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Luciana Mendonça Alves, César Reis, Angela Pinheiro, Simone Capellini, Muriel Lalain, Alain Ghio

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PROSODIC ASPECTS OF READING IN STUDENTS WITH DYSLEXIA

L.M. Alves[1,2], C. Reis[2], A. Pinheiro[2], S. Capellini[3], M. Lalain[4], A. Ghio[1]

[1]*LPL (Laboratoire Parole et Langage) - CNRS, Aix en Provence, France*
[2]*UFMG (Universidade Federal de Minas Gerais), Belo Horizonte, Brasil*
[3]*UNESP (Universidade Estadual Paulista Júlio de Mesquita Filho), Marília, Brasil*
[4]*Gipsa-lab, DPC (Département Parole et Cognition) – CNRS, Grenoble, France*

Introduction

Dyslexia has been thoroughly investigated for more than a century through the lens of the most widely-known fields. Issues of neurology, genetics, psychology, pedagogy and linguistics have been raised and important discoveries and observations have been made in recent years. However, when dyslexia is considered from a linguistic perspective, there are few studies in the field of prosody. In an effort to address this gap, the objective of this project is to understand the function of prosody in reading out loud for children with dyslexia.

Methods

Two groups were studied in order to verify the effect of dyslexia on the temporal prosodic aspects of reading for students with this condition. The first group was comprised of 10 members who had been diagnosed with phonological dyslexia (D) – and the other had 30 members without this diagnosis and with no evidence of other language or learning difficulties - control group (C). Both groups were comprised of students between the ages of nine and 14 years.

The methodology consisted of recording the reading of a text, followed by a retelling exercise and an objective test for text interpretation. The data were analyzed through perceptive and acoustic means. In the acoustic analysis, the *WinPitch* program was used. The temporal and melodic prosodic aspects of the oral reading and the retelling exercise were correlated with the data obtained from the objective interpretation tests.

Results and discussion

Our first observations of the prosody in reading for the dyslexic group studied – made through phonological analysis and prior to conducting an acoustic analysis – allowed us to identify a lack of rhythmic regularity when these subjects were reading. Their difficulty with delimiting tone groups, marking feet, and producing stresses caused problems for the dyslexic students in their phonological organization of intonation.

The following table illustrates the primary results obtained for the temporal acoustic measurements of the reading. The measurements of articulation rate and articulation time were proposed by Grosjean; Deschamps (1975) and Grosjean; Collins (1979), but they did not take pauses into consideration.

Variable	Means (± Standard Deviation) Dyslexics	Control	F Test (P-value)
Total elocution time (sec)	162.3 (±135.90)	46.94 (±9.48)	12.52 (**0.00**)*
Articulation time (sec)	91.70 (±66.20)	35.07 (±5.367)	8.71 (**0.00**)*
Elocution rate (syl/sec)	1.72 (±0.85)	3.69 (±0.556)	49.69 (**0.00**)*
Articulation rate (syl/sec)	3.11 (±1.79)	4.86 (±0.610)	8.83 (**0.03**)*
Number of syllables	213.6 (±62.5)	167.67 (±6.61)	7.34 (**0.00**)*
Number of pauses	97.80 (±64.70)	22.83 (±5.079)	26.69 (**0.00**)*
Duration of pauses (ms)	86.00 (±87.70)	11.53 (±3.719)	12.84 (**0.00**)*

TABLE 1: temporal acoustic measurements of reading

According to our observations, we obtained values that were statistically significant for all of the temporal variables studied, with weaker performance in the abilities of the dyslexic subjects. Consistent with the results of the research by Fawcett; Nicolson (2002), we particularly noted lower values in the articulation rate of the dyslexic subjects, demonstrating that the speed of producing each articulatory gesture is slower in children with a reading disability.

In the retelling exercise, however, we only obtained statistical differences when comparing the following variables: total elocution time (the dyslexic subjects required more time), and duration of pauses (longer for the dyslexic subjects).

With respect to the prosodic aspects of fundamental frequency (F_0), our principal findings are presented in table 2:

Variable	Mean in Hz (C / D)	D.P.	P
Initial F_0	239.92 / 190.53	53.19 / 56.04	**0.00**
Minimal F_0	183.84 / 148.25	46.98 / 48.97	**0.00**
Maximal F_0	309.63 / 234.48	68.42 / 73.05	**0.00**
Final F_0	211.51 / 180.81	98.78 / 56.59	**0.00**
Pitch Range	128.28 / 91.25	67.66 / 52.58	**0.00**

TABLE 2: F_0 measurements in reading

- Initial, final, maximal and minimal F_0 values: all of the measured values were lower for the dyslexic subjects. The analysis of these same values for different types of phrases (interrogative, exclamatory and declarative) indicates that the dyslexic subjects did not mark the differences between phrase types (or they made little differentiation).

- In order to objectively verify the melodic variation of these subjects while reading, we measured the pitch range, which is the variation between the maximal and minimal values obtained from the overall configuration of the F_0 curve. The subjects in the control group had vocal pitch range values that were significantly higher than those of the dyslexics.

- Another aspect to be observed, particularly in the comparison between the initial and final F_0 values, is declination, which is considered to be a time-related phenomenon where there is a gradual decline in the F_0 curve during an utterance (COHEN; t' HART, 1967; LADD, 1984). This phenomenon can be linked to physiological issues (LIEBERMAN, 1967; COLLIER, 1975), how grammar was learned (GUSSENHOVEN, 2004) and can even be under the control of the speaker (t' HART; COLLIER; COHEN, 1990). In this project we did not attempt to specifically measure the line of declination because it would have required a specific methodology and a very detailed analysis of all of the points of melodic configuration for each utterance. Through observing the initial and final F_0 points, we perceived this phenomenon in very simple terms. After analyzing the graphs for the dyslexic subjects, we observed this tendency was quite subtle, with an almost flat line drawn between the initial and final F_0 values.

For the retelling exercise, the same tendencies were observed in both groups. However, we noted the need to conduct research with spontaneous speech. We can confirm that the dyslexic subjects are not able to produce melodic variations in reading activities (reading as an activity itself and reporting on text that has been read).

Following is the analysis of the localized aspects observed in the prominent stressed and pre-stressed vowels for each tonal group:

- Duration: the values obtained for the production of the prominent stressed vowel were not particularly different between the groups, fluctuating between 0.17 and 0.19 seconds, a difference which was not statistically significant. Upon analyzing the values for the duration of pre-stressed vowels, we observed that the dyslexic individuals took significantly longer to produce these segments. We know that the vowel in the prominent stressed syllable is the most important element in prosodic studies because it holds the key characteristics for melodic movement. However, when we compared the results of our measurements of duration, we perceived that there was a difference in behavior between the groups, only related to the duration of the vowel in pre-stressed syllables. Specifically, we noticed that the dyslexic subjects produced these vowels with a significantly longer duration (0.13 sec) than the control group (0.08 sec). This explains the difficulty we observed in their identification of the prominent stress in some cases, since the dyslexic subjects held the stressed vowel with only a slightly longer duration than the pre-stressed, making the pre-stressed vowels longer than usual. This difficulty can be related to their perception of rhythmic alternation between stressed and non-stressed segments while reading. In the retelling exercise, however, there was no significant difference in the behavior of the groups. Therefore, in the processing of oral language, this perception seems to be accurate.

- Melodic amplitude: this variable refers to how much each of the melodic curve segments, understood as the prominent stressed and pre-stressed vowels of each utterance, changed from the initial point to the final, that is, the melodic interval. We noticed that the subjects in the control group presented significantly higher values in the prominent stresses vowels, with an average of 50.19 Hz, when compared with the dyslexics (29.73 Hz). In other words, the dyslexic subjects presented a lower amplitude of melodic variation in the prominent stressed vowel. These results are consistent with the lower values of pitch range observed in the overall configuration of the melodic curve for dyslexic subjects. These observations reaffirm the limitations of dyslexic subjects in their ability to make specific melodic movements when reading. In the retelling exercise, the amplitude values did not differ between the studied groups.

Speed of melodic change: to obtain this rate, we divided the value of the melodic interval by the duration of this interval, measured in Hz/sec, as proposed by t' Hart *et al.* (1990). Through the values presented in table 3, it can be observed that, in the control group, we obtained a mean value of 0.30 Hz/sec for the prominent stressed vowel, which is significantly higher than that of the dyslexics (0.14 Hz/sec). We can therefore certify that, besides having a lower melodic variation, the dyslexic subjects had less ability to make melodic changes. In other words, they spent more time to change the melody of the nuclear stress. It is interesting to note that this could also be applied to pre-stressed elements for dyslexic subjects since their weak definition of the stressed element resulted in the pre-stressed element having almost equal importance.

	Prominent stressed vowel			**Pre-stressed vowel**		
Group	**Mean (in Hz/sec)**	**Standard Deviation**	**P**	**Mean (in Hz/sec)**	**Standard Deviation**	**P**
C/D	0.30 / 0.14	0.30 / 0.14	**0.00**	0.22 / 0.13	0.33 / 0.16	**0.01**

Table 3: Speed of melodic change in Hertz per second

In the retelling exercise, however, when we compared the prominent stressed and pre-stressed vowels between the two groups, we did not obtain significant values for this change in melodic movement. In other words, in relating a read text, both groups had similar speed changes in melodic movement.

- Intensity: the results obtained from reading and retelling were analyzed, considering both local measurements, that is, the intensity of the stressed and pre-stressed vowels, as well as enunciation overall, measuring the peak signal of intensity for each uttered syllable. In both analyses, the dyslexic subjects presented lower levels of intensity in their reading.

We know, then, that F_0 and intensity are independent but related parameters, which was also proven by the studies of Alku; Vintturi; Vilkman (2001). According to the authors, the production of a higher voice frequency leads the speaker to increase the number of glottal stops per second, increasing the vibration of the wave of speech pressure, which in turn, elevates vocal intensity. An opposing rationale could be applied to our results which demonstrated that a lower intensity is related to lower F_0 values, thus identifying the interrelationship between F_0 and intensity. We can relate these two aspects to the profile of the dyslexic subjects portrayed during the reading activity: minor melodic variation, usage of lower F_0 and lower intensity, making these factors closely related.

- Correlation between the studied variables and text comprehension: in order to verify the factors related to the number of correct answers, we used the Gompit logistical regression. Through the logistical regression, we obtained a set of variables that explain part of the variation in the number of correct answers. Using this model, we correlated all of the studied prosodic variables to the relative data on comprehension and we found that the rate of elocution and duration of pauses were significant ($p<0.05$), indicating that a shorter duration of pauses and a higher rate of elocution would be associated with higher levels of text interpretation. The study of the other prosodic variables presented less conclusive results which suggests the need for a larger sample size in order to obtain more reliable observations.

Conclusion

Without attempting to consider all of the possible variables involved, this research revealed aspects of the prosodic nature of reading for dyslexic children. It defined a tendency among these individuals in their intonational and temporal structure when reading out loud, highlighting unique characteristics such as aspects related to the variation of fundamental frequency (clearly demonstrating a limitation in their ability to make melodic changes and to mark phrase type), aspects related to temporal processing (excessive use of pauses and placement outside their usual location, reduced speeds of reading and articulation) and difficulties in marking rhythm and prominent stresses, all of which form a profile for the dyslexic subjects in this study.

References

ALKU, P.; VINTTURI, J.; VILKMAN, E. Measuring the effect of fundamental frequency raising as a strategy for increasing vocal intensity in soft, normal and loud phonation. *Speech Communication*, v. 38, p. 321-334, 2001.

COHEN, A.; t' HART, J. On the anatomy of intonation. *Lingua*, v. 19, p. 177-192, 1967.

COLLIER, R. Physiological correlates of intonation patterns. *Journal of the Acoustic Society of America*, v. 58, p. 249-255, 1975.

GROSJEAN, F.; DESCHAMPS, A. Analyse contrastive temporalles de l'anglais et du français: vitesse de parole et variables composantes, phénomènes d'hesitastion. Basel: Phonetica, 1975.

GROSJEAN, F.; COLLINS, M. Breathing, pausing and reading. *Phonetica,* v. 36, p. 98-114, 1979.

GUSSENHOVEN, C. *The phonology of tone and intonation*. Cambridge: Cambridge University Press, 2004.

FAWCETT, A. J.; NICOLSON, R. I. Children with dyslexia are slow to articulate a single speech gesture. *Dyslexia*, oct-dec; 8, 4, p. 189-203, 2002.

LADD, R. Declination: a reviewand some hypotheses. *Phonology Yearbook*, v. 1, p. 53-74, 1984.

LIEBERMAN, P. *Intonation, Perception and Language*. Cambridge: MIT Press, 1967.

t' HART, J., COLLIER, R.; COHEN, A. *A perceptual study of intonation: an experimental-phonetic approach to speech melody*. Cambridge: Cambridge University Press, 1990.