The Relationship Between the Production of Stridents and Velars, and Sentence Length, IQ, and Chronological Age in Children With Down Syndrome

Rapports entre la production de fricatives et vélaires, et la longueur des phrases, l'âge chronologique et le quotient intellectuel chez les enfants atteints du syndrome de Down

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Abstract

Twenty-two children with Down syndrome who were 6:6 months to 12:7 of age were tested to assess the relationships between the production of stridents and velars, and sentence length, chronological age, and IQ. Sentence length was found to be the primary predictor of both stridency and velar production. Age was a secondary predictor for stridency deletion and velar deletion, while IQ was found to be a poor prognosticator for the variables examined in this study.

Résumé

On a effectué des tests sur vingt-deux enfants atteints du syndrome de Down qui étaient âgés de 6:6 à 12:7 ans en vue d'établir les rapports entre la production de fricatives et vélaires, et la longueur des phrases, l'âge chronologique et le quotient intellectuel. On a constaté que la longueur des phrases était le principal prédicteur de la production des fricatives et vélaires. L'âge était un prédicteur secondaire de l'omission des fricatives et vélaires, tandis que le quotient intellectuel s'est révélé un facteur de pronostic médiocre pour les variables examinées au cours de l'étude.

Introduction

The phonological patterns of children with Down syndrome have been examined in only a limited manner. In contrast, the factors thought to contribute to the overall developmental communication delay typical in this syndrome have been explored more fully. These factors– structural, motor and linguistic– have been considered from a variety of perspectives and will be presented here as the foundation for a further examination of the speech patterns in this population.

Structural deviations in this population directly related to speech production have been reported to involve the brainstem, cerebellum, maxilla, dentition, tongue, and the hearing mechanisms. According to Crome, Cowie, and Slater (1966), the brainstems and cerebellums of persons with Down syndrome are smaller, with an average weight 34% less than that of normals, implying a causative link to hypotonia. Deficits in long term motor programming are cited by Frith and Frith (1974) as contributing to the impaired planning of articulatory movements. Orofacial abnormalities that may interfere with normal speech development include a small oral cavity (Benda 1949; Engler, 1949), abnormal occlusion and agenesia (McMillian & Kashgarian, 1961; Zisk & Bialer, 1967), and hypotonicity of the tongue, cheeks, and lips (Crome, Cowie, & Slater, 1966). This hypotonicity often results in an open-lip posture with the tongue positioned anteriorly (Crosley, 1991). Finally, both conductive and sensorineural hearing losses have been identified as occurring frequently in persons with Down syndrome (Fulton & Lloyd, 1968; Balkany, Down, Jafek, & Krajicek, 1978; Davies & Penniceard, 1980; Gorp & Baker, 1984.)

With regard to the linguistic abilities of children with Down syndrome, delays have been found in their use of pragmatics, semantics, and syntax (Ryan, 1975; Andrews & Andrews, 1977; Evans, 1977; Layton & Sharifi, 1978; Greenwald & Leonard, 1979; Coggins, 1979; Gunn, 1985; Smith & Von Tetzchner, 1986; Miller, Budde, Bashir, & LaFollette, 1987). Stoel-Gammon (1990) found that language production lags significantly behind comprehension in children with Down Syndrome. The divergence of production and comprehension abilities was reported to increase with age. Syntax was also found to linger behind lexical development (Stoel-Gammon, 1990).

A variety of studies have noted a relationship between syntax and phonological ability in both normal and speech-delayed children (Menyuk, 1969; Shriner, Holloway, & Daniloff, 1969; Panagos, Quine, & Klich, 1979; Paul & Shriberg, 1982). For example, Menyuk and Looney (1972) reported that children who experienced difficulty with the grammatical structures of language also had phonological errors. Thus, grammatical complexity has been determined to be a critical factor for consideration in the investigation of intellectually normal children with articulation disorders (VandeMark & Mann, 1965; Panagos, Quine, & Klich, 1979; Paul & Shriberg, 1982). In particular, an increase in syntactic complexity, in the form of sentence length and maturity of linguistic structures, has been related to a decrease in the number of phonological processes used (Panagos, Quine, & Klich, 1979).

This relationship between syntax and phonology has also been found in the mentally retarded. Lenneberg, Nichols, and Rosenberger (1966) reported that children misarticulated fewer consonants at a simple word level than in either spontaneous speech or phonetically complex words. Rosin, Surft, and Bless (1987), in comparing children with Down syndrome to other retarded and nonretarded children, identified the occurrence of a shorter mean length of utterance, difficulties in diadochokinetic sequencing, an increase in syntax deviations, and more frequent articulation errors.

A limited number of studies have considered phonological process usage in persons with Down syndrome. Miller, Stoel-Gammon, Chapman, and Pentz (1987) assessed the pre- and early linguistic development of children with Down syndrome ages birth to 3 years. The processes produced by these young children were similar to mental-age matched normal children but were markedly higher in incidence. Of note was the finding that process usage had not begun to decrease by the age of three.

Bleile and Schwartz (1984), in examining the phonological processes used by three children with Down syndrome 3 to 5 years of age, reported that deletion of final consonants, initial cluster reduction, and stopping were the most prevalent processes. Bodine (1974), in assessing phonological processes in two children 5 to 6 years of age, identified cluster reduction, velar fronting, final consonant delection, assimilation, stopping, vowelization, gliding, and liquid deviations as the most frequent. Dodd (1976) analyzed the use of cluster reduction, consonant harmony, and simplification of the phonological system in school-age children with Down syndrome and compared them to retarded children with other etiologies and to preschool normal children. She found that the phonological abilities of the mentally retarded group not having Down syndrome were comparable to those of the mental age-matched normal group, while the subjects with Down syndrome made many more errors and were much more inconsistent than either of the other two groups. Others have verified that individuals with Down syndrome have a high, as well as inconsistent, phonological error rate (Sirkins & Lyons, 1941; Schlanger & Gottsleben, 1957). Cluster reduction, assimilation, stopping, vowelization, final consonant deletion, fronting, gliding, and liquid deviations have been identified as commonly used processes (Bodine, 1974; Dodd, 1976; Bleile & Schwartz, 1984).

Crosley and Dowling, (1989; 1989-90) examined aspects of the articulatory patterns of 22 children with Down syndrome and found that the incidence of syllable reduction could be predicted by a child's sentence length (Crosley & Dowling, 1989-90). This was also true for cluster reduction and liquid simplification (Crosley & Dowling, 1989). In contrast, the incidence of final consonant deletion was linked to three factors– sentence length, age, and IQ (Crosley & Dowling, 1989-90).

The purpose of this study was to determine the relationships between sentence length, age, and IQ, and velar and strident development in children with Down syndrome. Velars were selected because they reflect a low level of development but are often presistently in error in children with phonological disorders. Stridents represented a more complex developmental level and, thereby, provide an opportunity to assess the emergence of a later developing class of phonomes in children with Down syndrome.

Methodology

Subjects

Subjects consisted of 12 female and 10 male children with Down syndrome, age 6 years, 6 months to 12 years, 7 months, with a mean age of 9 years, 8 months. Using Grossman's classification of mental retardation (1973), three of the subjects fell within the level of mildly mentally retarded and 19 of the subjects were moderately mentally retarded. The mental ages of the children ranged from 2.6 to 6.0, with a mean of 4.5. All subjects were home-reared, attended a public school, and came from homes in which the primary language was English.

Method

Prior to testing, each potential subject's academic folder was reviewed to determine chronological age, IQ level, and past hearing history. IQ level was based on reported scores obtained from the *Stanford Binet* or the full scale *Wechsler's Intelligence Scale for Children-Revised* which had been administered within three years of the current study. Dates of previous hearing evaluations, the types of hearing tests, and test results were also recorded. Based on medical information taken from the academic folders, 16 out of the 22 subjects had a history of medically treated ear infections. A majority of children with Down syndrome have experienced variable degrees of hearing loss at some point during the development of speech and language (Fulton & Lloyd, 1968; Davis & Penniceard, 1980; Gorp & Baker, 1984). Thus, to be reflective of the population as a whole, hearing information was documented, but was not used as a predictor variable for phonological performance. Children with a diagnosed hearing loss were excluded from the study.

Each subject was administered a test battery that consisted of a pure tone hearing screening, *The Assessment of Phonological Processes-Revised (*APR-R) (Hodson, 1986), and a spontaneously elicited language sample. For all subjects, the pure tone hearing screening was presented as the first test. Testing was completed in a quiet room in the child's home environment with a calibrated Grasson-Staddler audiometer. Hearing was assessed at 20 dB HL for 500, 1000, and 2000 Hz and at 25 dB at 4000 Hz. Following screening, threshold testing was completed for each frequency that was not passed. A subject was considered to have failed the pure tone screening by missing more than one frequency in one ear or one frequency in both ears. Fifteen children passed the hearing screening; seven did not and were tested further. Hearing data for all subjects appear in Table 1.

Table 1. Hearing screening performance and related thresholds.

SUBJECT	500 Hz		1000 Hz		2000 Hz		4000 Hz		Overall
	L	R	L	R	L	R	L	R	
1	P	P	P	P	P	P	P	P	P
2	P	P	P	P	P	P	P	P	P
3	P	P	P	P	P	P	P	P	P
4	P	P	P	P	P	P	55	55	F
5	30	30	30	P	P	P	P	P	F
6	P	P	P	P	P	P	P	P	P
7	P	25	P	P	P	P	P	P	P
8	P	P	P	P	P	P	P	P	P
9	30	25	P	25	25	25	P	P	F
10	25	25	P	P	P	P	P	P	F
11	P	30	P	P	P	P	P	P	P
12	P	P	P	P	P	P	P	P	P
13	P	P	P	P	P	P	P	P	P
14	P	P	P	P	P	P	P	P	P
15	P	30	P	P	P	P	P	P	P
16	P	P	P	P	P	P	P	P	P
17	40	P	25	P	40	P	40	P	F
18	35	60	35	45	30	70	P	45	F
19	P	P	P	P	25	30	P	P	F
20	P	P	P	P	P	P	P	P	P
21	P	P	P	P	P	P	P	P	P
22	P	P	P	P	P	P	P	P	P

Screening was completed at 20dB HL for 500, 1000 and 2000 Hz and 25dB HL for 4000 Hz.
If screening was failed, the number = threshold.
P= Pass
F= Fail

Upon completion of the hearing assessment on the first day of testing, the APP-R was given. This procedure required that each child name common objects as they are presented by the examiner. This test assessed phonological process usage through 43 single word items of which 31 were one syllable and 7 were two word utterances. Phonemes were tested in pre- and postvocalic positions. If a subject did not name an object, a model was provided. Then the word was re-elicited later, after three additional items were named, to insure that the responses were produced as spontaneously as possible.

At the beginning of the second session, a language sample was collected and audiotaped. First, the examiner and subject interacted conversationally for a ten minute period. Then a 20 minute language sample was elicited using a variety of pictures and picture books that were presented in the identical order for all subjects. To further insure consistency across subjects in collecting the language sample, the same six open-ended questions were used in conjunction with the picture stimuli: (1) What is/are he/she/they/it doing? (2) Tell me what is happening. (3) What else? (4) How come? (5) Why? and (6) What? Each question was asked a minimum of three times per subject.

Following all data collection, the language and articulation samples were transcribed and analyzed. To determine Mean Length of Utterance (MLU) or Mean Length of Response (MLR), whichever was appropriate, the guidelines described by Kemp and Hedrick (Kemp, 1972; Hedrick, Prather, & Tobin, 1984) in their adaptation of Brown's stages of syntactical development were used. Previous research has documented the similarity between MLU and MLR (Bedrosian, Sykes, Smith, & Dalton, 1988; Hedrick, Prather, & Tobin, 1984). In this study, the rules for MLU were used when a subject demonstrated a sentence length score of 1.0 to 4.0. When a child's sentence length score surpassed 4.0, the rules for MLR were applied.

This procedure is based on the work of Klecan-Aker (1983). She described MLU as an index based on meaningful units or morphemes, that are bound in words. But, after 4.0, MLU measurement is no longer thought to be valid because MLU is based on morphemes that are developmental and mastered by 4.0. The logical extension is to count words instead of morphemes because, once the basic morpheme system is intact, children continue to develop sentence length by acquiring more words per unit (Klecan-Aker, 1983).

To obtain the articulation data, each child's responses to the APP-R were transcribed phonetically using narrow transcrition. The occurrences of velar deletion, velar fronting, stopping, stridency deletion, and nonstridency for stridency were tabulated. A percentage of occurrence for each process was calculated according to the procedures described by Hodson (1986).

Reliability

Several steps were taken to ensure that the data were transcribed and coded reliably. Prior to the study, five language samples, unrelated to the data used in the study, were scored by the experimenter and another judge Interjudge agreement was 98.5% for MLU and 99.2% for MLR. All utterances having more than one unintelligible word were deleted from the sample (Klecan-Aker, 1983). In addition, five randomly selected language samples from the study were scored by a second judge trained in language sample analysis. Agreement between the experimenter and second judge for these data was 100% for MLU and 99.36% for MLR.

Two individuals independently transcribed the articulation test responses in a random order. Upon completion, the data were compared. Differences in transcription were noted, and the transcribers were asked to listen again and retranscribe those items. Items that continued to have varied transcriptions were subjected to an additional procedure as described by Adams, Lewis, and Besozzy (1973). One of the original transcribers and a third individual considered those discrepant transcriptions that impacted on velar deletion, velar fronting, stopping, stridency deletion, and nonstridency for stridency substitutions. When only one or two discrepancies were found or when discrepancies constituted less than 5% of the data for a subject for a given process, those data were discarded from use in the study. The discarded data included 2.96% of the data for velars, 0.8% of the data for stopping, and 2% of the data for stridency. Forced agreement was used for those items for which there were three or more discrepancies for a given subject's data. Forced agreement occurred for 1.58% of the data for velars, 1% of the data for stopping, and 1.69% of the data for stridency.

To establish intertranscriber agreement for the scoring of the articulation protocols, five samples, unrelated to the data in the study, were scored by the experimenter and another judge. Agreement for the five processes scored was: velar deletion (93%), velar fronting (96%), stopping (93%), stridency deletion (96%) and nonstrident substitutions for stridents (100%). In addition, five articulation samples from the study were randomly selected and coded by a second scorer. Agreement for these samples was: velar deletion (91%), velar fronting (100%), stopping (86%), stridency deletion (92%), and nonstrident substitutions for stridents (85%).

Statistical Analysis

Test results were analyzed using the SPSSX software computer package (Spss Inc., 1983). Pearson r correlations were calculated for all variables. In addition, multiple regression procedures were used to determine the relationship of the independent variables of sentence length, IQ, and chronological age, to the dependent variables of velar deletion, velar fronting, stopping, stridency deletion, and nonstridency substitution for stridency. A line of best fit which minimized prediction errors and determined whether a relationship existed among the variables was generated. The regression analysis assessed the degree of the relationship, the additive effects of variables upon prediction, the amount of variance accounted for by each variable, and the related significance levels. A forced hierarchical regression strategy was employed. The order of entry for the independent variables as predictors was: sentence length, IQ, and age-in-months. This order reflected the relative importance of each variable as cited in the literature. The F-test, using the Model I error term, was used for significance testing (Cohen & Cohen, 1983).

Results

The data for 22 children with Down syndrome consisted of the following: sentence length, chronological age, IQ, and the dependent phonological process variables. Six of the

Table 2. Percentage of occurrence of phonological processes.

Process	Range of ocurrence %	Mean %
Velar deletion	0-58	16.18
Velar fronting	0-42	6.59
Stopping	0-13	3.81
Stridency deletion	0-67	23.13
Nonstridency for Stridency	0-30	5.68

Table 3. Pearson *r* correlations among the dependent variables.

Phonological Processes	Pearson *r* Correlation	Significance *P* value
Velar Deletion-Velar Fronting	.49	< .05
Velar Deletion-Stopping	.60	< .001
Velar Deletion-Stridency Deletion	.83	< .001
Nonstridents for Stridents-Velar Deletion	.56	< .01
Velar Fronting-Stopping	.43	< .05
Velar Fronting-Stridency Deletion	.62	< .001
Stopping-Stridency Deletion	.81	< .001
Stopping-Nonstridents for Stridents	.88	< .001
Velar Fronting-Nonstridents for Stridents	.33	NS

children had velar usage that was intact and three youngsters demonstrated stridency production that was without error. As reported in Table 2, the children in this study varied markedly in the usage of velar deletion, velar fronting, and stridency deletion. Nonstridents for stridents and stopping were used infrequently.

The relationships among the dependent variables, as indicated by the Pearson *r* correlations, are shown in Table 3. Table 3 indicates a high degree of correlation between all pairs of the dependent variables. The exceptions are velar fronting and nonstridency for stridency.

The regression summaries for velar deletion (VD), velar fronting (VF), stopping, stridency deletion, and nonstridency for stridency substitutions are reported in Table 4. As can be seen in this table, sentence length was a significant predictor for VD, VF, stopping, and strident deletion, accounting for 30.3%, 19.6%, 17.7%, and 27.3% of the variance, respectively. Thus, as sentence length increased, the use of these processes decreased.

Regression findings were further analyzed to determine, if the effects of sentence length were held constant, how much additional variation could be predicted from the variable age. As can be seen in Table 4, age was a significant predictor for VD, accounting for an additional 2.8% of the variance, and for stridency deletion, accounting for an additional 0.1% of the variance. As age increased, the incidence of VD and stridency deletion decreased.

Table 4. Regression analysis summary table.

Variable	Multiple *R*	Squared *R*	% *R* Change	*F*	Significance
Velar Deletion					
Sentence Length	.551	.303	30.3	8.72	< .01
Age	.575	.331	2.8	4.70	< .05
IQ	.586	.344	1.3	3.15	< .05
Velar Fronting					
Sentence Length	.443	.196	19.6	4.88	< .05
Age	.445	.198	.2	2.34	NS
IQ	.477	.227	2.9	1.77	NS
Stopping					
Sentence Length	.421	.177	17.7	4.32	< .05
Age	.440	.193	1.6	2.28	NS
IQ	.455	.207	1.4	1.57	NS
Stridency Deletion					
Sentence Length	.523	.273	27.3	7.53	< .05
Age	.524	.274	.1	3.60	< .05
IQ	.528	.279	.5	2.32	NS
Nonstridency for Stridency					
Sentence Length	.399	.159	15.90	3.80	NS
Age	.402	.161	.2	1.83	NS
IQ	.406	.165	.4	1.18	NS

The relationship between IQ and each of the dependent variables was then considered. The purpose was to determine, if the effects of sentence length and age were held constant, how much additional variation could be predicted from the variable IQ. As noted in Table 4, IQ was a significant predictor only for VD, accounting for 1.3% of the variance. Thus an increase in IQ was associated with a decrease in VD.

First-order interactions were assessed for each of the analyses. There were no significant interaction effects among the independent and dependent variables. These findings indicated that confounding of the data among the variables did not occur.

Discussion and Summary

This study was designed to examine the relationships between the independent variables of sentence length, chronological age, and IQ and the dependent variables, velar deletion, velar fronting, stopping, stridency deletion, and nonstridency for stridency substitutions. Significant inverse relationships were found between the independent variable of sentence length and four of the dependent variables, velar deletion, velar fronting, stopping, and stridency deletion. An association between syntax and phonological processing has been demonstrated repeatedly in intellectually normal, speech-delayed children (Menyuk, 1969; Shriner, Holloway & Daniloff, 1969; Panagos, Quine & Klich, 1979; Paul & Shriberg, 1982). Therefore, children with Down syndrome, performed like normal children with phonological errors showing that an increase in sentence length is accompanied by a decrease in phonological process usage. In particular, a reduction in the percentage of incidence of velar deletion, velar fronting, stopping, and stridency deletion was noted.

Velar deletion and stridency deletion were found to be significantly related to age. Ingram (1976) stated that velars emerge during the stage he calls the phonology of the simple morpheme and tend to be intact by age 4. Stridents, on the other hand, typically emerge later, during the stage called completion of the phonetic inventory, and match adult forms by age 7. In the normal child, age clearly has been linked to phonological development. In addition, Crosley and Dowling (1989) reported that age was a significant predictor of final consonant deletion in children with Down syndrome. In this study, velar and stridency deletion decreased with age, indicating that children with Down syndrome, as they get older, do improve their phonological skills in a manner similar to that of the normal child.

In contrast, nonsignificant relationships were found between age and the processes of velar fronting, stopping, and the use of nonstridents for stridents. This study and previous work by Crosley and Dowling (1989) linked age to the deletion of final consonants, including deletion of velars and stridents. But, this study suggests that velar fronting, stopping, and the substitution of nonstridents for stridents may be exceptions to this trend. Omission of a sound category would reflect a more basic developmental process, and children with Down syndrome, with age, improved in that area. The use of a substitution for either velars or stridents would indicate a higher level of development because the child has acknowledged that a phoneme is needed to mark the space, although the accurate phoneme is not used. The percentages of incidence of velar fronting, stopping, and the substitution of a nonstrident for a strident were extremely low in this study, which may have indicated that movement into a substitution rather than omission stage had only begun. If older children with Down syndrome had been included in this study, the age factor may have been significant.

IQ was significantly related to velar deletion, but not to the remaining phonological processes. A specific reason for this significant relationship between IQ and velar fronting is difficult to determine. Perhaps the usage of velar deletion represents such a low developmental level as to produce greater effects, than the other processes, relative to the variable IQ. This could have also been a spurious finding. Thus, this result must be interpreted with caution and warrants further study.

IQ was found to be a poor predictor of the phonological processes of velar fronting, stopping, stridency deletion, and nonstridents for stridents. Research examining the relationship between these variables in normal or retarded children has been limited. Crosley and Dowling (1989; 1989-1990) found that IQ was a poor predictor of final consonant deletion, syllable reduction, cluster reduction, sonorant deleted, and liquid simplifications. Furthermore, Miller, Budde, Bashir, and LaFollette (1987) reported that mental age was not predictive of sentence length in children with Down syndrome. In this study, sentence length was related to velar fronting, stopping, and stridency deletion but not to IQ, supporting the findings of this earlier research.

In summary, sentence length was found to be the primary predictor of velar deletion, velar fronting, stopping, and stridency deletion in this group of children with Down syndrome. Further, the occurrence of stridents in these children's productions documented that these youngsters had progressed beyond the stage of the simple morpheme (Ingram, 1976). Future research might focus on the continuing development of the phonological systems in children with Down syndrome as age and sentence length progress beyond the level of the subjects in this study.

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