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Maximum Repetition Rates in Children At-Risk for Dyslexia

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Maximum Repetition Rates in Children At-Risk for Dyslexia

by

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Introduction

My senior thesis has focused on current research exploring precursor communication skills being conducted by Dr. Ben Massen at the Radboud University Medical Center in Nijmegen in the Netherlands. To that end, I worked in an acoustics lab analyzing Maximum Repetition Rates (MRR), also known as diadochokinetic rates, DDKs, in young children's speech development. This four year funded research project began in 2004.

In this paper I will provide an overview of the underlying theoretical considerations guiding the study and then describe my particular contribution to the effort, completed during Fall semester 2005 while I was a foreign exchange student.

Description of Research Study

This is a longitudinal study that follows the communication development of children from two months to five years of age. The study will then go on to measure their reading and spelling skills during their first years of schooling. Study participants come from a wide geographical region in Amsterdam, Groningen, Nijmegen, and Utrecht. All study participants in each city provided the same baseline measures and included hearing acuity, measures of phonetic and visual processing skills, early development of typical behaviors and vocabulary (reported by parent questionnaires), nonverbal intelligence, and measures of receptive and expressive language, and phonological awareness between the age of 3;6 to 5 years. (Maassen, 2005) These are the shared assessments across all study subjects. As well, each participating city is focusing on additional aspects of language development in the subject cohort. In Groningen further assessments are being done in the areas of grammar and morphological development. The researchers in Amsterdam are focusing on the cognitive attributes of attention and inhibition function, and developmental phonology is being assessed in Nijmegen. The researchers in Utrecht are doing a study focusing on children with specific language impairments (SLI).

There are two main research questions being targeted in this study. By closely tracking the children from a young age up until they start school, every step of their language development process can be closely followed. The first main question of the study is "what are the developmental interactions (direction of causality) between mild speech-language impairment, phonological processes and phonological awareness, and reading and spelling problems?" (Maassen 2005) The researchers are trying to determine if there is a relationship between these different areas of language. Does a problem in one of these areas adversely affect another area creating a deficiency in the child's language? The researchers are also looking at problems with neurophysiological processes. Is there a problem with any of the systems (speech motor control, phonological and syntactic systems, perception, lexicon) involved in speech and/or reading and writing? If so, is this neurophysiological deficit related to any external speech and/or literacy problem?

The next question addresses specificity. If there are external speech and/or literacy problems or behaviors found, can these indicate a specific disability? Are there certain behaviors or a combination of behaviors that are specific to auditory processing disorders (APD), specific language impairment (SLI), developmental apraxia of speech (DAS), or dyslexia?

Children with dyslexia, speech motor control problems, and specific language disorders often share a number of impaired early language skills. Often, it is impossible to tease out what deficit was first manifested and whether one deficit lead to another. A longitudinal research design is best able to examine these questions.

In order to address these questions, the researchers in Nijmegen selected the following speech tasks and analyses:

Speech tasks

- picture naming
- word and pseudo-word repetition
- maximum repetition rate of mono-, bi- and trisyllabic sequences (DDKs)
- sentence imitation

Speech analyses

- Broad phonetic transcription, followed by statistical analyses of phoneme production and phonological analyses of phonemes in context (syllable structure; consonant cluster; consonant-vowel combinations).
- Acoustic analyses aimed at assessing speech and movement rate, pauses, variability in repeated productions, segment lengths, spectral quality and coarticulation effects. (Ben Maassen, 2005)

MMR Acoustic Analysis

My part in this research study, and the basis of my senior thesis was the analysis of the DDK measures collected by the researchers in Nijmegen. The use of diadochokinetic rates (DDKs) are an appropriate motor control task when assessing the developmental skills of multiple age groups. They are particularly appropriate when working with children who are at-risk for dyslexia. There was a study done targeting dyslexic teenagers. The teenagers (mean age of 13) with dyslexia performed significantly worse than the control group on all DDK tasks, particularly the more complicated consonant-vowel syllable strings (Angela Fawcett & Nicolson, 2002). DDKs are useful in assessing motor coordination and articulatory control and are an important part in the evaluation of speech motor skills in children (Thoonen, Maassen, Gabreels, & Schreuder, 1998).They are particularly good for kids with dyslexia because the linguistic component involved in word repetition is eliminated (Angela Fawcett & Nicolson, 2002).

I analyzed speech data for 25 children aged 53 mos. Ten of these children were at-risk for dyslexia based on a family history where at least one parent had dyslexia. The other 15 children served as the control group. I analyzed average length of the syllable utterance, (strings of /pa/, /ta/ and /ka/ produced at a rapid rate by each child). These data were saved to the "averages" spreadsheet. I also measured the duration of each multiple consonant-vowel combination in /pata/ and /pataka/, This was done for each acceptable sample available. For the second measurement, recorded in the "syllables" spreadsheet, I selected the best sample in each category and measured the duration of each gesture in the sample. There were ten categories: /pa/ fast, /pa/ normal, /ta/ fast, /ta/ normal, /ka/ fast, /ka/ normal, /pata/ fast, /pata/ normal, /pataka/ fast and /pataka/ normal. Following is an explanation of the data I received and my methods of analysis. There is also a description of the spreadsheet I created. Raw data are not included due to proprietary concerns.

Sample Selection

The recorded data consist of three different types of diadochokinetic (DDK) speech tasks: monosyllabic (/pa/ /ta/ /ka/), bisyllabic (/pata/), and trisyllabic (/pataka/)samples. These five gestures were typically performed at both a normal (n) and fast (s) speech rate. All three types of speech tasks are included in both the "averages" and the "syllables" spreadsheets. Inclusion criteria for each sample included:

1. All repetitions must be correct
2. Repetitions must be consecutive

Best sample operating definition included:

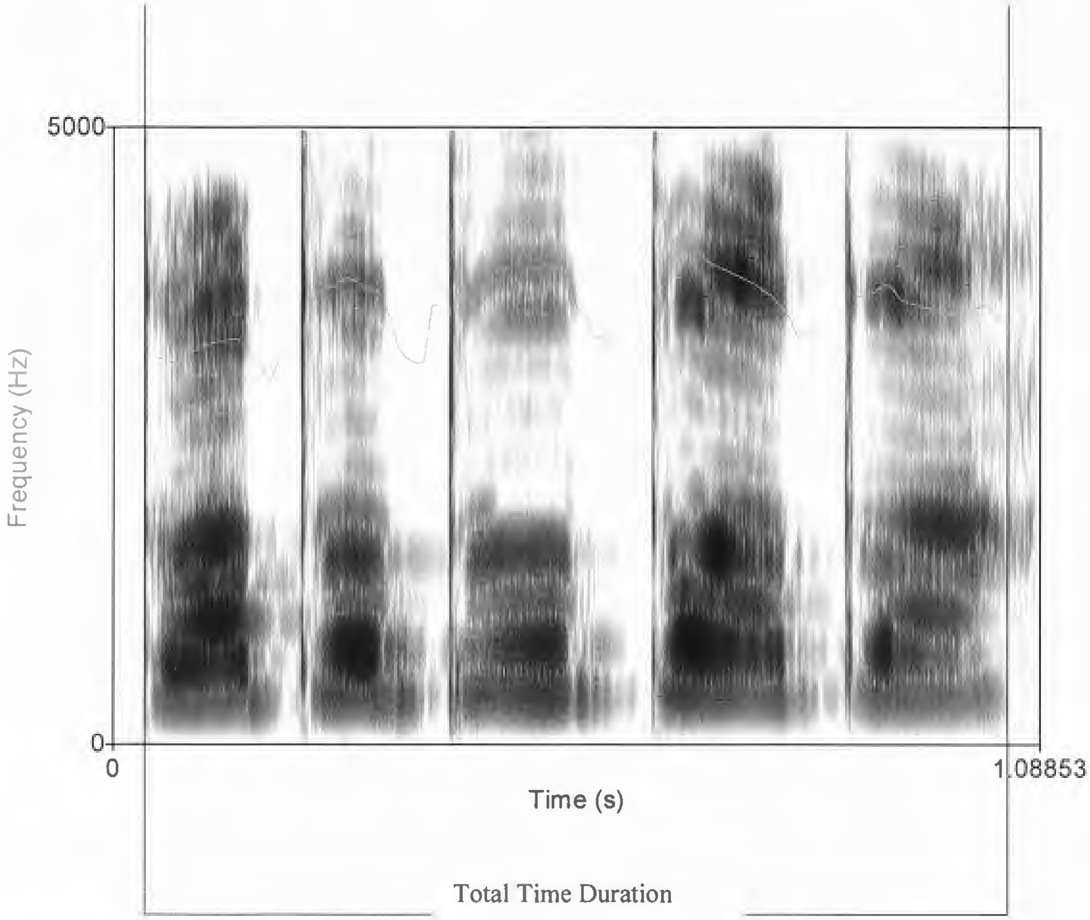
1. Steady rate of repetitions
2. Firm consistent voice – no fluctuation in intensity or pitch
3. Best graphic display on spectrogram

For monosyllabic gestures, five correct consecutive repetitions had to be produced. For bi and trisyllabic gestures only three correct consecutive repetitions had to be present. Each speech task has a normal and fast rate whenever possible. Both regular and failed speech samples were used. A sample was considered failed if not every repetition was correct. A failed sample was only used when a regular sample was not present. When using a failed sample, correct consecutive repetitions were pulled from the sample and used as a regular sample.

The Averages Spreadsheet

In the averages spreadsheet 4 numbers were calculated. When using monosyllabic tasks, only two numbers were calculated: seconds/syllable and average seconds/syllable. For bi and trisyllabic tasks all four numbers are present. These are: seconds/syllable, seconds/item, average seconds/item, and average seconds/syllable. Seconds/syllable and second/item were calculated for each speech sample that met the criteria. The average seconds/syllable and average seconds/item were the averages of the seconds/syllable (and item) measurements so there would be only one number for each category.

The analysis was done using the Praat program. When viewing a spectrogram in this program a light blue voicing line is visible. Each analysis was based on this line. The total time duration measurement of the sample started at the beginning of this line on the first correct syllable and terminated at the end of the last correct syllable in the sequence. (See figure below)



Monosyllabic Samples

The total time duration was measured for each speech sample. To find the seconds/syllable, the total time duration was divided by the number of gestures present. The number of syllables was not constant through each sample. The total time duration was divided by the number of syllables present to find seconds/syllable and also to make the numbers comparable. By doing this, the number of syllables is not a factor that will skew the results. After finding the seconds/syllable, the last number to calculate for monosyllabic sequences was the average seconds/syllable for each sound and rate. If there was only one sample in the category, the number was the same as the seconds/syllable. If there was more than one number in the category, the average was calculated.

Bi and Trisyllabic Samples

For bi- and trisyllabic samples, the same measurement techniques described above were used. Once the total duration was found, the seconds/string was calculated. Seconds/string was the duration of each /pata/ or /pataka/. To find this number the total time duration is divided by the number of correct and consecutive /pata/ or /pataka/s present in the total time duration.

Once the seconds/string was calculated the seconds/syllable was calculated. For bisyllabic samples the seconds/string was divided by two to find the seconds/syllable. This is because there are two syllables present in /pata/. For trisyllabic sequences, the seconds/item was divided by three because of the three syllables in /pataka/.

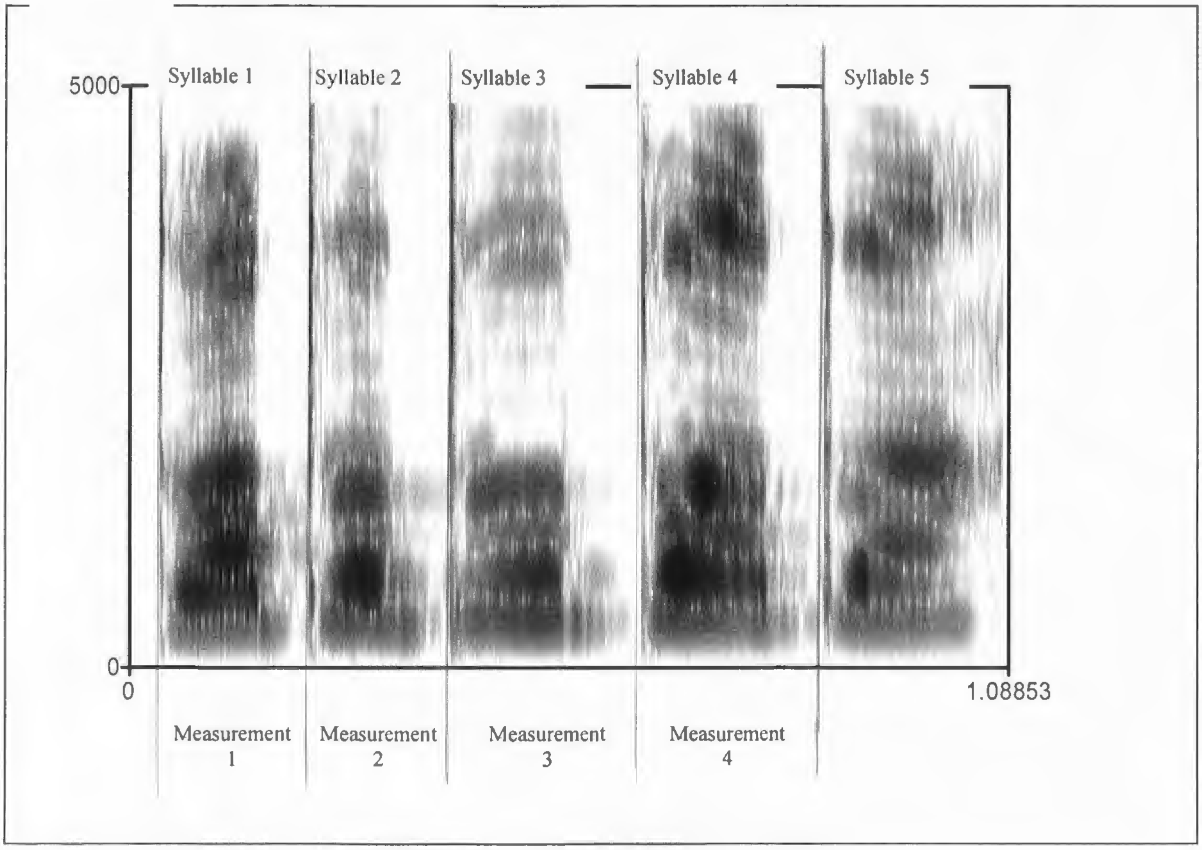
Finding the average seconds/item was exactly the same method described above for calculating monosyllabic average seconds/syllable. When this number was found the average seconds/syllable was calculated. This was done for bisyllabic samples by dividing the average seconds/item by two. For trisyllabic sequences it was the same, except instead of dividing by two, divide by three.

Jitter Measurements

The first page of the spreadsheet "DDK Syllables" is an overview of all the syllables measured for each child. The following pages of the spreadsheet are the data for each specific sound. Jitter calculations were also done on these sound specific pages.

All measurements were done in the Praat program. The measurement started at the first burst and ended at the burst of the following syllable (See monosyllabic example Figure 1). Since a following syllable was needed for the measurement, the last syllable in each group could not be measured. This is the reason there are only four syllable measurements when there are actually five syllables present.

Figure 1



Monosyllabic samples /pa/ /ta/ and /ka/ were measured for each syllable. Bisyllabic samples measured the duration of each /pata/ (See Figure 2), and trisyllabic samples (See figure 3) measured the duration of each /pataka/ in seconds.

Figure 2

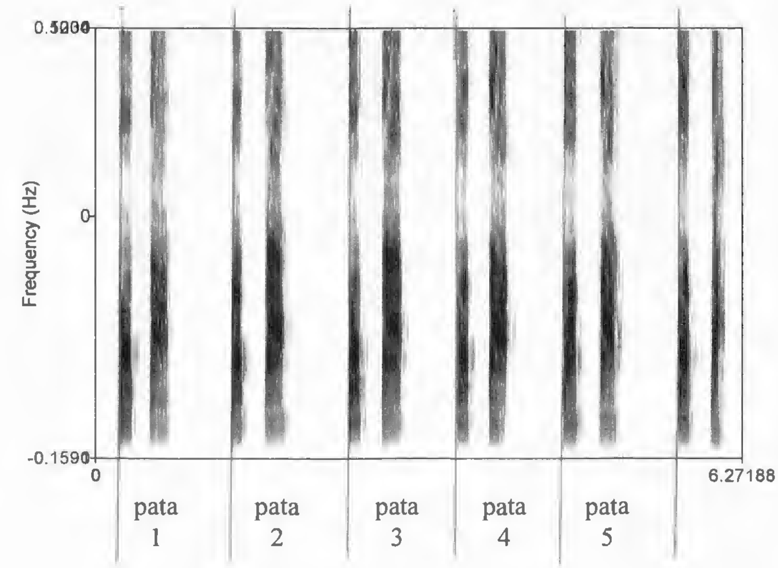
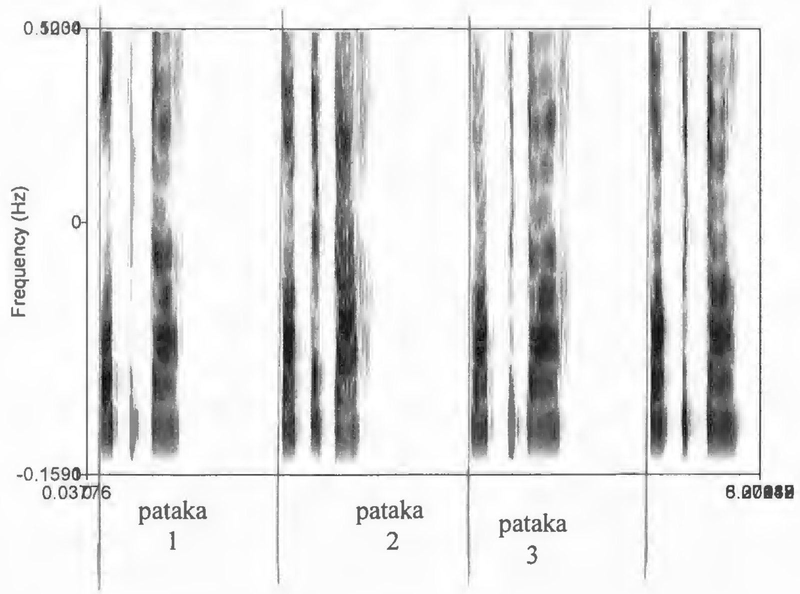


Figure 3



After each gesture was measured, jitter was calculated. Jitter is the cycle-to-cycle variability in frequency of vocal fold vibration. (Ferrand, 2001)This was done using the formula:

$$\frac{\sum (D_{(i)} - D_{(i-1)})^2}{\text{Mean}}$$

While data analysis is ongoing and statistical tests have not been run, it appeared that the at-risk children for dyslexia performed speech motor control tasks with similar speed and accuracy as the control group. It is possible that developmental differences found in later years between DDK rate in dyslexic and children with normal reading skills has yet to emerge by 53 months of age. Perhaps too, a larger sample size may provide different findings.

This honors project enabled me to develop sophisticated laboratory-based acoustic analysis skills of speech utterances. It has extended the foundation established in Speech Science and has allowed me to see the connection between speech motor control and other related linguistic skills such as reading and writing.

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