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Phonological deficits in Cantonese-speaking children with Down Syndrome

Ho Siu Lai, Daphne

A dissertation submitted in partial fulfilment of the requirements for the Bachelor of Science (Speech and Hearing Sciences), The University of Hong Kong, April 30, 1997.
This study investigated the articulatory performance of seventeen Down Syndrome children with seventeen non-Down Syndrome intellectually impaired children, who were matched for mental age and chronological age, acted as controls. All subjects produced thirty-six target words which included all Cantonese consonants, vowels, and tones in four conditions namely (i) spontaneous single word (ii) imitated single word (iii) spontaneous sentence and (iv) imitated sentence. Results show that the Down Syndrome group made significantly more segmental errors and number of phonological processes than the non-Down Syndrome group in all conditions. The Down Syndrome group demonstrated improved performance in imitation than in spontaneous production. Also, they came across greater articulatory defects in spontaneous sentence than single word production. The control group, on the other hand, showed no difference across speech conditions. Qualitative analysis comparing errors made in producing sentence and single word spontaneously was also performed in terms of the number of consonant, vowel, and tone errors, frequency of occurrence of the identified phonological processes, and the number of distinctive features deviated from targets. This paper discusses the level of processing deficit that might underlie the articulatory defects in the Down Syndrome population using Hewlett’s (1990) model of phonological processing and phonetic production. Implications for therapeutic intervention, and directions for future investigations are also considered.
INTRODUCTION

Most surveys indicate a markedly high incidence of speech defects in the mentally handicapped population in Western countries (Dodd and Leahy, 1989). Although no large-scale survey has been conducted to investigate the situation in the Cantonese-speaking mentally handicapped population, a survey done by Tse (1996), which based on information collected from 37 special schools in Hong Kong, indicated that an average of 82.6% of pupils demonstrate speech and language problems. Studies of speech and language in the mentally retarded population have typically reported that articulatory problems are particularly severe for subjects with Down Syndrome. The incidence of articulatory defects in this population is higher as compared to other groups of mentally retarded (Blager, 1980; Dodd and Leahy, 1989; Parsons and Iacono, 1992; Pueschel, 1990). The problem of inadequate articulatory precision leading to poor intelligibility in persons with this chromosome disorder has frustrated parents and therapists (Borghi, 1990) and calls for clinical attention.

In reviewing past research involving speech defects of individuals with Down Syndrome, most studies have focused their attention in describing the phonetic and phonological performance in this population. They aim to find out whether the phonological performance in this biologically well-defined subgroup is best characterized as delay, or atypical pattern.

The first study to attempt to systematically investigate the speech of children with Down Syndrome was that of Bodine (1974). The two subjects in Bodine's study evidenced errors which were found in normal phonological development (e.g. fronting of velar stops). Stoel-Gammon (1980) investigated the phonological skills of four children
with Down Syndrome. Results indicated that the errors evidenced by the subjects were systematic in nature and the errors were similar to those errors found in individuals with normal developing speech but at younger chronological ages (e.g. production of initial fricatives and affricates as stops and substitution of glides for liquids). Thus, the author felt her study supported the notion that children with Down Syndrome had delayed rather than deviant phonological skills. This conclusion was further supported by Bleile and Schwartz (1984) in their observations of the speech of three children with Down Syndrome.

The issue of delayed versus deviant performance in Down Syndrome speech has also been addressed in longitudinal studies. Smith and Stoel-Gammon (1983), for example, investigated the development of stop consonant production in the speech of five children with Down Syndrome and four normals. The authors found no unusual phonological behaviours in the stop productions of their subjects but developmental errors.

Taken together, results of these studies seem to support the claim that children with Down Syndrome have delayed phonological performance. However, the picture of phonological skills in this population is not a simple one. Considerable evidence has also been provided indicating that children with Down Syndrome have distinct patterns of articulatory defects. Dodd (1976) found that phonological analyses of school-age children with Down Syndrome revealed many more errors and inconsistencies than were present in the speech of other children with mental retardation or normal children matched for mental age. Furthermore, the children with Down Syndrome made fewer errors when words were imitated than when they were produced spontaneously. Rosin,
Swift, Bless and Vetter (1988) also found significantly poorer intelligibility in their adolescents with Down Syndrome than in a control group of children with mental retardation due to other causes matched for mental age. Stoel-Gammon (1981) identified both developmental and atypical phonological processes in her subjects with Down Syndrome. Also, they showed a greater frequency of errors and a greater range of error types. Similar results were obtained in Parsons and Iacono (1992)'s study which investigated the phonological skills in 30 Down Syndrome children. These findings suggest both the general pattern of delay and the different characteristics to be found in the speech of children with Down Syndrome.

A cross-linguistic study done by So and Dodd (1994), which compared groups of Cantonese-speaking Down Syndrome children with mental age matched intellectually impaired subjects due to other causes, also revealed that children with Down Syndrome made a greater number of inconsistent errors, were more likely to produce non-developmental errors, and were better in imitation than in spontaneous production. In another aspect, the articulatory impairment in the Down Syndrome population seems to be persistent and resistant to therapy (Miller, 1988, Horstmeier, 1987) and lags behind other aspects of communicative development such as language comprehension (Miller, 1988).

These findings cannot be wholly accounted for by anatomical factors such as the relatively larger tongue (lingual hyperplasia) as has been suggested in the literature (Olbrisch, 1982); and assessments of speech intelligibility before and after partial glossectomy show no significantly change (Marger-Bacal, Witzel, and Munro, 1987; Parsons et al, 1987). Results of analysis reveal that many subjects under investigation
were capable of producing nearly all phonemes although they made many speech errors (e.g. Stoel-Gammon, 1980; Parsons and Iacono, 1992). Also, Down Syndrome children are found to have better performance in imitation than spontaneous production (e.g. Dodd, 1976; Miller, 1988, van Borsel, 1988). These also make it difficult to attribute the distinct articulatory error patterns solely to abnormalities of the oral structure nor the often-reported physiological conditions in this population including chronic upper respiratory tract infection, hypotonicity of the orofacial musculature (Meyers, 1990), and fluctuating hearing loss (Downs, 1980).

Whereas phonological development seems to be linked to general developmental levels in the severely retarded children due to unknown cause, Down Syndrome children seem to have an additional interference that needs to be accounted for to explain the uneven performance (Blager, 1980).

Recently, investigators have attempted to pinpoint where breakdown is occurring to explain the articulatory defects in Down Syndrome speech. For example, Dodd (1976; 1995) suggests that the unintelligible speech associated with Down Syndrome involves a more central specific deficit in the speech-processing chain rather than peripheral one. As suggested by the author, one plausible candidate deficit may be a generally impaired ability to learn programmes for sequences of fine motor movements which could account for inconsistent errors and better performance in imitation than spontaneous production. So and Dodd (1994) argue that the primary difficulty children with Down Syndrome seem to have is knowing what sounds to produce, rather than actually articulating them. They suggest that the speech disorder in this population arises from an impaired phonological planning level.
AIM OF THE PRESENT STUDY

The studies to date have suggested that individuals with Down Syndrome have speech with numerous similarities to that of normal individuals, but that some differences do exist of both a qualitative and quantitative nature. Although information concerning the phonological performance of the Down Syndrome population is increasing, the data base remains relatively small, especially with regard to Cantonese-speaking individuals. Also, no studies have given considerations to the articulatory performance of Down Syndrome children in connected speech as compared to single word production. According to Parsons and Iacono (1992), unintelligibility of Down Syndrome speech might be related to “motor programming problems” which appear during conversational speech but is not obvious on single word. The present study was thus designed to pursue this line of investigation. It aimed to confirm and to extend prior research by determining whether (i) Down Syndrome children have greater articulatory defects than intellectually impaired individuals due to unknown cause, (ii) Down Syndrome have better performance in imitation than in spontaneous production, and (iii) Down Syndrome have greater articulatory defects in producing sentence than single word.

It was hypothesized that if the deficit was inherent to the Syndrome, surface speech errors identified in English-speaking Down Syndrome individuals would also be found in Cantonese-speaking ones. In other words, they would have greater articulatory defects than other groups of mentally retarded and have better performance in imitation than in spontaneous production. In another aspect, if the deficit was due to an impaired ability to plan motor movement for speech, individuals with Down Syndrome would
come across greater articulatory deficit in producing sentence than single word as greater planning load was evidenced.

METHOD

Subjects

Thirty-four children with intellectual impairment participated in this study; seventeen of them were diagnosed as having Down Syndrome and seventeen with intellectual impairment of unknown origin. The subjects recruited came from three local special schools for moderate grade mental retardation and were selected randomly by school teachers or speech therapists. The two groups of children were matched pairwise for chronological and mental age using information available in school records. None of the children included had hearing impairment or apparent structural abnormalities.

The Down Syndrome group consisted of fifteen boys and two girls. The mean chronological age and mental age were 10;07 and 2;08 respectively. The non-Down Syndrome group consisted of eleven boys and six girls. The mean chronological age and mental age were 10;06 and 2;09 respectively. Two one-way ANOVAs revealed no significant difference between the two groups in either chronological age \[F(1,32)= 0.30, p>.05\] or mental age \[F(1,32)= 0.12, p>.05\].

Stimuli

A set of thirty-six colour photographs, each showing an object, was used to elicit single word responses. Another set of photographs, each showing a girl carried out an action on those objects for obtaining single word responses, was used to elicit sentence
responses. The thirty-six target words and the sentence stimuli are shown in Appendix 1a and 1b. The target words contained all Cantonese consonants, vowels and tones. They sampled each consonant, vowel, and tone at least twice (except /kw^){. Appendix 2 illustrates their corresponding distribution. The target sentence consisted of subject-verb-object syntactic structure which was found to be manageable by the mentally retarded children in a pre-testing.

**Procedure**

Each subject produced the thirty-six target words in four speech tasks namely (i) spontaneous single word production (ii) imitated single word production (iii) spontaneous sentence production and (iv) imitated sentence production. To elicit single word responses, subjects were asked to name the objects shown by photographs spontaneously. After that, subjects were asked to imitate the experimenter’s naming of the same set of objects. To elicit sentence responses, the experimenter first modelled the use of the target sentence to describe pictures followed by training trials attempted by subjects. Subjects then described the photographs spontaneously followed by imitated sentence production.

Each test session lasted about thirty-seven minutes and was audiotaped on a SONY WM-GX614 cassette recorder and TDK tape.

**Transcription & Reliability**

All the tapes were transcribed phonetically by the author. Three tapes were selected randomly and transcribed by three Year IV students of the Department of Speech & Hearing Sciences, the University of Hong Kong, to check for interrater-
reliability. According to Andrews & Fey (1986), the inter-rater agreements were calculated as the total number of transcription agreements divided by the total number of transcription agreements plus disagreements. The agreements obtained were 94%, 91%, and 95% for the three interraters.

Scoring

A target-error analysis was performed for the thirty-six target words, giving rise to the following data for each subject in the four conditions of production:

(1) Number of segmental errors (consonant errors + vowel errors + tone errors)

(2) Number of phonological processes

Phonological process analysis was done to reveal any specific types of errors and error patterns (McReynolds and Elbert, 1989). Processes which were identified were mainly taken from the work of So and Dodd (1994) which has described phonological processes used by Cantonese-speaking Down Syndrome children. However, other possible existence of regular error patterns was also considered. Use of a phonological rule was credited if there were at least two examples of the error-type made in different lexical items.

DATA ANALYSIS

I. Number of segmental errors

The data were subjected to a two-way analysis of variance in which group (Down Syndrome and Mentally Retarded) was a between-subjects factor and speech task (spontaneous single word, imitated single word, spontaneous sentence, and imitated sentence) was a within-subjects factor. The results are summarized in Figure 1.
Results of ANOVA revealed a reliable effect of group (F(1,32)=26.73, p<.0001). Post-hoc Scheffe test (p<.001) showed that the Down Syndrome group made significantly more segmental errors than the mentally retarded group (means=31.07 and 13.62 respectively). The effect of speech task was significant (F(3,96)=71.68, p<.0001). The interaction between the factors was also significant (F(3,96)=29.36, p<.0001), indicating that the number of segmental errors made by the groups varied according to speech task. Post-hoc Scheffe testing of interaction showed that:

For the Down Syndrome group,

1. subjects made significantly fewer errors in imitation than in spontaneous production (p<.001) in producing both single word and sentence;
2. subjects made significantly more errors in spontaneous sentence than spontaneous single word production (p< .01) as well as in imitated condition (p< .001).

For the Mentally Retarded group,

1. subjects did not differ in the number of errors made in imitation and in spontaneous production in producing both single word and sentence (p> .05);
2. subjects did not differ in the number of errors made in spontaneous single word and spontaneous sentence production (p> .05).

II. Number of phonological processes

Figure 2 illustrates the mean number of phonological processes generated in the four speech tasks by the two subject groups.

![Bar chart](image-url)
Results of ANOVA revealed a reliable effect of group \((F(1,32)=18.53, p<.0001)\)

Post-hoc Scheffe testing \((p<.001)\) revealed that the Down Syndrome group produced significantly more types of phonological processes than the control group. The effect of speech task was also significant \((F(3,96)=13.96, p<.0001)\) whereas no interaction was shown. Post-hoc comparison using Scheffe test indicated that:

**For the Down Syndrome group,**

1. subjects made significant fewer phonological processes in imitation than in spontaneous condition \((p<.05)\) in producing single word;
2. subjects did not differ in the number of phonological processes produced in spontaneous single word and sentence production \((p>.05)\) as well as in imitated condition \((p>.05)\).

**For the Mentally Retarded group,**

1. subjects did not differ in the number of phonological processes produced in imitation and spontaneous production \((p>.05)\);
2. subjects did not differ in the number of phonological processes produced in spontaneous single word and sentence production \((p>.05)\).

**Further Analysis**

The errors made in spontaneous single word and spontaneous sentence production in the two groups were further analyzed according to the following measures:

1. **Number of consonant, vowel, and tone errors**

   The mean number of consonant, vowel, and tone errors made by the two groups children in spontaneous single word and sentence condition are shown in Table 1. For the Down Syndrome group, subjects made significant greater number of consonant errors in
spontaneous sentence than in single word production as revealed in one-way analysis of variance with repeated measures (\(F(1,16)=22.56, p<.001\)) whereas the number of vowel and tone errors did not differ. Similar analysis revealed that there was significant increase in both initial and final consonant errors (\(F(1,16)=11.64, p<.05; F(1,16)=7.23, p<.05\) respectively). For the control group, subjects did not differ in either the number of consonant, vowel, or tone errors produced across the two speech tasks.

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<th>Consonant errors</th>
<th>Vowel errors</th>
<th>Tone errors</th>
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<td><strong>Down Syndrome group</strong></td>
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<td></td>
<td></td>
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<tr>
<td>Spontaneous single word</td>
<td>30.35</td>
<td>2.88</td>
<td>2.00</td>
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<tr>
<td>Spontaneous sentence</td>
<td>35.47</td>
<td>3.76</td>
<td>2.59</td>
</tr>
<tr>
<td><strong>Mentally Retarded group</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spontaneous single word</td>
<td>13.59</td>
<td>0.94</td>
<td>0.53</td>
</tr>
<tr>
<td>Spontaneous sentence</td>
<td>14.12</td>
<td>1.24</td>
<td>0.29</td>
</tr>
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Table 1: Mean number of consonant, vowel, and tone errors produced in spontaneous single word and sentence production in the two subject groups

II. **Frequency of occurrence of the identified phonological processes**

Figure 3 and 4 show the frequency of occurrence of the identified phonological processes in the two groups. For the Down Syndrome group, there was a general increase in the frequency of phonological processes identified. Results of one-way analysis of variance with repeated measures indicate that only the increase in final consonant deletion and initial consonant deletion reached a significant level (\(F(1,16)=4.62, p<.05; F(1,16)=4.73, p<.05\) respectively). For the Mentally Retarded group, the increase in Deaspiration was significant (\(F(1,16)=6.27, p<.05\)).
Figure 3: Mean frequency of the identified phonological processes in spontaneous single word and sentence production in the Down Syndrome group

Figure 4: Mean frequency of the identified phonological processes in spontaneous single word and sentence production in the Mentally Retarded group
III. Number of distinctive features deviated from targets

Systemic simplification errors were analyzed by computing the ratio of number of distinctive features modifications to the number of substitution errors made (DF/E ratio). A larger DF/E ratio indicates less approximation to the targets. A modified version of The Sound Pattern of English (SPE) Distinctive Feature Matrix for Consonants (Chomsky and Halle, in Hyman, 1975) was used as a reference (Appendix 3). Table 2 displays the mean values.

A one way analysis of variance revealed no significant difference in the number of distinctive features deviated from targets for both the Down Syndrome group (F(1,16)=1.12, p>.05) and the Mentally Retarded group (F(1,16)=1.00, p>.05) across the two speech conditions.

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<tr>
<th></th>
<th>Spontaneous single word</th>
<th>Spontaneous sentence</th>
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<tbody>
<tr>
<td>Down Syndrome group</td>
<td>3.90</td>
<td>3.37</td>
</tr>
<tr>
<td>Mentally Retarded group</td>
<td>4.13</td>
<td>3.89</td>
</tr>
</tbody>
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Table 2: Mean DF/E ratios in spontaneous single word and spontaneous sentence in the two subject groups

DISCUSSION

This study investigated the articulatory performance of Down Syndrome children as compared to a control group of children with mental retardation due to other causes matched for chronological and mental age. All subjects participated in four speech tasks namely (i) spontaneous single word production (ii) imitated single word production (iii) spontaneous sentence production and (iv) imitated sentence production. The major findings in this present study may be summarized as follows:
(1) On the whole, Down Syndrome children had greater articulatory impairment than matched intellectual impaired non-Down Syndrome children in that they produced greater frequency of errors and range of error types across all speech tasks.

(2) The Down Syndrome group had better articulatory performance in imitation than in spontaneous condition in that they made fewer errors in imitating single word and sentence than they did in spontaneous production. Also, they generated fewer error types at least at single word level in imitation whereas the control group had stable performance across imitation and spontaneous production.

(3) The Down Syndrome group came across greater articulatory defects in producing sentence than single word spontaneously in that they made significantly more segmental errors generating from the same types of error patterns. Further analysis revealed that they made significantly more consonant errors in sentence than in single word. By investigating the corresponding effect on the identified phonological processes, significantly more initial and final consonant deletion errors were made whereas the number distinctive features deviated from targets for the substitution errors did not differ across the two conditions. The control group, on the other hand, made the same number and types of errors across the two conditions.

**Comparison with other findings**

The findings of the present article are in agreement with the phonological performance characterized Down Syndrome speech reported in Western works. The work of So and Dodd (1994), which investigated the phonological abilities of Cantonese-speaking Down Syndrome children, also reported the same characteristic patterns of
speech errors. Taken together, cross-linguistic studies provide clue to the nature of the
deficit underlying the speech difficulties of children with Down Syndrome. Despite the
differences of the phonological systems of English and Cantonese, similar surface error
patterns were obtained. This may suggest that the deficit is an inherent part of the
Syndrome, irrespective of the ambient language. Investigation on languages other than
English and Cantonese in the future may throw more light to the nature of phonological
deficits associated with Down Syndrome.

Two-lexicon theory and processing model

There have been a number of accounts of the mental mechanisms underlying
disordered phonology (Ingram, 1991). Lately, the idea has been gaining around that there
is not just a single, modality-independent lexicon in which phonological representations
are stored (Hewlett, 1990). Instead, there are two: an “input lexicon” for word
recognition and an “output lexicon” for word production. In what follows, the findings
of the present study along with other commonly recognized error patterns of Down
Syndrome speech will be handled in a two-lexicon model proposed by Hewlett (1990) in
order to address the plausible processing deficits directly. Although the two-lexicon
model is by no means universally accepted as the superior model, it is likely to be a
better approximation to what we really utilize in speaking (Menn, 1983).

Descriptions of Hewlett’s (1990) model

Hewlett (1990) proposes that in receiving the perceptual representation of a word
from the Input Lexicon, the Motor Programmer will devise a motor plan necessary to
mediate the mapping rules between the Input and Output Lexicons. The motor plan will then be relayed to a Motor Processing component which assembles the motor plan of the sequence of gestures involved in pronouncing the word, and determine the precise values of the articulatory parameters involved. When a motor plan has been devised and as the system becomes more practiced at implementing the plan, this is relayed to the Output Lexicon which then allows direct accessing of the word without reference to the motor programmer. Thus the model provides two routes to the motor processing component; the fast route (F) where the word is accessed directly from the Output Lexicon, and the slow route (S) where a word is selected from the Input Lexicon and a motor plan for it must be devised by the Motor Programmer.

Figure 5: Hewlett's (1990) model of phonological processing and phonetic production
Levels of processing deficit

Spontaneous versus imitated production

In spontaneous naming, children with Down Syndrome employ the usual Fast Route by selecting the lexical representation of a word directly from the Output Lexicon and then assembling a motor plan by the Motor Processing component. In imitation, on the other hand, it is postulated that the Input Lexicon is activated as an auditory image which provides immediate and rich perceptual targets for the spoken output is available, thereby mediating the Motor Programmer to devise a new motor plan which is accessed directly by the Motor Processing for implementing the plan, i.e. Slow Route is being utilized.

The findings that Down Syndrome children made fewer number and type of errors in imitation than in spontaneous production are taken to imply that they have difficulty generating a phonological output, pointing to a central rather than a peripheral deficit. In terms of Hewlett’s model, Down Syndrome children may have underspecified representations in the Output Lexicon. In imitation, as the processing route by-passes the impaired Output Lexicon, meaning that the motor plan structured is not constrained by the child’s phonological system, more accurate spoken outputs are resulted. The unstable lexical representations stored in the Output Lexicon may also lead to variable surface realizations of a word in spontaneous production as a child may select a sound segment to fill in a slot randomly, resulting in inconsistent speech errors.

Given the greater dependence on auditory processing and storage in speech imitation (Rosenberg, 1982), the improved performance in imitation than spontaneous production may also imply that an impaired input processing is unlikely to account
totally for the speech errors although input factors cannot be entirely discounted. In a similar vein, deficit in motor execution necessary to produce the speech sounds cannot be attributed solely to explain the articulatory deficit as well.

As both imitation and spontaneous production must involve the final stage of speech planning, the fact that Down Syndrome children are not error free in imitation may suggest further that they have an impaired ability in planning the output, be the deficit is due to the construction of the plan (motor programming), or the implementation of it (motor processing), or both. Production of inconsistent errors may also be explained by this level of deficit on top of unstable lexical representations. Individuals may trial a new motor plan for each time a word is produced, resulting in the observed inconsistency of surface errors.

*Spontaneous single word versus spontaneous sentence production*

Spontaneous production of both single word and sentence should employ the same fast route. However, in producing a sentence, simultaneous motor planning of more articulatory gestures is required, leading to an increased planning load as compared to single word production. Down Syndrome evidenced greater articulatory defects in sentence production than single word production, suggesting, at least, deficits in motor implementation.

As revealed in the qualitative analysis, Down Syndrome children produced high frequency of syllable structural errors (including initial and final consonant deletion) in single word and sentence production. This unexpectedly high percentage of syllable structural errors produced by Down Syndrome children, which is not evidenced in the control group of children, may indicate that motor planning difficulty manifests in
assembling the syllable structure of words, even at single word level. As significantly more initial and final consonant deletion errors were made in sentence production than single word, this may indicate further that the increased motor planning load in producing sentence results in increased motor processing load, especially at the Syllable Level. This is not without reason to speculate that simplifying a syllable structure may be a strategy employed by individuals of Down Syndrome to resolve the motor planning problem.

Western findings also report syllable structural processes are among the most prevalent processes identified children and adolescents with Down Syndrome such as syllable deletion (Stoel-Gammon, 1980; Parsons and Iacono, 1992), final consonant deletion (Bleile and Schwartz, 1984; van Borsel, 1988; Parsons and Iacono, 1992), and cluster reduction (Bleile and Schwartz, 1984; van Borsel, 1988; Parsons and Iacono, 1992). This cross-linguistic similarity of surface error patterns may imply the use of strategies with similar nature for compensating the underlying processing deficit, despite differences in the linguistic coding system.

The Segmental Level in the Motor Processing component should also be affected in face of the increased planning load as more systemic simplification errors were also made. However, the number of distinctive features deviated from targets did not differ in spontaneous single word and sentence production. This may be explained by the reason that manifestation of motor planning problem is greater at the Syllable level in the Motor Processing component. By simplifying the syllable structure, the speech production system allows enough processing capacity for the production of the increased strings of speech sounds with similar degree of deviation from targets.
**Imitated single word versus imitated sentence production**

Down Syndrome children were also observed to have greater articulatory defect in producing sentence than single word under imitated condition. This phenomenon may also support the notion that processing deficit lies at Motor Processing. Despite the fact that a perceptual target is provided in both cases, imitated sentence production involves increased planning load than imitated single word, resulting in greater number of errors. However, this phenomenon may also be explained by alternative reasons such as auditory memory deficit in the Down Syndrome population which has been suggested in the literature (e.g. Pueschel, 1988; Ellison and Gillis, 1993, cited in Chapman, 1995). Auditory memory deficit may lead to decay in the perceptual representations of words during imitated sentence production as a child needs to store the auditory image of the target word longer which appears at the end of a sentence, resulting in less accurate speech production. Confirmation of these speculations, of course, awaits further research.

**The Mentally Retarded group**

Children with mental retardation due to other causes, on the other hand, made the same number and types of errors, irrespective of production conditions. Also, they made consistent errors and did not get benefit from imitation. This is an indication of the stability of their phonological systems, implying that they have a stable lexical representation of words or perhaps a less flexible motor implementation system. Errors made are suspected to be due to the formulation of non-adult like realization rules for mapping input perceptual representations onto corresponding output articulatory presentations. Following Hewlett’s model, the level of impairment may lie at the Motor
Programmer. Children with subnormal cognitive ability may have an impaired ability in abstracting knowledge from the mental lexicon about the nature of the phonological system to be acquired.

**Conclusion**

To sum up, based on the findings of the present study, it is speculated that the articulatory deficits in the Down Syndrome population may be due to an impaired ability to store a fully-specified lexical representation in the output lexicon and an impaired ability to establish correct motor plans for timing and sequencing phonetic segments from an abstract lexical representation. The underlying deficit for children with mental retardation due to undetermined origin, on the other hand, may be due to an impaired ability to devise correct motor plans for mapping perceptual representations and output representations.

There is increasing evidence showing that Down Syndrome is associated with a characteristic pattern of articulation deficit. However, the picture of Down Syndrome speech at present is still far from clear and many more data are needed before any definite statements can be formulated. It may be time now to address the processing deficits underlying Down Syndrome speech directly via experimental procedures.

**Biological foundation of motor speech problem**

Anatomical investigations have revealed that the cerebellum of Down Syndrome patients is particularly small both in comparison to normal brains and in comparison to other parts of the mongol brain (Frith and Frith, 1974). In view of the role the cerebellum plays in motor performance, we might expect that the performance and learning of motor skills, including those for speech production, would be specifically
impaired in this particular group of subnormals. This organic factor may help account for their inconsistent production and lack of maintaining phonological rules, severe articulation disorders, and dysfluency (Blager, 1980).

**Asynchrony of language development**

Studies of children and adolescents with Down Syndrome have frequently indicated problems in expressive language development greater than one might expect on basis of cognitive delay in nonverbal domains or language comprehension. For example, Miller (1988) reported that significant numbers of children with Down Syndrome demonstrate deficits in productive language relative to mental age and syntax over vocabulary deficit. Fowler (1990) proposed an apparent limit or ceiling to syntax acquisition on the basis of observed plateauing in mean length of utterances (MLU) that was unrelated to mental age. Speech motor control deficits have been advanced as one plausible explanation to account for this finding (Miller, 1988). It has been speculated that these deficits might preclude the production of utterances as long and complex as their language skills would allow, leading to production only deficit. Whether expressive language deficit, as suggested in the literature, is related to output processing deficit underlying the speech processing chain remains unresolved at the present stage of knowledge. Further elaboration on this area may increase our understanding on the suspected motor skills problem in this population.

**Synergistic view of language**

According to the synergistic view of linguistic disorders suggested by Schwartz et al. (1980), there is a complex interaction and interdependency among various aspects of linguistic behaviours. In connected speech production, past researches have indicated that
demands of processing syntactic and semantic information have disrupted phonological processing with resulting misarticulations in English-speaking children (e.g. Pangos and Prelock, 1982; Paul and Shriberg, 1982). However, preliminary researches conducting to both normal-developing and phonological disordered children seem to suggest that interaction of phonology, semantics and syntax is not evidenced in Cantonese (e.g. Chan, 1993; Cheung, 1993; Chu, 1995). One plausible explanation may be that all those subjects had normal cognitive ability such that it is less likely for an increase in syntactic and semantic demands in connected speech to cause trade-offs in their phonological output (Chan, 1993).

In the current investigation, the non-Down Syndrome mentally retarded children exhibited stable phonological performance across sentence and single word productions, suggesting that the interaction of different linguistic domains may not be evidenced in Cantonese, even in populations with cognitive impairment. The exceptional performance of Down Syndrome children may need to be accounted for by additional interference in their speech production system. However, as controls of language level were lacking, this prevents us from making any conclusive statements concerning the discrepancy of phonological performance of Down Syndrome children in sentence and single word production as phonological trade-offs may have contributed to the greater impairment in sentence production. This tentative finding, however, is one that merits a closer look with the synergistic view of language in the mentally retarded population in general as well as in the Down Syndrome subgroup.

CLINICAL IMPLICATION

The most commonly used assessment and therapy programmes for children with phonological problems are based on the phonological descriptions of the child's speech
production (Grunwell, 1981; Hoden and Paden, 1983). However, description of symptomatology may fail to account for the distinct speech error patterns associated with Down Syndrome. Thus, clinicians may need to go beyond description and consider where the child may be having problems in speech processing in order to design effective intervention programs targeting specific deficits.

Concerning the inconsistent errors produced by Down Syndrome children, Dodd (1995) suggests that one major goal of speech therapy should be to establish consistency of word production. The use of core-vocabulary approach has been advocated targeting this problem. Words which can stress functional power of language and teach specific phonological regularities are chosen for therapy. Only one pronunciation is allowed for each of the target words; that is, the words do not have to be pronounced correctly, but if an error is made, it has always to be the same, developmental errors. Dodd and Leahy (1989) have reported positive results in a training programme for parents of children with Down Syndrome using this therapeutic approach.

Where the primary problem lies in motor programming as speculated in the non-Down Syndrome mentally retarded children, the therapeutic goal must be directed in developing new motor plans (Williams and Chiat, 1993). Therapy aimed at promoting listening, awareness, and monitoring of contrasts (e.g. Hodson and Paden, 1983; Dean and Howell, 1986) may be effective in encouraging the child to break programming "habits" and attempt new programmes. Kumin et al. (1994) also suggest that difficulty in coordination, sequencing, and timing can be addressed through a multi-sensory approach that includes visual, auditory, and motokinesthetic cues.
FURTHER INVESTIGATIONS

Further investigations could focus on the motor control deficits in the Down Syndrome population, specifically to speech production as well as other motor tasks. It is hypothesized that if individuals in this biologically distinct subgroup have a general impaired ability to formulate correct motor plans for motor acts, they should perform poorly on both verbal and non-verbal tasks. As suggested by Hewlett (1990), evidence for immaturity of motor control comes mainly from studies of duration, variability, and coarticulation in children's speech. Speech of execution, and consistency in execution, of physical movements are frequently used as indices of maturity and skill in motor behaviour. Another line of investigation may consider a systemic investigation of errors of a phonetic nature in Down Syndrome speech. Comparisons of language and phonological skills are also warranted. Of greater urgency is the need to investigate methods of remediating persisting phonological impairment in this population.

As mentioned previously, controls of language level were lacking in the present study. Further research may take this into account and include a control group of children with normal cognitive ability for comparison. Subjects recruited in this study were having moderate grade of mental retardation. Further studies may attempt subnormal subjects with higher cognitive functioning so as to find out whether degree of cognitive impairment will affect the picture.

ACKNOWLEDGMENT

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REFERENCES


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Appendix 1b: The target sentence stimuli

1. The girl is holding a pen.
2. The girl is eating an apple.
3. The girl is holding a plate.
4. The girl is pointing to a table.
5. The girl is pointing to her leg.
6. The girl is playing the piano.
7. The girl is holding a sock.
8. The girl is pointing to her eye.
9. The girl is holding a flower.
10. The girl is playing a ship.
11. The girl is holding a shoe.
12. The girl is pointing to her tongue.
13. The girl is holding a leaf.
14. The girl is holding a bowl.
15. The girl is holding a tortoise.
16. The girl is holding a dress.
17. The girl is holding a cup.
18. The girl is holding a basin.
19. The girl is holding a knife.
20. The girl is eating candy.
21. The girl is playing a sword.
22. The girl is holding a flag.
25. The girl is eating bread.
26. The girl is drinking milk.
27. The girl is pointing to her teeth.
28. The girl is holding a pair of trousers.
29. The girl is eating ice-cream.
30. The girl is bleeding.
31. The girl is eating chocolate.
32. The girl is holding a fish.
33. The girl is playing a slide.
34. The girl is holding a clock.
35. The girl is drinking orange juice.
Appendix 2: Frequency of occurrence of consonants, vowels, and tones for the target words

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Appendix 3: Modified SPE Distinctive Features Matrix for Cantonese Consonants

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