: (1) Is speech or prosodic status associated with gender or level of intellectual functioning? (2) Is speech or prosodic status associated with estimated potential for independent living? (3) Is speech or prosodic status adequately accounted for by cognitive-linguistic constraints or do the data suggest additional constraints in speech-motor processes?

METHOD

Speech Sampling

A total of 116 audio-taped speech samples were obtained from a sample of adults with mental retardation living in the Madison, Wisconsin, area. Subjects were noninstitutionalized, working at settings ranging from work activity centers to independent jobs in the community. Examiners were four research assistants participating in a larger study of the behavioral adjustment of 192 adults with mental retardation (Reynolds & Baker, 1988). The parent study attempted to sample persons from all the major agencies in the community that provided social-vocational services to adults with mental retardation. Topics in a structured interview procedure ranged from questions about work and social settings to inquiries about current feelings and social adjustment. Thus, the interviews included some topics not usually discussed in normal discourse. Each of the four examiners was assigned a well-maintained Marantz PMD 201 audiocassette recorder with matching Sony EC-3 external microphone and high quality TDK audiocassette tapes. The examiners were trained to use recording procedures consistent with those used in speech disorders research (Shriberg, 1986, Shriberg & Kent, 1982), including practice keeping microphone-to-mouth distance constant at approximately 15 cm.

From structured interviews with professionals and from case records reflecting a variety of primary sources, the examiners obtained subject data on gender, age, level of retardation, etiology, other handicapping conditions, medications, mental health status, self-care skills, social skills, present living setting, and present work setting.

Subject Selection

Due to the time-intensive tasks of narrow phonetic transcription and prosody judgments, the design of the study was to describe the articulatory and prosodic characteristics of 40 (21%) of the original 192 subjects in the Reynolds and Baker (1988) study. First, 116 of the 192 tapes (60%) were randomly selected as potential candidates for the eventual sample. Next, the 116 tapes were screened by one of the authors (CW), a certified speech pathologist, to remove from further consideration tapes that (a) had unacceptable signal quality or excessive background noise, (b) were from persons who were non-ambulatory, (c) were from persons who sounded frankly dysarthric (six tapes), using screening criteria in Darley, Aronson, and Brown (1975), (d) were from persons for whom records were not available on age, gender, race, or level of mental retardation, (e) were from persons outside the range of 20–50 years (excepting one 55-year-old needed for demographic balance), and/or (f) were from persons outside the range of mild to moderate levels of retardation, that is, excluding borderline and severe or profound involvement as determined by AAMD classification (Grossman, 1977) available in agency records. The age criterion was useful to minimize the effects of aging on perceptual evaluations of articulation and voice. The restriction for intellectual level was useful to allow generalization to the subsector of this population most likely to be in the work force. From the remaining pool of 89 eligible tapes, 40 samples were randomly selected to comprise four, 10-subject groups balanced by gender and the two levels (mild, moderate) of retardation.

Table 1 includes cross-tabulated subject descriptions and frequency distributions for the original 192 subjects and the 40 subjects selected for study. Descriptive data were not available for all categories for all subjects, but the unreported data do not affect study questions. A total of 22 of the original subjects (12%) were reported to have Down syndrome. The eight tape samples from these persons that were eventually retained for analyses (20% of the final sample) were distributed evenly across mild (four tapes) and moderate (four tapes) levels of mental retardation. A variety of living settings were represented in the original group: 32% were living in a group home, 26% in a structured community setting, 19% with parents, 5.7% independently in apartments, .5% (1 subject) commuted to work from an institution, with the remaining 15% in other living arrangements or unreported.

The final set of data in Table 1 are the distributions of subjects' assigned scores on the Estimated Probability of Independent Living Index (Reynolds, 1981). A score on this 5-point index was obtained from a professional who was familiar with the subject. Estimates of the person's probability of independent living were based on a wide
TABLE 1. Demographic information for the original group ($N = 192$) and the transcribed group ($n = 40$) of adults with mental retardation.

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</table>

spectrum of anecdotal information on the person's past and present adaptive functioning. Reynolds (1981) reports significant correlations \( r_s \) in the mid .60s) of these estimates with scores on the Personal Competency Scale (Reynolds, 1981) and the Adaptive Behavioral Scale (Nihira, Foster, Shellhaas, & Leland, 1975).

As shown in the paired data columns in Table 1, the 20% sampling design was successful in yielding a study sample that is generally comparable to the original population across each level of the demographic and case history variables.

Phonetic Transcription

The 40 continuous speech samples were transcribed by one of the authors (CW) using the narrow phonetic transcription system described in Shriberg and Kent (1982) and the response definitions described in Shriberg (1986). The transcriber, who was then functioning as a member of a phonetic transcription team in a child phonology research project, used well-developed methodologies for glossing, segmenting, transcribing, and formatting continuous speech for computer analyses (Shriberg, 1986; Shriberg, Hincke, & Trost-Steffen, 1987; Shriberg & Kwiatkowski, 1980; Shriberg, Kwiatkowski, & Hoffmann, 1984). All utterances meeting technical criteria were transcribed, with the exclusion of a few emotionally laden utterances (i.e., involving a register change) from several subjects that occurred in response to questions about feelings and social adjustment. All transcription was completed during a 5-month period using a regularly serviced Dictaphone 2550 audiocassette playback device in a sound-treated booth. A randomly selected 15-tape sample (38%) indicated that the transcribed speech samples averaged 12 minutes, with a range of 5–18 minutes.

Intrajudge and interjudge transcription reliability assessments were obtained on a randomly selected five-tape sample (12.5%) stratified by gender and level of mental retardation. The interjudge agreement estimate compared the original transcriptions with those completed by another transcriber working on a research project in child phonology. Point-by-point percentage of agreement figures were calculated by an application program (Shriberg & Olson, 1988) that yields consonant and vowel/diphthong agreement information based on both broad and narrow phonetic transcription. The overall intrajudge percentages of agreement for consonants, for narrow and broad levels of agreement respectively, were 77.5% and 90.3%. The overall intrajudge agreement for vowels, respectively, were 77.6% and 96.9%. Narrow and broad interjudge agreement for consonants, respectively, were 71.0% and 86.4%; for vowels, 85.0% and 96.8%. These data are consistent with previous studies in child phonology using narrow phonetic transcription (e.g., Shriberg et al., 1984; Shriberg, Kwiatkowski, Best, et al., 1986), with broad phonetic transcription figures in the low- to mid-90s averaging approximately 10–15 percentage points higher than narrow transcription of the same samples.

Speech and Prosody Analyses

The 40 transcripts were processed by a software package that yields several language and speech analyses (Shriberg, 1986). Relevant details for each speech analysis will be provided in the presentation of results.

Prosody data for the 40 continuous speech samples were obtained from an enhanced version of a procedure used in previous research with speech-disordered children (Shriberg & Kwiatkowski, 1982; Shriberg, Kwiatkowski, Best, et al., 1986). For the purposes of the present study the two authors and a research colleague (J. Kwiatkowski) extended the system for use with adults with mental retardation. The procedure provides percentage competence data in six prosodic domains: Phrasing, Rate, Stress, Loudness, Pitch, and Quality. The three judges rated each of these six suprasegmentals for 12
randomly selected utterances from each speech sample. A consensus procedure was used to assign a rating of 1 or 0 to each parameter, indicating "within normal limits" or "abnormal," respectively. Abnormal was defined in the training sessions as a suprasegmental difference that would call attention to itself in normal discourse, much as only certain articulatory differences (e.g., dentalized /s/, but not palatalized /s/) are considered "errors" in clinical speech pathology (cf., rationale in Shriberg & Kent, 1982). A second coding level was used to retain information on the bases for all 0 ratings. For example, quality ratings were supplemented by the examiners' entries of a common list of numbered codes for laryngeal and supralaryngeal behaviors (e.g., breathy, nasal). Although the inter-judge reliability for such response definitions in the voice literature has been low when assessed on a per-judge basis, consensual validity can be obtained from a panel of experienced judges. The prosody ratings used in all analyses reflected the consensus decision of the three judges, using non-independent, interjudge consensus procedures modified from Shriberg et al. (1984).

RESULTS

Organization and Statistical Analysis of the Speech Data

The organization of the speech and prosody measures was guided by the results of a recently completed principle components analysis of a database of 352 audiotaped continuous speech samples from speech-normal and speech-disordered children. Among a variety of potential hierarchical models of speech and prosody variables in continuous speech, these analyses support a partition of the speech data into three descriptive dimensions termed sociolinguistic, phonemic, and diacritic (see Kohn, 1988 for a generally comparable speech production model for analysis of phonologic deficits in aphasia).

Briefly here, the sociolinguistic domain includes 10 dependent variables that have unique conceptual and/or statistical variance in indexing a speaker’s severity of involvement (Shriberg & Kwiatkowski, 1982), including the percentage of vowel and consonant sounds articulated correctly, intelligibility of speech, and the six prosody variables. Scores on these 10 different speech and prosody variables are taken collectively to reflect a speaker’s sociolinguistic competence in continuous discourse. Specifically, they reflect a speaker’s ability to communicate and affect judgments others make of a speaker’s speech and prosody pattern in discourse settings.

The 10 variables within the phonemic domain include eight sound changes that can be attested as phonologically natural deletions and substitutions and that meet criteria for descriptive adequacy (Shriberg, 1983; Shriberg & Kwiatkowski, 1980; Shriberg, Kwiatkowski, Best, et al., 1986). The other 2 of the 10 categories account for the remaining non-natural deletion and substitution errors on consonant singletons and consonant clusters in the speech sample. These two categories can be viewed as reflecting the residuals among speech errors, including those speech sound changes not accounted for by one of the eight natural phonological processes. A speaker’s error profile across these 10 variables is viewed as diagnostic, in relation to reference data on children with normal speech acquisition and children with developmental phonologic disorders. Specifically, error profiles differing from the 92% of the reference data that can be accounted for by the eight natural processes are proposed to reflect mechanism, cognitive-linguistic, or psychosocial constraints not observed in early normal acquisition or in children with speech delays of unknown origin (Shriberg, 1982; Shriberg, Kwiatkowski, Best, et al., 1986).

Finally, the diacritic domain includes 10 classes of speech changes that reflect allophone-level errors (phoneme distortions) across phonetic feature classes and word position. The linguistic analyses software package (Shriberg, 1986) includes cross-tabulated outputs for distortions considered speech errors (e.g., lateralized /s/) as well as those that are perceptually notable, but not typically viewed as errors in the clinical speech pathology literature (e.g., palatalized /s/ (Shriberg & Kent, 1982; Shriberg, 1986). Both such articulatory differences might also have diagnostic significance, reflecting mechanism, cognitive-linguistic, or psychosocial constraints at a subphonemic level.

Preliminary inspection of the distributions of all dependent variables, including both the speech and prosody variables, indicated that these percentage data contained too many 0% and 100% scores for parametric statistics. Hence, all findings are based on the results of nonparametric, rank-order statistics implemented by the algorithms in SPSS-X (SPSS-X, 1988). Because of the number of statistical tests per analyses, all significance levels are considered advisory, with no attempt to limit reporting to only those p values meeting arbitrary family-wise criteria. The pattern of errors within and across dependent variable groups is the primary datum of this descriptive study, with exact p values included for all obtained differences at the .10 level and beyond.

Representativeness and Comparability of the Speech Samples

A series of one-way analyses of variance were first performed to ensure that the continuous speech samples from the four groups were structurally similar to available reference data on continuous speech samples and comparable to one another. Using the four-group, gender/level of mental retardation classification as the index variable, analyses were run for several descriptive variables that did meet criteria for parametric analyses, including the percentage of occurrence of each of 10 intended canonical form types, percentage of intended consonant types, average word per utterance, and type-token ratios. On all measures (the percentage data distributions did not require arcsin transformations), nonsignificant analyses indicated that speech samples from the four groups
did not differ from one another. Moreover, comparisons of these distributional data to continuous speech sample data from a group of normally speaking children (Hoffmann & Shriberg, 1982) and from a group of speech-delayed children (Shriberg & Kwiatkowski, 1983) indicated extremely similar descriptive statistics (means, standard deviations), with no statistically significant means differences. These preliminary analyses confirmed that the obtained samples did not differ structurally across gender or the two levels of mental retardation and that they were not structurally different from comparable reference data. Thus the continuous speech samples were structurally sufficient and representative for the needs of the speech and prosody analyses.

**Question 1: Gender and Level of Retardation**

The first study question concerning the association of gender and level of mental retardation with each of the 30 variables in the three speech and prosody domains was tested with Kruskal-Wallis One-Way Analyses of Variance by Ranks for each variable. Table 2 is a summary of the results, including trimmed mean (5% of the scores trimmed from each end of the distribution) percentage values, ranges, and two-tailed Kruskal-Wallis $p$ values at or beyond the .10 significance level (with $p$ values beyond .05 indicated by an asterisk). Following a series of comparisons of nonparametric inferential statistics (median, mode) to parametric statistics (mean, trimmed mean), the decision was to use the trimmed mean as the primary descriptive statistic for all groups in Tables 2 and 3 and all group trends in Figures 2, 4, 5, and 6. Compared to the mean, median, or mode, the 5% trimmed mean appeared to be most sensitive to differences in group profiles. Specifically, the mean was too sensitive to extreme scores and the median and mode were not informative for illustrating group profiles because of the large number of 0% or 100% scores per variable. Note also that the trimmed mean and range entries for the diacritic data were greatly attenuated, due to the need to base percentage calculations (i.e., the denominators) on all possible candidate phonemes for allophonic modification, even linguistically unlikely phonemes. As indicated by the nonsignificant nonparametric $p$ values for each of the 30 variables in Table 2, neither gender nor level of mental retardation was significantly associated with the speech or prosodic characteristics of these adult speakers.

**Question 2: Speech and Prosody as Communication Handicaps**

**Sociolinguistic Profile**

The second study question addresses potential associations between the speech and prosody characteristics of these adults and their probability of successful independent living. Given the nonsignificant findings for gender and level of mental retardation, results of the first analysis shown in Figure 1 reflect the performance of the entire group of speakers. Included in Figure 1 are box plots for each of the 10 speech and prosody variables that form the index of sociolinguistic competence. The five horizontal lines on each plot indicate respectively, the 90th, 75th, 50th, 25th, and 10th percentile, with data points above and below these values plotted as circles. Table 2 includes the trimmed mean percentages and range data for each of these 10 sociolinguistic variables. The following three observations concern the central tendencies (medians), the dispersion of scores (range percentiles and outliers), and the Quality scores.

First, using a conservative value of 85% or above as a cut-off point for "within the normal range" (cf., Shriberg & Kwiatkowski, 1982), the central tendency (50th percentile) speech and prosody values of these adult speakers were within the normal range on only four of the 10 variables. As shown in Figure 1, median percentage values were at 100% for utterances having appropriate Loudness and appropriate Pitch, and in the mid-90s for correct Vowels and percentage of Intelligible Words. For the remaining six variables, median percentages ranged from just below 85% (Consonant Singletons; Phrasing, Stress), to the mid-low 70s (Consonant Clusters; Rate), to 0% for utterances with appropriate Quality. Second, with the exception of the percentage of correct Vowels, the dispersion values indicated an extremely wide spread of scores for all variables. Interquartile ranges (25th–75th percentiles) were largest for Rate and Stress, with 10th–90th percentile spreads and single data points ranging well over 50 percentage points for most of these 10 speech and prosody variables. Finally, subsequent item level analyses of the Quality data indicated a variety of inappropriate vocal behaviors observed frequently throughout the speech sample. Most frequent were voices judged harsh, hoarse, and/or nasal.

To summarize the descriptive data to this point, the data in Figure 1 suggested a generally lowered group profile across the 10 indices of sociolinguistic competence. The diversity of individual competence profiles, however, was quite varied. Although only 1 of the 40 adult speakers in this sample had a voice quality judged normal on over 90% of the judged utterances, many had scores within normal limits for the other 9 variables.

**Estimated Probability of Independent Living**

The second analytic approach to the question addressed in this section was to reference speech and prosody data to subjects grouped according to an estimate of their probability of successful independent living. To provide adequate statistical power, the original five-level probability of independent living estimate (see Table 1) was collapsed to form two subgroups of approximately equal size. A Lower Probability group of 18 subjects was assembled, consisting of persons originally estimated to have less
Table 2. Descriptive and inferential statistics for the four gender-by-level-of-mental-retardation groups. All data are percentages; means are trimmed.

<table>
<thead>
<tr>
<th>Domains</th>
<th>Sociolinguistic</th>
<th>Phonemic natural processes</th>
<th>Other deletions and substitutions</th>
<th>Alllophonic</th>
<th>Epenthetics/Ties</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mild (n = 10)</td>
<td>Moderate (n = 10)</td>
<td>Mild (n = 10)</td>
<td>Moderate (n = 10)</td>
<td>p*</td>
</tr>
<tr>
<td></td>
<td>(\bar{x})</td>
<td>Range</td>
<td>(\bar{x})</td>
<td>Range</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vowel-Diphthong</td>
<td>95.07</td>
<td>90.48–100.00</td>
<td>93.16</td>
<td>83.64–96.38</td>
<td>96.30</td>
</tr>
<tr>
<td>Consonant Singletons</td>
<td>84.15</td>
<td>73.04–94.60</td>
<td>79.90</td>
<td>59.02–80.60</td>
<td>80.80</td>
</tr>
<tr>
<td>Consonant Clusters</td>
<td>80.63</td>
<td>50.00–94.03</td>
<td>67.58</td>
<td>33.33–83.46</td>
<td>74.05</td>
</tr>
<tr>
<td>Intelligibility</td>
<td>94.58</td>
<td>81.71–100.00</td>
<td>91.81</td>
<td>77.38–97.22</td>
<td>92.10</td>
</tr>
<tr>
<td>Phrasing</td>
<td>76.85</td>
<td>50.00–100.00</td>
<td>81.25</td>
<td>41.67–100.00</td>
<td>84.37</td>
</tr>
<tr>
<td>Rate</td>
<td>75.90</td>
<td>16.70–100.00</td>
<td>68.70</td>
<td>16.70–100.00</td>
<td>58.30</td>
</tr>
<tr>
<td>Stress</td>
<td>76.85</td>
<td>25.00–100.00</td>
<td>89.55</td>
<td>25.00–100.00</td>
<td>59.40</td>
</tr>
<tr>
<td>Loudness</td>
<td>96.50</td>
<td>75.00–100.00</td>
<td>88.54</td>
<td>16.67–100.00</td>
<td>91.67</td>
</tr>
<tr>
<td>Pitch</td>
<td>90.74</td>
<td>16.67–100.00</td>
<td>92.71</td>
<td>41.67–100.00</td>
<td>79.20</td>
</tr>
<tr>
<td>Quality</td>
<td>14.81</td>
<td>0.00–58.33</td>
<td>2.08</td>
<td>0.00–91.67</td>
<td>16.67</td>
</tr>
</tbody>
</table>

*Higher scores reflect percentage of correct segments (variables 1–3), percentage of intelligible words (variable 4), and percentage of utterances with acceptable prosody (variables 5–10). *Due to technical considerations some of the prosody comparisons include 1–3 missing subjects per group, with p-values adjusted accordingly. *Higher scores indicate percentage of occurrence of incorrect targets for each of the 10 variables. *Kruskal-Wallis One-Way Analysis of Variance by Ranks; * = p < .05.
than a 40% probability of successful independent living (Levels 1–2). The remaining 19 subjects, those perceived as having a greater than 40% probability of successful independent living (Levels 3–5), comprised the Higher Probability group. For reasons undocumented in subject folders from the original Reynolds and Baker (1988) study, scores were unavailable for 3 of the 40 subjects.

Descriptive data for the two groups and the results of Mann-Whitney Two-Sample Rank Order tests for the 30 speech and prosody variables are shown in Table 3. For the exploratory goals of the present study potentially reliable statistical findings for these estimate data are again provided for two-tailed p values of ≤ .10. Across the three domains, the trimmed means trends and several statistical findings suggest that persons estimated to have a higher probability of successful independent living have better speech and prosodic skills. A total of 9 of the 30 contrasts yielded p values less than .10, including 4 of the 10 sociolinguistic competence variables, 4 of the 10 phoneme-level errors, and 1 of the 10 diacritic-level error types. A total of 8 of these 9 speech and prosody comparisons favored the adults with higher estimated probability of independent living, with the only reversal being the curious trend (p < .068) for persons in the higher probability group to have lower rank-ordered performance scores on the prosodic variable Stress. The absolute magnitudes of some of the significant differences appear to be small, but it is not possible to estimate the clinical significance of mean differences at this level of the data.

These trends prompted additional analyses at subordinate levels of the three phonologic domains. Database information available at the feature class and error-type levels were inspected, again using Mann-Whitney tests with p values of ≤ .10 as advisory. These analyses included data for subtle distortions not usually considered socially unacceptable (e.g., palatalized /s/), as well as for allophonic changes that are usually considered clinically unacceptable (e.g., dentalized /s/). At the most general feature level, the group estimated to have a lower probability of independent living had more articulatory errors on both sonorants (p < .029) and obstruents (p < .039), both voiced (p < .073) and voiceless (p < .036) sound classes, and among six manner-class comparisons, with the class of stops (p < .039). Among 17 vowel/diphthong comparisons they had more errors on /a/ (p < .002), /aw/ (p < .012), /æ/ (p < .067) and /ay/ (p < .08). Among the 24 consonant comparisons the lower probability subgroup had more errors on /h/ (p < .002), /l/ (p < .048), /r/ (p < .064), and /w/ (p < .090). Finally, among 34 comparisons reflecting non-error, distortion-level sound changes, three potentially reliable differences suggested that the

**Figure 1.** Sociolinguistic performance data for 40 adults with mental retardation. Boxplots for each of the 10 speech and prosody variables include percentile values (horizontal lines) for the 90th, 75th, 50th, 25th, and 10th percentiles, with individual data points (circles) shown for scores above and below the 90th and 10th percentiles, respectively. Percentiles collapse for some variables, depending on their distributional character.
Table 3. Descriptive and inferential statistics for a comparison of subjects’ estimated probability of independent living. All data are percentages; means are trimmed.

<table>
<thead>
<tr>
<th>Domains</th>
<th>Lower Estimated Probability of Independent Living (n = 18)</th>
<th>Higher Estimated Probability of Independent Living (n = 19)</th>
<th>p^d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(\bar{x})</td>
<td>Range</td>
<td>(\bar{x})</td>
</tr>
<tr>
<td><strong>Sociolinguistic a</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Vowel-Diphthong</td>
<td>94.17</td>
<td>83.64–97.83</td>
<td>94.99</td>
</tr>
<tr>
<td>2. Consonant Singletons</td>
<td>78.83</td>
<td>59.02–86.52</td>
<td>83.59</td>
</tr>
<tr>
<td>3. Consonant Clusters</td>
<td>67.76</td>
<td>33.33–86.67</td>
<td>75.83</td>
</tr>
<tr>
<td>4. Intelligibility</td>
<td>89.09</td>
<td>49.28–97.79</td>
<td>93.98</td>
</tr>
<tr>
<td>5. Phrasing b</td>
<td>77.56</td>
<td>25.00–100.00</td>
<td>85.71</td>
</tr>
<tr>
<td>6. Rate b</td>
<td>76.92</td>
<td>16.67–100.00</td>
<td>64.29</td>
</tr>
<tr>
<td>7. Stress b</td>
<td>85.90</td>
<td>25.00–100.00</td>
<td>66.67</td>
</tr>
<tr>
<td>8. Loudness b</td>
<td>87.82</td>
<td>08.00–100.00</td>
<td>97.62</td>
</tr>
<tr>
<td>9. Pitch b</td>
<td>83.97</td>
<td>8.00–100.00</td>
<td>95.83</td>
</tr>
<tr>
<td>10. Quality b</td>
<td>4.49</td>
<td>0.00–75.00</td>
<td>16.67</td>
</tr>
<tr>
<td><strong>Phonemic</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>natural processes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Cluster Reduction</td>
<td>40.53</td>
<td>7.14–100.00</td>
<td>27.87</td>
</tr>
<tr>
<td>2. Liquid Simplification</td>
<td>14.42</td>
<td>0.00–50.00</td>
<td>16.75</td>
</tr>
<tr>
<td>3. Final Consonant Deletion</td>
<td>12.50</td>
<td>6.32–20.00</td>
<td>9.44</td>
</tr>
<tr>
<td>4. Stopping</td>
<td>9.92</td>
<td>0.00–42.11</td>
<td>8.07</td>
</tr>
<tr>
<td>5. Unstressed Syllable Deletion</td>
<td>5.96</td>
<td>0.00–20.00</td>
<td>2.55</td>
</tr>
<tr>
<td>6. Velar Fronting</td>
<td>3.12</td>
<td>0.00–37.50</td>
<td>0.00</td>
</tr>
<tr>
<td>7. Palatal Fronting</td>
<td>0.00</td>
<td>0.00–4.00</td>
<td>0.00</td>
</tr>
<tr>
<td>8. Assimilation</td>
<td>0.43</td>
<td>0.00–2.50</td>
<td>0.22</td>
</tr>
<tr>
<td><strong>Other deletions and substitutions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Singletons</td>
<td>5.13</td>
<td>2.15–21.43</td>
<td>3.57</td>
</tr>
<tr>
<td>10. Clusters</td>
<td>0.84</td>
<td>0.00–7.69</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Allophonic</strong> c</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Velopharynx</td>
<td>0.14</td>
<td>0.00–6.05</td>
<td>0.24</td>
</tr>
<tr>
<td>2. Lip</td>
<td>0.26</td>
<td>0.00–0.83</td>
<td>0.35</td>
</tr>
<tr>
<td>3. Stop Release</td>
<td>0.15</td>
<td>0.00–0.86</td>
<td>0.04</td>
</tr>
<tr>
<td>4. Juncture</td>
<td>0.17</td>
<td>0.00–1.17</td>
<td>0.22</td>
</tr>
<tr>
<td>5. Stress-Timing</td>
<td>0.10</td>
<td>0.00–0.83</td>
<td>0.07</td>
</tr>
<tr>
<td>6. Tongue Configuration</td>
<td>4.27</td>
<td>1.78–7.03</td>
<td>4.03</td>
</tr>
<tr>
<td>7. Tongue Position</td>
<td>0.05</td>
<td>0.00–0.72</td>
<td>0.12</td>
</tr>
<tr>
<td>8. Larynx</td>
<td>0.17</td>
<td>0.00–0.78</td>
<td>0.13</td>
</tr>
<tr>
<td>9. Strength</td>
<td>0.15</td>
<td>0.00–0.61</td>
<td>0.19</td>
</tr>
<tr>
<td>10. Epenthetics/Ties</td>
<td>0.61</td>
<td>0.00–2.51</td>
<td>0.32</td>
</tr>
</tbody>
</table>

^aHigher scores reflect percentage of correct segments (variables 1–3), percentage of intelligible words (variable 4), and percentage of utterances with acceptable prosody (variables 5–10). ^bDue to technical considerations some of the prosody comparisons include 1–3 missing subjects per group, with p-values adjusted accordingly. ^cHigher scores indicate percentage of occurrence of incorrect targets for each of the 10 variables. ^dMann Whitney Two-Sample Rank Test; * = p < .05.

lower probability group had proportionately more errors involving shortened vowels (p < .067), unreleased stops (p < .067), and palatalized fricatives (p < .062). Hence, compared with speakers whose estimated probability of success was above 40%, speakers with a less than 40% estimated probability of success had more speech errors divided among both vowels and consonants.

**Analysis of Transcriptionists’ Comments**

A third analysis series prompted by the statistical findings in Table 3 focused on the online anecdotal comments recorded by the transcriber as she completed narrow phonetic transcription. A provision in the software allowed for text strings to be entered adjacent to the gloss of words, with a system of abbreviation conventions used for efficiency (Shriberg, 1986). These included notations about sampling and transient recording conditions, additional categorization of phonetic and phonologic events not captured in the analyses programs, and description of any paralinguistic behaviors occurring during speech sampling.

Output from a Comments Analysis yielded relevant data (transcripts on which at least one comment had been entered) for 32 of the 40 samples, with randomized sampling for balance yielding 16 samples from each of the two probability of independent living groups. For comparison with these adult samples a group of 32 speech samples was randomly selected from a database of 64...
continuous speech samples from 3–6 year children with speech delays of unknown origin. Comparison of the type and frequency of transcriber comments to those made while transcribing speech-delayed children provides some estimate of the potential theoretical and clinical significance of the former (see below for extended discussion of this issue). Methods used to record, transcribe, and computerize these comparative reference data were similar to those used for the adult sample of 40 speakers (Shriberg, 1986; Shriberg & Kwiatkowski, 1982; Shriberg, Kwiatkowski, Best, et al., 1986). The second author, who was the transcriber in the present study, was also one of two consensus transcribers for the reference data. Although anecdotal comments of transcribers obviously lack an estimate of interjudge or intrajudge agreement, they do reflect the observations of well-trained research personnel who spent considerable time with each transcription and were blind with respect to the current concerns.

Table 4 is a summary of the Comments Analysis comparisons. Simple comments and percentage data are provided for each category of comment observed in the two data bases. All comments were sorted into three main categories: Speech-Prosody, Fluency, and Nonspeech Noises (a fourth category was used to annotate technical problems, for example environmental noises, overtalk). The additional subdivisions in Table 4 attempt to characterize the possible origins of each commented behavior, including speech-mechanism and linguistic processes.

To allow quantitative comparisons between the two probability of independent living groups, per-group percentages were calculated from the totals in Table 4. The percentages in the Speakers column reflect the contribution of each group to the total number of speakers who had at least one occurrence of a target comment in their transcript. The percentages in the Comments column reflect the contribution of each group to the total number of comment type occurrences. Using the combined tallies from both subgroups of adults with mental retardation, the same procedures were used to compare the comments entered for the 32 mentally retarded adult speakers with the comments entered for the reference sample of 32 speech-delayed children.

Entries in the left set of data columns in Table 4 indicated that neither probability of independent living group was clearly more involved than the other, with most percentages in the eight comparisons centered around the unconditional probability of 50%. With the exception of “nasal noises,” for which the majority of observations on speakers and comments were taken from the higher probability of independent living group, these anecdotal data suggested that the two estimated probability of independent living groups had essentially similar frequencies on seven of the eight types of commented behaviors.

Entries in the right set of data columns in Table 4, which compare comments made while transcribing the adult speakers to those made while transcribing children with speech-delays, suggest a clear difference in the pattern of percentages for the two groups. The speech-delayed children contributed the majority of the number of speakers and comments on two of the eight variables (ID. laryngeal-prosodic; IIA. language), whereas the adult group contributed the majority of the number of speakers and comments on four of the eight variables (IB. nasal noises; IIB. speech noises; IIIA. normal non-speech noises; and IIIB. inappropriate nonspeech noises). Thus, in comparison to children with developmental speech disorders, these adult speakers were observed to punctuate their continuous speech with a variety of suprasegmental and paralinguistic behaviors.

**Question 3: Evidence for Speech-Motor Constraints on Speech and Prosody**

**Rationale**

The third and most complex question posed of these data focuses on alternative explanations for these speakers' speech and prosody errors. As noted previously, speech-motor deficits would surely impact linguistic development, but few data are available that directly address the question. The following analyses are organized to present both additional descriptive findings and to interpret these data as either supporting or failing to support the hypothesis of speech-motor involvement. Figures 2, 4, 5, and 6 are comparisons of the trimmed means (henceforth, for convenience, means) for the present subjects with means data from the reference group of 64 children described previously. It is important to specify the rationale underlying the inferential model.

The first of the two interrelated premises underlying the comparisons in Figures 2–6 recalls the premise about the explanatory power of natural versus nonnatural speech sound errors discussed earlier. Briefly, the claim is that certain speech sound errors reflect cognitive processing demands for phonological encoding, whereas others may reflect lower-level speech-motor control problems. Specifically, information from a variety of sources suggests that deletion and substitution errors may result from limitations in processing capacity, while certainplace, manner, and timing distortions reflect speech-motor involvement. Ultimate confirmation of apparent speech-motor involvement would require both diachronic and synchronic information about whether underlying lexical representations and allophonic-forms were ever correctly acquired and supportive acoustic, kinematic, or physiological measures of the speech data. In the present data, all measurement is perceptual, and we have no information on early speech acquisition. Nevertheless, findings of certain consistent distortion errors in this group of speakers compared to reference data would provide a first step in support of the speech-motor hypothesis.

The second of the two hypotheses underlying the comparisons in Figures 2–6 is that the reference comparison data are veridical reflections of the linguistic performance in continuous speech of children with functional
TABLE 4. Summary statistics for two Comments Analysis comparisons. The middle columns are findings for the adult speakers divided into lower versus higher estimated probability of independent living groups. The columns to the right are findings for the group of adults with mental retardation compared to comparable findings from a sample of 3-6-year-old speech-delayed children.

<table>
<thead>
<tr>
<th>Category</th>
<th>Subtype</th>
<th>Sample Comments</th>
<th>Lower vs. Higher Probability of Independent Living Groups</th>
<th>Adults with Mental Retardation vs. Children with Delayed Speech</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Speakers Lower Group</td>
<td>Higher Group</td>
</tr>
<tr>
<td>Speech-Prosody</td>
<td>Phonemic</td>
<td>&quot;metathetic&quot; (within words)</td>
<td>13</td>
<td>54%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;assimilation&quot; (across words)</td>
<td>7</td>
<td>43%</td>
</tr>
<tr>
<td></td>
<td>Nasal</td>
<td>&quot;nasal release&quot; &quot;nasal voice&quot;</td>
<td>13</td>
<td>31%</td>
</tr>
<tr>
<td></td>
<td>Oral</td>
<td>&quot;unusual lateral&quot; &quot;noisy fricative&quot;</td>
<td>7</td>
<td>43%</td>
</tr>
<tr>
<td></td>
<td>Laryngeal-Prosodic</td>
<td>&quot;rushed&quot; &quot;mumbled&quot;</td>
<td>33</td>
<td>64%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;slow&quot; &quot;strained&quot; &quot;loud&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;voice break&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;whispered&quot; &quot;pitch&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals Speech-Prosody</td>
<td></td>
<td></td>
<td>66</td>
<td>53%</td>
</tr>
<tr>
<td>Fluency</td>
<td>Language</td>
<td>&quot;repetitions&quot; &quot;false starts&quot;</td>
<td>10</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;prolongations&quot; &quot;audible inhalations&quot;</td>
<td>41</td>
<td>61%</td>
</tr>
<tr>
<td>Totals Fluency</td>
<td></td>
<td></td>
<td>51</td>
<td>57%</td>
</tr>
<tr>
<td>Non-Speech Noises</td>
<td>Normal</td>
<td>&quot;laugh&quot; &quot;yawn&quot; &quot;sigh&quot;</td>
<td>17</td>
<td>65%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;throat clear&quot; &quot;cough&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inappropriate</td>
<td>&quot;grunt&quot; &quot;burp&quot; &quot;lip smack&quot;</td>
<td>37</td>
<td>60%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;snort&quot; &quot;sniff&quot; (unrelated to cold) &quot;tongue click&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals Non-Speech Noises</td>
<td></td>
<td></td>
<td>54</td>
<td>61%</td>
</tr>
</tbody>
</table>

*Transcriptionists used a set of abbreviation conventions (Shriberg, 1986) to enter many of these and other comments into the transcripts for computer processing. There were 16 subjects in both the Lower and Higher Probability groups (see text). There were 32 subjects in both groups (see text). To make the appropriate comparisons between adults and children, the original figures were adjusted for some comment types used in only one data set.
involvement (i.e., speech-only or speech-language delays). Results from extensive assessment protocols in associated studies indicated that these children did not have a clinically diagnosable structural, sensory-motor, cognitive, or affective disorder. Thus, the term functional, as an adjective modifying the speech errors observed in the reference data, is taken to mean that the source or origin of the errors is adequately accounted for by cognitive-linguistic delays associated with a failure in learning. Variants of such learning-based positions in the classic speech pathology literature (e.g., Milisen, 1954; Templin, 1957; Van Riper & Irwin, 1958; West, Kennedy, & Carr, 1947) are crucially dependent on the well-documented finding that developmental speech errors can be ordered on various gradients of phonetic difficulty (Locke, 1983; Stoel-Gammon & Dunn, 1985; Vihman, 1988). In the present context involving a general appeal to parsimony, the primary premise is that similar speech error profiles for the adult and child speakers in Figures 2–6 support at least a provisional assumption of similar causal antecedents. Alternatively, each statistically significant departure in the adult data from the corresponding child reference point will call to question the explanatory sufficiency of the cognitive-linguistic processing deficits associated with mental retardation.

With rationale for the following series of analyses based on these two premises, it will be argued that (a) the speech profiles of these adult speakers can be adequately accounted for by their cognitive constraint, which limits available resources for phonological encoding, and (b) the prosody and paralinguistic data presented in previous sections and certain of the speech data to be presented here suggest secondary involvements in sociolinguistic competence.

**The Phonological Process Data**

The averaged phonological process data in Figure 2 indicate that these adults with mental retardation have fewer phoneme deletion and substitution errors than the reference group of speech-delayed children. Differences are greatest for six of the seven left-most sound changes (excluding Final Cluster Reduction), which average from 10% to over 80% occurrence in the speech-delayed children. The essentially similar *shapes* of the two sorted distributions is interpreted as general support for the cognitive-linguistic account, with specific support suggested by each of the three data points at which there is a convergence of the two trends. Compared to the error trends for the children, the adults with mental retardation have higher than expected mean scores (i.e., reversals) in three process categories: from left to right in Figure 1 these are final cluster reduction, final consonant deletion, and unstressed syllable deletion (3+ syllables). By definition, final consonant deletion and unstressed syllable deletion involve *deletion* at a surface level of a singleton consonant or syllable that ~resumable~ is present at an underlying level. As discussed previously, the continuous speech data alone do not allow linguistic analyses to determine each speaker’s inventory of contrastive phonemes, possible lexical representations, or obligatory and

optional allophone rules. However, the transcripts clearly indicated both correct articulation and inconsistent deletions on the same word forms, indicating at least some level of representational adequacy in the underlying forms that underwent final consonant deletion (Gierut, 1985; Shriberg & Smith, 1983). Also for cluster reduction, the third convergence point in Figure 2, most error types involve deletion of one or more members of the cluster rather than substitutions (speech-sound distortions are ignored in the linguistic software's response definition for cluster reduction; Shriberg, 1986).

Considering that normal speech acquisition is characterized diachronically by decreasing consonant deletions, the persistence of consonant deletions into adulthood is consistent with information processing models that appeal to demand-limited resources as explanatory mechanisms. Extended discussion of such issues is deferred until after all findings have been presented. Here it is noted that rather than implicating unstable if not inaccurate underlying lexical representations, or difficulty assessing those representations, the inconsistent deletions of sounds and syllables are more consistent with problems at later stages of speech production. Three such possible stages are a morphophonemic stage, at which morphosyntactic processes transform an abstract allomorph to its appropriate morphophonemic representation; a phonetic assembly stage, in which lower-level feature specifications such as durational characteristics are assigned on the bases of language and dialectal rules; and an execution stage, in which these linguistic assignments are translated to speech-motor commands. The following subsections describe the results of three analyses to examine the evidence for involvement at the morphophonemic stage and speech-motor stage, with inspection of data for the phonetic assembly stage considered later.

**Morphologic load.** Both positive (e.g., Harris & McCade, 1988; Menyuk & Looney, 1972; Panagos, 1974; Panagos, Quine, & Klich, 1979; Paul & Shriberg, 1982; Prelock & Panagos, 1989; Schmauch, Panagos, & Klich, 1978) and negative (Archer, 1983) findings for the increased morphologic load hypothesis underlying articulation errors have been reported for young speech-delayed children, whereas findings for school-age children with residual /s/ distortions have all been negative (Cohen, 1978; Leonard & Ritterman, 1971; Lybolt, 1979; Mulroy & Hoffman, 1979). In the present context the significantly higher occurrence of final cluster reductions in these adult speakers with mental retardation might plausibly reflect speech production difficulties at this stage of processing. The data in Table 5 assess support for the morphologic load explanation of increased cluster reductions in these adult speakers compared to the trend for speech-delayed children. Percentages of correct clusters are shown separately for final clusters that do not have morphophonemic function compared to the three types of grammatical morphemes for which sufficient data were available, with further division according to the presence of /s/ or /z/ in the cluster. The total of 602 clusters available for this analysis were appropriately equally divided between monomorphemic-final clusters (321, 53.3%) and morphophonemic-final clusters (281, 46.7%). An additional tabulation of these entries indicated that clusters in all columns were distributed across sentence-initial, sentence-medial, and sentence-final positions.

Table 5. Percentage of correct monomorphemic final clusters compared to correct morphophonemic final clusters.

<table>
<thead>
<tr>
<th></th>
<th>Monomorphemic Final Clusters</th>
<th>Morphophonemic Final Clusters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Including /s/, /z/</td>
<td>Not Including /s/, /z/</td>
</tr>
<tr>
<td>No. Correct</td>
<td>131</td>
<td>190</td>
</tr>
<tr>
<td>59.9%</td>
<td>74.2%</td>
<td>68.2%</td>
</tr>
</tbody>
</table>
alveolar sounds, /d/, /l/, /r/, and the sounds /s/, /z/, and /l/. Relative to their phonetic difficulty, these errors are heterogeneous in both voicing and manner and the high involvement of alveolar consonants is statistically consistent with the high proportion of alveolars (25%) in English. More directly, these seven sounds are also among those with high percentages of deletions by the speech-delayed children whose data are shown in Figure 2, although some of the children also have a high proportion of deletions of nearly every eligible English consonant. In view of the spread of errors across place, manner, and voicing features and the similarity in type to those of young children with speech delays of unknown origin, the articulatory pattern of final consonant deletions does not appear to reflect motor-execution constraints motivated by a gradient of presumed phonetic difficulty.

To assess the possible evidence for a phonetic-load explanation in the cluster data, phoneme-level information was assembled on initial and final clusters from the continuous speech samples of the 40 adult speakers, the 64 speech-delayed children, and a group of 72 normally-speaking 3–6-year-old children (Hoffmann & Shriberg, 1982; Shriberg, 1986). Several lines of inquiry again failed to motivate a specific, phonetic-level explanation for the increased final cluster reductions in the adult speakers. First, in 3–6-year-old children who are either speech-delayed or acquiring speech normally, reduction of initial clusters occurs more frequently than reduction of final clusters. As shown in Figure 2, children with speech delays evidence word-initial cluster reductions more than twice as frequently (approximately 85%) in their continuous speech as word-final cluster reduction (approximately 40%), a ratio of 2.1:1. Note that the reverse situation obtains for the adults with mental retardation, with word-initial cluster reduction occurring approximately half as frequently (approximately 20%) as word-final cluster reduction (approximately 40%), a ratio of 0.5:1.

It is important to note here that other data from the children with speech delays of unknown origin also support the interpretation that deficits in cognitive-linguistic processing provide a sufficient explanation for the speech errors of the adult speakers. For the purposes of associated work, the speech-delayed children have been divided into those with language-production delays versus those with normal language production, on the bases of mean length of utterance, sentence structure stage, and grammatical morpheme use stage (Miller, 1981; Paul & Shriberg, 1982). Children with no language production delays, as categorized using the Shriberg, Kwiatkowski, Best, et al. (1986) procedures, have initial cluster to final cluster error (substitutions and deletions) ratios on these three language production variables of 2.3:1, 2.6:1, and 2.6:1, respectively. In contrast, children with productive language delays as indexed by these three variables have lowered initial cluster to final cluster error ratios of 1.7:1, 1.6:1, and 1.7:1, respectively. Hence, the overall initial cluster to final cluster error ratio of 2.1:1 reported above for these children reflects data averaged across children who do and do not have productive language delays. The present finding of a lowered initial cluster to final cluster error ratio of 0.5:1 in these adult speakers provides additional support for the primacy of the cognitive-linguistic processing deficit as a sufficient explanation for the final cluster errors.

Word-final cluster data. The third test of support for an execution-stage explanation of these speakers’ increased word-final cluster reductions was to examine the phonetic contexts in which deletions did and did not occur. The final cluster data were inspected from the perspective of a variety of literatures indicating that clusters containing homorganic sounds are more likely to be spoken with deleted sounds than clusters made up of heterorganic sounds (De Nil & Brutten, 1988; Haggard, 1973), with explanation generally focusing on speech-motor constraints. Figure 3 is a plot of the mean percent correct clusters divided into homorganic and heterorganic two-element clusters at each word position. Also shown are summary data points for three-element (termed multi-element) clusters, which did not occur with sufficient frequency to plot in initial, medial, and final position. Chi-square analyses indicated that the approximately 10-point gap between the percentage correct of final sounds in heterorganic compared to homorganic clusters was statistically significant in the medial position \( \chi^2(\text{df}=1) = 4.07; p < .05 \) and summed over all positions \( \chi^2(\text{df}=1) = 6.34; p < .02 \). As shown in Figure 3, the data points for all multi-element clusters are approximately 10 percentage points lower than the homorganic percentages. Item analyses of the individual words did not reveal particular patterns of deletions across phonetic classes. Hence, the cluster errors of these adults, averaging 70% for heterorganic clusters, 60% for homorganic clusters, and 50% for multi-element clusters, conform to available normative information on phonetic constraints affecting speech production in children.

Summary. Several forms of evidence support the primacy of these speakers limited phonological encoding capacities as a sufficient explanation for the phoneme deletion and substitutions subsumed by the construct of natural phonologic processes.

![Figure 3. Cluster data for 40 adults with mental retardation.](image-url)
First, the error patterns of these adult speakers across the eight natural process categories are essentially similar to those of children with phonologic delays of unknown origin. The eight natural process error types account for over 92% of the deletions and substitutions of these speakers, with less than 8% of the remaining errors considered uncoded by a natural process analysis. These figures are virtually identical to those obtained in a similar analysis of thirty-eight 3-10-year-old speech-delayed children (92% natural processes, 8% other; Shriberg & Kwiatkowski, 1983) and figures computed on the current group of 64 speech-delayed children (93% natural processes, 7% other), with the speech errors presumed to have their origins in some type of developmental delay affecting the encoding of phonological forms.

Second, the three major departures in the adult speakers' patterns compared to the speech-delayed children's primarily involve higher rates of deletions. Additional children's analyses indicated that these sound and syllable deletions fell within the class of natural phonological processes described above, with no evidence of a morphophonemic load gradient, or feature- or phoneme-level phonetic-difficulty gradient among the errors. The conditional probability of errors on final clusters with morphophonemic function was not different from the unconditional probability of all final cluster reductions. And, word-final singleton and cluster deletions occurred in all sentential positions and involved sounds that presumably are easy to articulate (e.g., /n/ and /t/) as well as those more typically observed in the residual articulation errors of non-retarded adults (e.g., /r/ and /l/).

These phoneme-level analyses fail to implicate difficulties at stages of speech production responsible for long-term underlying lexical representations, morphophonemic processing, or motor assembly. For convenience, it is useful to defer inspection of the evidence for diacritic-level processing deficits to later discussion.

The Consonant Data

Figure 4 provides the consonant error data, with mean percentage correct scores here reflecting sounds that were not deleted, substituted for, or distorted, with the latter class including traditional response definitions for distortions and additions used in clinical speech pathology (Bernthal & Bankson, 1988; Shriberg, 1986; Shriberg & Kent, 1982; Van Riper & Irwin, 1958). The profile for the reference group forms an essentially monotonic and fairly linear function from the nearly always correct glide /j/ to the seldom correct liquids /l/ and /r/ (including for completeness, the infrequent fricative /s/). For the present purposes, four consonant subgroups in the reference data may be discerned. These arbitrary divisions are suggested by visible knees in the curve in relation to useful percentage correct boundaries on the ordinate. The first group consists of the eight sounds averaging 80%–100% correct in speech-delayed children, with successive groups comprising a 6-member 60%–80% correct group, a 2-member 20%–40% group, and an 8-member 0%–20% group. This four-group division corresponds extremely well to the normal speech acquisition mastery data, with the rank ordering of correctly articulated sounds defying simple explanatory account by manner, place, or voicing features. It is exactly the parallel between this function and the age-referenced normal mastery data (e.g., Arlt & Goodban, 1976; Prather, Hedrick, & Kern, 1975) that supports the claim that these speech-involved children are best viewed as having a speech delay, rather than a disorder. For the most part, their
errors are those that typically are seen in younger children acquiring speech normally. To the extent that the speech profile for the adults with mental retardation is similar, the inference would be that their errors, too, reflect cognitive processing constraints rather than motor execution or more peripheral structural constraints.

For the first two consonant groups in the reference profile in Figure 4, the eight sounds averaging 80%–100% correct and the six sounds averaging only 60%–80% correct, three reversals in the adult speakers' trend are most notable. Lower average correct rates were obtained for /dl/, /l/, and /n/. The lower scores on the cognate stops and velar nasal are readily accounted for by the previous data on deletion of final consonants and final consonant cluster reduction. Additional analyses indicated that whereas each of these three sounds was 71%–90% accurate word-initially and word-medially (/n/ is not distributed word initially), they averaged only 67–73% correct word-finally, with deletion errors accounting for 16%–26% of all errors.

For the lowest two consonant groups in Figure 4 (i.e., the two affricates within the 20%–40% boundary and the eight sounds averaging 0%–20% correct) lowered scores approaching the children's occur on /dz/, /z/, /t/, /l/, and /n/, with notably higher trends including data points for the five sounds /s/, /z/, /l/, and /g/. The lower scores on the cognate stops and velar nasal are readily accounted for by the previous data on deletion of final consonants and final consonant cluster reduction. Additional analyses indicated that whereas each of these three sounds was 71%–90% accurate word-initially and word-medially (/n/ is not distributed word initially), they averaged only 67–73% correct word-finally, with deletion errors accounting for 16%–26% of all errors.

These consonant data are interpreted to be generally consistent with the persisting cognitive-linguistic constraints associated with mental retardation on two accounts. First, as with the phonological process data, the consonant error profile in Figure 4 generally shadows the profile of a group of children whose speech delays of unknown origin are assumed to reflect cognitive-linguistic delay. The reversals in the trends for /dl/, /l/, and /n/ were confirmed to reflect the final consonant deletion errors discussed in the section on phonological processes, with additional analyses indicating that the lowered accuracy was not due to distortions more typical of sensory-motor or structural speech involvement. Second, the remaining differences indicating less involvement in sibilant and liquid /l/ distortions suggest that these adults at least eventually have sufficient motor control to habituate variably correct sibilants and liquids in continuous speech.

The Vowel Data

Figure 5 includes the mean vowel data for the adults with mental retardation, compared with the sorted vowel data for the group of 64 speech-delayed children. Trends for the 16 vowel/diphthong comparisons yield essentially similar profiles, but as with the process and consonant data, the adult speakers have more accurate articulation than the children. With some small differences, but no visibly significant reversals, the adult speakers' distribution of total errors appears to be intermediate between that expected from non-involved adult speakers and the speech-delayed children. A total of 5 of the 11 vowels do not maintain the performance gap observed between all other points among the two trend lines. From left to right in Figure 5 the five vowels/diphthongs are /i/, /u/, /a/, /au/, and /u/. Four of these vowels/diphthongs (excepting /a/...
and including the second member of the diphthong /ʊ/ involve high tongue placement. Otherwise, they include both front and back tongue cavity placement and tense and lax intrinsic tongue configuration. To attempt to determine if they might share some articulatory feature at the level of error type, the diacritic-level modifications occurring on these five vowels/diphthongs were inspected. The linguistic software provided output that included both sounds considered phonemic distortions and sounds considered modified, but not tallied as distortions. Close review of these data did not suggest a reliable pattern of modifications for these five vowels/diphthongs, with inconsistent modifications (on a vowel/diphthong in the same and different words) including lowering, raising, centralizing, nasalizing, glotalizing, and other supralaryngeal and laryngeal sound changes.

The error data in Figure 5 are viewed as generally consistent with the primary cognitive-linguistic deficit, with no evidence for specific structural or speech-motor involvements affecting vowel articulation. Moreover, although these speakers make more total vowel errors than presumed normal for adults, their correct forms suggest that they have acquired the allophone-level English vowel rules affecting articulatory place and duration.

The Diacritic Data

Figure 6 includes diacritic data for the two groups, with the sorted percentages of occurrence for the child database forming the comparison function. Included are data points for 34 of the 45 diacritic symbols described in Shriberg and Kent (1982), with the other 11 symbols not relevant in the present context. As referenced above, the software tallied and percentaged the occurrence of a diacritic only if the transcriber had indicated that a sound was inappropriately modified, (i.e., a speech sound distortion). The absolute percentages for the 34 diacritics are low because they are calculated over all sounds in the transcript. Hence, for example, the approximately 1% occurrence of the dentalized [t] diacritic in the children's profile is based on all consonants, vowels, and diphthongs in the transcript, rather than on only eligible or likely sounds such as fricatives or fricatives in certain environments. Although the magnitude of available class- and sound-level percentages obviously is larger for each diacritic, the current analytic need for overall profile comparison is better served by the attenuated, but inclusive, percentages graphed in Figure 6.

As shown by the profiles of the two trends in Figure 6, the two common allophone-level errors in children—dentalized sibilants and derhotacized /r/, /l/, and /w/—are also the two most prevalent distortion types in the adults. However, dentalization, presumably on fricatives, is proportionally lower, with derhotacized sounds proportionally more pervasive in the adults than in the speech-delayed children. The remaining diacritic data indicate essentially similar trends for the two groups, with no notable reversals within the narrow range of involvements as plotted here.

DISCUSSION

METHODOLOGICAL ISSUES

The discussions of theoretical and clinical issues to follow should be viewed within constraints of the meth-
Personal adjustment. Although the resulting data might never have been seen in vocational and social settings. It also must be divided into mild and moderate levels of retardation and higher and lower estimated probability of independent living, these divisions may not have been sufficiently sensitive to differences that are important in the context of the current study.

2. Conversational speech samples continue to be used in contemporary mental retardation studies of dysfluency (e.g., Wilcox, 1988), and language production (e.g., Rosenberg & Abbeduto, 1987), but articulation tests remain the most common clinical and research technique for assessing speech (Kumin, 1986). The continuous speech sampling situation in the present study was typical, with subjects asked to respond to questions about personal adjustment. Although the resulting data might fairly reflect a conservative estimate of typical performance, it is also possible that the sampling situation engendered in at least some subjects speech behaviors never seen in vocational and social settings. It also must be recognized that continuous speech samples obtained in clinical contexts may underestimate at least the mean length of turns compared to samples taken in home contexts (Bedrosian & Prutting, 1978). On balance, however, the continuous speech sample is seen as preferable to alternative modes of speech testing with persons with mental retardation; see discussions of possible validity problems with delayed imitation (Klink et al., 1986), carrier phrases (Kimelman et al., 1985), narratives (Schlanger, 1953), and oral reading (Weinberg & Zlatin, 1970).

3. The speech and prosody data in the current study are taken from perceptual instruments, unsupported by acoustic data. Although most of the large-scale work in speech disorders has a similar limitation (Lof & Shriberg, 1989), the vowel, diacritic, and suprasegmental data of this study must be regarded with special caution given the lack of a concurrent validity estimate and lowered reliability coefficients. As presented previously, reliability of the vowel data at the level of narrow phonetic transcription is lower than the consonant data. More generally, the validity of the diacritic symbols used in this and associated studies has yet to be substantiated by correlative acoustic data. The prosody assessment procedure has undergone extensive revision, with emerging data indicating acceptable validity and reliability coefficients (Shriberg, Kwiatkowski, & Rasmussen, 1989a; 1989b).

4. The linguistic analyses obtained from the software used in this study can be described as "relational" (Stoel-Gammon & Dunn, 1985), with no attempt to provide per subject independent data on phonetic inventories, canonical forms, or sets of contrastive phonemes. It is possible that subject-level linguistic analyses would provide additional or alternative views on the phonological systems of the 40 subjects.

5. No information on language comprehension or language production variables is available in the present data. Measures such as mean length of utterance and estimates of sentence complexity were not appropriate to derive from the speech sample, due to the question-answer format and limitations in number of utterances per sample (Miller, 1981). Hence, it was not possible to test potentially interesting associations among speech and prosody variables and subjects' language comprehension or language production status (cf., Miller, 1987b).

6. The current study does not differentiate the data from the 8 speakers with Down syndrome from those of other speakers. The demographic heterogeneity of both this smaller sample and the remaining 80% of subjects prohibited meaningful comparative subgroup analyses.

Theoretical Issues

The three major descriptive findings in the speech data are the high rates of deletion errors (including final consonant deletions, cluster reductions, and syllable deletions), the overall inconsistency of token-to-token performance, and the presence of vowel errors. The first two findings, consonant deletions and inconsistency, are entirely consistent with the prior speech literature in mental retardation, including both the large-group survey studies and the small-group linguistic analyses. Given that these data were obtained in continuous speech contexts in which subjects were engaged in highly propositional discourse, both findings are viewed as support for the primacy of these individuals' cognitive-linguistic deficits affecting both phonological acquisition and performance. The interpretation proposed here is that the trend for word-final, inconsistent consonant deletion errors is consistent with a processing constraint affecting the motor assembly stage of speech production. Rather than reflecting problems with the establishment, selection, or access of lexical representations, or with the avoidance of
phonetically difficult consonants—the evidence for each having been negative—the data suggest that word-final units were simply more vulnerable in the word-assembly process than earlier units in the precommand string.

The presence of vowel errors (Figure 5) and certain of the diacritic-level data (Figure 6), if interpreted as reflecting phonetic imprecision, could be viewed as evidence for early and persisting speech-motor control problems. Whereas the early vowel/diphthong errors of normally speaking and functionally speech-delayed children presumably do not persist into adulthood, these adults with mental retardation had perceptible articulatory modifications of vowels and diphthongs. Although these speakers did not have proportionally more diacritic-level errors than the children, 1 speaker had 12 nasal emission errors and another speaker had 40, suggesting the possibility of velar control problems in at least these 2 speakers.

Note that the hypothesis of a phonological encoding deficit introduced at the outset of this paper includes the assumption that most of adult speakers in the present study did not undergo normal speech and language acquisition. Rather, they presumably experienced delays in both the cognitive-linguistic development subserving the acquisition of phonological organization and word forms and in maturation of the articulatory systems subserving speech production. Accordingly, speech sound distortions in the present speakers are not explained by calling them articulatory or phonetic, rather than phonological errors. In a developmental, rather than acquired disorder, all three error types—distortions, substitutions, and deletions—might, in fact, be attributed to imperfect phonologic representations, incomplete allophone rules, and/or deficits in motor planning or execution. Only certain distortion errors might be motivated from neuromotor (e.g., gesture reduction: Keller, 1987) or peripheral (e.g., velopharyngeal sufficiency: Trost, 1981; Warren, 1986) perspectives, compared to place distortions that can as readily be motivated from psycholinguistic learning perspectives (e.g., dentalized, lateralized, derhotacized, and so forth). In the present context, it is the token-to-token inconsistency of all errors that provides the strongest rationale for viewing even the vowel/diphthong distortion errors as products of cognitive processing deficits, rather than speech-motor processing constraints.

Finally, the prosody data (Figure 1) and the assembled comments by the transcriber on paralinguistic behaviors (Table 4) present another challenge to the sufficiency of the limited cognitive processing resources hypothesis. Many speakers in this sample had notable involvements in phrasing, rate, and stress, and nearly all had a perceptible difference in vocal quality. As in the adult neurogenic literature (e.g., Kent & McNeil, 1987; Kent & Rosenbek, 1982) such abnormal suprasegmental characteristics might provide a window on neural substrates associated with motor control deficits. Again, however, it cannot be inferred from these perceptual data alone whether the lowered performance is due to faulty mechanisms or faulty learning. Most of these individuals were at least at some time institutionalized, with the obvious implication of poor models for normal discourse. More clearly, the prevalence across speakers and high frequency of occurrence of certain non-speech behaviors (Table 4: IIIA and IIIB) suggests deficits in pragmatic knowledge and monitoring during person-to-person discourse. Informative technical descriptions of all such behaviors must await well-controlled studies using discerning observational instruments.

The interim conclusion here is that these speakers’ speech errors are consistent with a primary cognitive deficit affecting phonological encoding, with their prosodic and paralinguistic differences reflecting a persisting sociolinguistic constraint. Irrespective of theoretical origins, these speech, prosody and paralinguistic deficits have significant implications for clinical issues, the topic of some final considerations.

**Clinical Issues**

*The Perception of Social-Vocational Competence*

Several findings of this study suggest an association between these adults’ speech and prosody characteristics and their potential for successful social-vocational adjustment. To the extent that speech and prosody variables mediate the perception of social-vocational competence, the negative findings for gender and level of mental retardation suggest that findings can be generalized to all adults with mental retardation having demographics similar to those sampled in this study. In particular, the negative findings for level of intelligence are informative for social-vocational issues, although their potential theoretical value is lessened by the lack of better measures of intelligence. Inspection of individual subjects’ error patterns in the present study indicated virtually no relationship with level of mental retardation. Mackay and Hodson (1982) also found no differences in either the severity or the pattern of speech errors in children with Down syndrome enrolled in classes for educable compared to trainable educational levels. For the purposes of continued study and within the methodological constraints listed above, it is interesting to speculate on possible clinical implications of the findings.

*Speech error patterns.* One possibility consistent with the current data is that speech and/or prosody characteristics do have a significant influence on the perception of social-vocational competence. The assumption that any type of clinically defined speech error contributes to perceived social and vocational competence is only indirectly supported in the speech pathology literature (e.g., Mowrer, Doolan, & Wahl, 1974; Silverman, 1976) and no pertinent studies have been reported in the mental retardation literature. Traditional approaches to articulation testing in children weight deletions, substitutions, and distortions in decreasing order relative to their effect on perceived deviance (Jordan, 1960), but the empirical support for such claims is not strong. Nevertheless, it is interesting to pursue a speech-mediational perspective in
relation to the array of between-group differences reported above.

The most prominent differences in the lower and higher estimated probability of independent living groups are the obtained differences in the percentages correct for consonants, consonant clusters, and unstressed syllable deletion, with the marginally significant difference in intelligibility (see Figure 1) providing the most direct metric of sociolinguistic competence. These same errors are seen in young speech-delayed children, but are not typically observed otherwise in adults with residual articulation errors. Perhaps even more suggestive are the advisory statistical differences and between-group error trends associated with vowels and stops (see Table 2). Vowels and stops are among the earliest sound classes to emerge correctly in normal speech acquisition. Moreover, when the error types of speech-delayed children are described in allophonic detail, vowels and stops are less often and less severely involved than fricatives, affricates, and liquids (Shriberg, Kwiatkowski, Best, et al., 1986).

From a speech-motor control perspective, vowel- and stop-error profiles in the speech of children or adults generally are prominent only in the presence of structural (e.g., Phillips & Harrison, 1969), sensory (e.g., Osberger & McCarr, 1982), or motor (e.g., Darley et al., 1975) involvements. From a sociolinguistic perspective, vowels play the primary role in dialectal and social registers, as well as providing the prosodic medium to convey affect. Hence, the findings for vowels and stops could suggest that involvements within these feature classes may be particularly costly for the perception of communicative competence. Together with the general profile of deletions of final consonants, deletions in final clusters, and unstressed syllable deletion, phoneme- and diacritic-level errors on vowels and stops may contribute more to perceived deviance than the residual consonant articulation errors (e.g., dentalized and lateralized /s/, derhotialized /t/, vowelized and velarized /I/) normally retained in some adults and documented in prevalence studies of non-retarded persons in this age group. Alternatively, of course, the significant associations between the obtained error patterns and estimates of probability of independent living may be only correlative, with other salient factors in these adult speakers mediating the informants' social and vocational competence estimates.

**Prosody.** The findings for prosody have clear implications for social perceptions. Within the methodological limitations listed above, perceptible deviations from normal voice quality were apparent in the continuous speech of over 80% of these adult speakers. Many speakers also had deviant phrasing, rate, stress and/or oral communication parameters that presumably are strongly associated with perceived communication competence, as well as more general impressions of intelligence, ability, and social attractiveness (cf., Seigman & Feldstein, 1987).

**Paralinguistic patterns.** The annotated comments of the transcribers are viewed as important data bearing on perceived social competence. The two probability of independent living groups did not differ in their percentages of inappropriate verbal-vowel behaviors; as above, methodologic considerations might have limited the sensitivity to real differences in these data. For the adult-child comparisons, clear differences in the proportion of nonspeech noises, in particular, suggests that many adults with mental retardation have paralinguistic behaviors that detract from their perceived competence. At even low rates of occurrence in continuous speech, such behaviors presumably violate the pragmatics of normal discourse. Taken together with speech findings and the prosody findings, speakers who also evidence difficulty monitoring sociolinguistic conventions would likely experience considerable difficulty in both social and vocational contexts.

**Implications for Intervention**

The segmental and, particularly, the suprasegmental error patterns of most of these individuals impressed the authors as handicapping for successful vocational and social functioning. As Siegel demonstrated over two decades ago in a series of elegant studies (e.g., Siegel, 1967), the perception of mental retardation biases the form and content of dyadic communication. Such considerations provide rationale for efforts to normalize, including reduction of distracting gestures (e.g., Farkas, Munro, Chir, & Kolar, 1985; Rudrud, Ziarnik, & Coleman, 1984) and choice of conversational topic (e.g., Wildman, Wildman, & Kelly, 1986). The outcome of the training study by Wildman, Wildman, and Kelly led these researchers to conclude: "... community dwelling mentally retarded adults can be taught to make changes in their conversational behavior that are viewed positively by others living in their communities" (p. 443). In the opinion of the present authors, the intelligibility and especially the social acceptability of these speakers' conversational exchanges could be improved markedly if normalized by more fine-grained attention to allophone-level precision, prosodic patterns, and the elimination of distracting paralinguistic behaviors. Unfortunately, this recommendation runs counter to contemporary trends in both special educational policy and cognitive-learning research in mental retardation, trends that warrant brief consideration.

**Special education issues.** The argument that it is ineffective and inefficient to target articulation for intervention in mental retardation dates back to several influential positions advanced until the mid-1960s. In contrast to the more optimistic conclusions reached by Schneider and Vallon (1954) and Schlanger (1958), Immel (1947), West et al. (1947), and Wilson (1966) were among the researchers who concluded that progress in typical speech management contexts was ineffective or too slow with children with mental retardation (primarily Down syndrome) to justify intensive services. Such conclusions seem to be based on both the available data on improvement rates, using the intervention technologies of the time, and the inference of both cognitive-linguistic and speech-motor involvements in these children.
From a different perspective, more current intervention movements associated with the terms deinstitutionalization, mainstreaming, transitioning, quality of life, and best practices have contributed to the perspective that molecular work on speech articulation is simply not a high priority for persons with exceptional educational needs. In comparison to time spent on language form, content, and use (e.g., Bedrosian & Prutting, 1978), as well as adaptive, social, and vocational skills (e.g., Matson & Ollandick, 1988; Matson, Manikam, Coe, Raymond, Taras, & Long, 1988; Owings & Guyette, 1982; Wildman et al., 1986), articulation drills are viewed as low priority, if not an inappropriate use of an increasingly shrinking pool of special education teachers and related community agency resources (cf., Education of the Handicapped, 1988). Implicit in these views is an assumption that speech-motor deficits limit the expected long-term performance levels that can be achieved by persons with mental retardation. With the exception of the period of behaviorist-oriented articulation programming of the 1960s and 1970s, current intervention emphasis is focused on those functional skills that will best prepare persons for community integration (cf., Trent, Green, & Evans [1987] for a useful review of assessment tools). As a gross comparison with contemporary curricula in regular education, this special education move away from work on speech sounds is consistent with trends in general education that also deemphasize basics (i.e., grammar, spelling, and geography) in favor of courses that have more social and vocational relevance.

Cognitive-learning issues. In addition to educational policy issues, cognitive-learning issues are important to consider in formulating intervention suggestions for persons with mental retardation. In addition to structural, sensory, and motor involvements discussed earlier, the information processing difficulties of persons with Down syndrome have been attributed to deficits in many psycholinguistic processes, including auditory processes (e.g., Eilers, Moroff, & Turner, 1985; Merrill & Mar, 1987; Pueschel et al., 1987), imitative processes (Lustman & Zigler, 1982), memory processes (e.g., Ellis & Wooldridge, 1985; Ellis, Deacon, & Wooldridge, 1985; Varnhagen, Das, & Varnhagen, 1987), and sequencing processes (e.g., Dodd, 1975; Rosin et al. 1988). Each of these psycholinguistic variables has fundamental implications for the content and form of intervention. Given the reported difficulty in generalization, the most general suggestion is that speech and particularly prosody may be difficult intervention targets for persons with mental retardation (for a more hopeful perspective on prosody, see Reiche, Siegel, & Bettie, 1985). Again, the findings of this study failed to support a specific speech-motor involvement as a significant component influencing speech and prosody in social discourse. Rather, they seem to provide strong support for need to explore alternative intervention programs directed specifically at speech and prosody normalization. The present findings are consistent with current interest in microcomputer-aided intervention programming, with emphasis on visual modalities and informative graphics (cf., Bull, Cochran, & Snell, 1988; Shriberg, Kwiatkowski, & Snyder, 1986, 1989, 1990). Particularly as voice recognition technologies become available to transcend segmental and suprasegmental information reliably, microcomputer-aided intervention programs would seem to hold excellent promise for normalizing the speech and prosody of persons with mental retardation. The complexity of such technical, educational, social-vocational, and ethical issues must be addressed if this discipline is to effectively service the communication needs of these relatively new members of the vocational community.

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