CHANGING DURATION PATTERNS AND Fo RANGE WITH AGE

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The paper is concerned with correlation of prosodic characteristics of duration and pitch range with age/ Based on corpus analysis are the selected parameters of mean syllable duration, mean intonation phrase duration, mean pause duration and pitch range. Experiment: 30 speakers, aged 17-76. Correlation and regression methods revealed syllable and pause duration as well as pitch range dependence on age.

Keywords: correlation of prosody and age, syllable and pause duration, pitch range, corpus analysis, correlation coefficient, regression equation

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ИЗМЕНЕНИЯ ДЛИТЕЛЬНОСТИ И ДИАПАЗОНА РЕЧИ С ВОЗРАСТОМ

В статье рассматривается корреляция просодических характеристик длительности и диапазона речи с возрастом. На основе корпусного анализа избираются параметры средней длительности слога, фразы, паузы, величины диапазона. Контрольный эксперимент: 30 чел. возраст 17-76. Реализация корреляционного и регрессионного метода анализа позволила выявить зависимость слога, паузы и диапазона от возраста.

Ключевые слова: корреляция просодии речи и возраста, длительность слога и паузы, диапазон голоса, корпусный анализ, коэффициент корреляции, уравнение регрессии.

1. Introduction

The aim of the present study is to find how duration of speech units, such as syllables, intonation phrases, pauses, as well as pitch range of speakers change over a long period of socially and communicatively most productive life span. We are especially interested in unprepared talk data based on face-to-face interaction in interviews.

Talking about oneself, giving facts of one's biography in an interview is a most typical and natural style of spoken communication. However, the manner of self-presentation and the prosodic features of duration in particular, may change with time, being indicative of articulation habits developing with communicative and linguistic experience and cognitive processes in speech planning [1].Physical, cognitive and social factors may affect the basic prosodic parameters of pitch and tempo, among which only lowering Fo-mean has been proved to be a reliable sign of ageing through life [2].Tempo variation, as indicated by duration parameters, appears to be more prone to psychological factors and can be treated as a personality marker [3].

As is well known, tempo, or speaking rate, is a complex phenomenon. The overall impression of fast, normal or slow tempo may depend on both the articulation rate and on the proportional duration of silent pauses in speech [4]. The relevant references for a medium range of articulation rate in English are: Goldman-Eisler [5] estimating it as being between 4.4 and 5.9 syllables per second, which can be calculated as 227-170 ms; Lindblom [6] reporting the average duration of syllables as ranging between 160 and 200 ms, and Laver suggesting, as a rule of thumb, that speaking rate of more than 240 words per minute would count as a notably fast speaking rate, and fewer than 160 as a notably slow rate. An important point made in the speaking rate description was an assumption that it doesn't change with either style or formality of the situation but may vary sociolinguistically. [7].

We set ourselves the task of checking whether duration patterns are just as constant throughout the life periods of youth, young age, mature age and old age as they are reported for various styles and situations.

2. Previous work

For our preliminary overview of previously obtained data we drew on three corpora researches done under the first author's supervision with the total of 117 American English speakers. Here are the basic findings obtained in the course of the overall prosodic analysis which are relevant for the present study.

1) In the analysis of reading and monologue of 59 speakers (28 men and 31 women) recorded in the city of Anchorage it was found that mean syllable duration (MSD) varies geographically, that southern drawl in the speech of migrants is still noticeable and measurable; Fo range positively correlates with social status [7];

2) New patterns of duration change were found in the speech of 40 speakers (17 men and 23 women) recorded in four regions along the Atlantic coast: mean syllable duration increases from North to Southern Midland, but in the South tempo slows down at the expense of longer pauses.[8].

3) By grouping 18 speakers (10 men and 8 women) according to their life stages (youth, young age, mature age, old age) and discriminating the duration of accented and unaccented syllables a few specific duration patterns were found: speakers in the "youth" group tend to prolong unaccented syllables, speakers of old age increase the duration of pauses [10].

There are two main observations to be made with regards to the styles of speech:
• in reading there is a tendency for MSD to grow with age, while in speaking the consistency of values is an open research question;
• in both reading and speaking Fo range tends to grow with age.

In the researches the overall prosodic analysis of socially and geographically diverse population included, among other things, data on comparison of MSD and Fo range across four age groups.

It was found that only in reading there was a tendency for men aged 40-49 and for women aged 50-60 to exceed the range of normal tempo. The values of MSD in interview fall within the range of 190-223ms (table 1).

The results suggest that age differences in articulation rate, as evidenced by MSD values in interviews, consist in nuances rather than categorical distinctions between

normal and fast, or normal and slow tempo ranges. Thus, for instance, there is a difference of around 30 ms between the group values of people whom we could describe as "youth", aged 19-29, and the next group of still young people aged 30-39. That was the maximum difference we observed in the speaking data, and it was worth checking in the present study.

3. Corpus, method, parameters

The subjects were 30 educated middle class speakers of American English, 12 men and 18 women (students, journalists, writers, actresses, a teacher, a bank manager, a diplomat, a lawyer, a historian, an engineer, a technician, a literary critic, a theologian, a housewife, a pensioner), citizens of the USA, residents of diverse geographical regions.

The subjects were engaged in telling their life stories, talking about their jobs, studies, recreation. The recordings were made in the USA in 1980s and 1990s in the form of an interview. Only monologue parts of the talks were chosen for analysis, normalized at 1 min, and processed with Speech Analyzer v.2.4.

The total duration of the narrow corpus is 30 min.

The relevant acoustic parameters are:
• mean Fo range;
• mean syllable duration (MSD);
• mean ip duration (Mip);
• mean pause duration (MPD).

The measurements taken were averaged for each speaker and individual mean values were compared. Statistical correlation analysis and regression analysis followed.

4. Statistical analysis

The goal of our study is to assess the way and the extent to which age affects Fo range and duration characteristics of the respondents presented in table 2.

The parameters are presented in table 3:

The correlation analysis method was used to estimate the dependence of the duration and Fo-range parameters shown in Table 3 on the age of the respondents. It enabled us to determine the way and the extent to which age affects temporal characteristics and pitch range of American English speakers.

The method was based on the calculations and analysis of Pearson paired linear correlation coefficients calculated by the formula:

$$R_{xy} = \frac{\overline{xy} - \overline{x} * \overline{y}}{\sigma_x \sigma_y}$$

The calculations are presented in Table 4.

Table 1. MSD in four age groups (ms)

age	reading		interview	
group	m	f	m	f
19-29	226	210	218	223
30-39	235	214	194	190
40-49	276	222	216	207
50-60	246	315	220	211

Table 2. Individual scores of 30 speakers' Fo-range and duration values: MSD, Mip, MPD

NN	Age years	Fo range st	MSD ms	Mip ms	MPD ms
1	17	3	223	1560	833
2	17	2	201	2406	375
3	21	2	262	2618	720
4	21	6	242	1442	433
5	23	2	256	2300	371
6	23	7	235	1857	310
7	25	5	230	3213	605
8	27	9.3	274	2051	642
9	27	8	264	2367	306
10	28	4	205	1997	260
11	29	3	199	2586	442
12	30	7	184	2386	581
13	31	4	207	1659	474
14	33	4.5	252	1764	590
15	33	5	230	2760	453
16	39	1.5	296	3252	507
17	40	2	232	2155	621
18	45	8	219	1754	523
19	45	5	262	2877	852
20	50	8	214	1581	615
21	50	3	275	1927	464
22	53	8	245	1808	504
23	54	7	225	1903	678
24	55	9	257	3100	752
25	55	9	166	1713	744
26	57	13	178	1422	252
27	60	13	1783	1374	590
28	63	4	205	2050	737
29	68	3	189	2647	615
30	76	6	260	1823	754

Table 3. Fo range and duration parameters

NN	Parameter	Symbol	unit
1	Age	X_1	years
2	Fo range	X_2	st
3	MSD	X_3	ms
4	Mip	X_4	ms
5	MPD	X_5	ms

Table 4. Paired correlation coefficients matrix of Fo range and duration parameters

variable	X_1	X_2	X_3	X_4	X_5
X_1	1.000	.587	-.499	-.159	.550
X_2	.687	1.000	-.424	-.130	-.043
X_3	-.499	-.424	1.000	.369	.093
X_4	-.159	-.130	.369	1.000	.133
X_5	.550	-.043	.093	.133	1.000

The following conclusions can be drawn from the analysis of the paired correlation coefficients matrix:

• correlation of Fo range with age, MSD with age, MPD with age is significant ($r_{x_1 x_2} > 0.5$; $r_{x_1 x_5} > 0.5$) according to Student's t-criterion:. ($t_{p_{x_1 x_2}} = 3{,}207$; $t_{p_{x_1 x_3}} = 2.983$; $t_{p_{x_1 x_5}} = 4.112$). Error probability is at 5%.

• There is a 95% probability that there is no correlation between age (X_1) and mean ip duration (X_4) in the population surveyed ($|(r_{x_1 x_4}| = 0.159 < 0.5)$; ; Student's t-criterion at 1.057).

The next step was to conduct regression analysis method to obtain the analytical form of correlation between the parameters subject to analysis (table 3). The results are presented in Table 5.

The regression equations shown in Table 6 are statistically significant according to the Fisher-Snedecor F-ratio ($F_{p_1} = 119.602$ $F_{p_2} = 140.667$; $F_{p_3} = 367.747$) at the level of probability of p=95% and contain significant parameters — Student's t regression coefficients at various levels of probability:

• regression coefficients in the regression models reflecting the effect of age on Fo range (t_p =2.820) and MPD (t_p =2.976) are significant at the probability level of 95%;

• regression coefficient in the model of estimating the effect of age on MSD is significant with the error probability of 15% (p=0.85).

The goodness of fit of the regression models shown in Table 5 was confirmed by the values of the average approximation error:

$$\bar{\varepsilon} = \sum \frac{|y_i - \bar{y}_x|}{y_i} *100\%$$

where y_i i stands for the empirical values of the parameter;

$\bar{y}_x$ stands for theoretical values of the parameter calculated by the regression equation.

The average approximation error values vary within the acceptable margin of error: $\varepsilon_1 = 5.945$; $\varepsilon_2 = 9.172$; $\varepsilon_3 = 3.705$, which confirms the relevance of the models shown in Table 5 for actual age-specific Fo range and duration characteristics of the respondents.

The interpretation of the regression models obtained makes it possible to conclude that each one year of the respondents' lives Fo range increases by .073 st and MSD decreases by .405 ms.

Table 5. Regression models of age-specific Fo range and duration parameters: MSD and MPD

N	Parameter		Regression models
1	Fo-range	X_2	$\overline{X}_{2(x_1)} = 2.791 + 0.073 x_1$
2	MSD	X_3	$\overline{X}_{3(x_1)} = 244 - 0.405 x_1$
3	MPD	X_5	$\overline{X}_{5(x_1)} = 41.065 + 3.549 x_1$

Table 6. Precision characteristics of age-specific Fo range and duration parameters regression models

NN	Regression models	Average residual	Average error	F Fisher-Snedecor
1	X_2	2.372	5.945	119.602
2	X_3	26.882	9.172	140.667
3	X_5	13.842	3.705	367.747

To conclude:

Multidimensional methods of statistical analysis of 30 American English speakers' scores in interviews identified the following duration patterns: decrease of MSD and increase of MPD with age; it also confirmed the increase of Fo range with age.

5. Conclusions

We conducted the analysis of duration patterns in interviews to find whether the syllable as a basic articulation unit and the intonation phrase as a basic unit of intonation change with time over a long period of life. By assessing the way age affects duration scores across different age groups or at successive life stages we make observations about articulation rate development "in apparent time". By estimating these effects through individual scores analysis we find how gradual the process is.

The statistical analysis gave enough evidence to conclude that duration patterns of the syllable do change with age: syllable length tends to be shorter while pauses become longer. No significant correlation was found between age and the length of the intonation phrase.

It was also important for our study to consider the vertical, alongside with the horizontal dimension of prosody change: Fo range is a sign of the voice flexibility. It has been confirmed that Fo range turns to be wider with time, basically at the expense of a lower register, as the data on lowering Fo mean suggests.

There are certain limitations to the validity and universality of our conclusions which are due to the absence of a fairly representative number of senior age speakers.

References

1. Durand, J. Laks, B. (eds.), 2004. Phonetics, Phonology, and Cognition. Oxford University Press.

2. Helfrich, H. 1979. Age Markers in Speech. In: Scherer, K.R., Giles, H. (eds). Social Markers in Speech. Cambridge University Press, 63-98.

3. Scherer, K.S. Personality Markers in Speech. In: Scherer, K.R., Giles, H. (eds). Social Markers in Speech. Cambridge University Press, 147-210.

4. Lehiste, I., 1970. Suprasegmentals. Cambridge MA: Massachusetts Institute of Technology Press.

5. Goldman-Eisler, F., 1968. Psycholinguistics: Experiments in Spontaneous Speech. London: Academic Press.

6. Lindblom, B., 1983. Economy of speech gestures. In: P.F. MacNeilage (ed.), The Production of Speech. New York: Springer-Verlag, pp. 2

7. Laver, J., 1994. Principles of Phonetics. Cambridge 17-246. University Press, 539-546.

8. Poletayev, D., Shevchenko, T., 1997. Sociolect I Prosodiya. Angliyskiyi Lexicon: Poznanye i Kultura..Moscow: MGLU, v. 438.

9. Babushkina, E., Shevchenko, T., 2000. Stereotipy Severa I Yuga v Amerikanskom Proiznosheniyi. Zvuchashchaya Rech: Teotiya I Praktika. Moscow, MGLU, v.453.

10. Romanova, E.Yu., Shevchenko, T.I., Sadovnikova N.A,.2010. Prosodiya i Vozrast: Opyt Statistycheskogo Analyza Rechi. Fonetika I Fonologiya Zvuchashcheyi Rechi. Vestnik MGLU, Moscow: Rema.(forthcoming).