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Age-dependent types and frequency of disfluencies

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Abstract

The age-dependent changes of one's speech production from childhood up to old age are relatively well known. However, there has been less research conducted concerning the possible alterations of the disfluency phenomena in speakers' spontaneous speech determined by age. Our hypothesis is that permanent changes are going on in the operation of speech production processes from early childhood up to old age, and that those changes can be studied via observing disfluency phenomena. A series of experiments has been carried out with the participation of altogether 30 Hungarian-speaking persons, children, midle-aged adults and old subjects (ages of 77). Their spontaneous speech was recorded and analyzed concerning the articulation and speech tempi, silent and filled pauses, as well as other disfluency phenomena (like false starts, repetitions, slips, etc.). The aim of the research is to explore the invariant and variable factors of the disfluencies depending on age. The results highlight also the individual differences that seem to be independent of the age factor.

1. Introduction

Spontaneous, "fluent" speech involves all sorts of disfluency phenomena. Silent pauses, hesitations, repetitions, fillers, grammatical errors, mis-selected lexical items, self-corrections, prolongations, false starts, slips of the tongue, etc., are all due to some disharmony between speech planning and execution. Speech disfluencies are generally defined as phenomena that interrupt the flow of speech and do not add propositional contents to an utterance [4].

The functions and motivations of disfluencies are manifold. Some of them, like silent pauses, are there to facilitate breathing, but also to enable the speakers to harmonise their speech processes and to leave time for the listeners to digest what they have heard. Other disfluency phenomena occur as "errors", large numbers of which may be rather distracting for the listener.

According to recent data concerning the numbers of hesitations and/or "errors" occurring in speech [1, 4], spontaneous speech contains an instance of disfluency every six words, whereas in longer monologues, they occur every 3.6 words (due to the specific function of monologues, this count does not involve silent pauses).

Characteristic methodological differences can be observed in disfluency research [3, 5]. One approach tries to draw conclusions concerning the features of disfluencies on the basis of collected corpora; the drawbacks of that approach are that collection tends to be selective and that exact proportions of occurrence are difficult to establish for the various types of disfluency. The other approach analyses disfluencies occurring in a given spontaneous speech corpus, making it possible to get more exact information about the operation of production processes. On the other hand, it might be a problem that the various types of disfluency do not occur in balanced numbers (or not at all) in the corpus studied.

Disfluency phenomena have served as a basis for several models of speech production [2, 6]. Figure 1 shows an adaptation of Levelt's [8] speech production model indicating the production levels at which disfluencies may occur (cf. [7]). It can be seen that signs of uncertainty (pauses, hesitations, repetitions, fillers) arise at the conceptual level of speech planning, whereas "errors" can be committed at all levels of the process.

The characteristics of speech can be determined by a number of factors, one of them being age. In early childhood, learning how to speak requires the loading of the mental lexicon, the consolidation of articulatory movements, and the acquisition of grammatical, phonological, as well as pragmatic regularities of the given language. Two to three-year-old children commit seven times as many errors in their speech than adults do [10]. By the age of nine to ten, the process of first language acquisition can be seen as by and large completed, yet children of that age still need a lot of practice before they pick up the speech experience that is needed for school work.

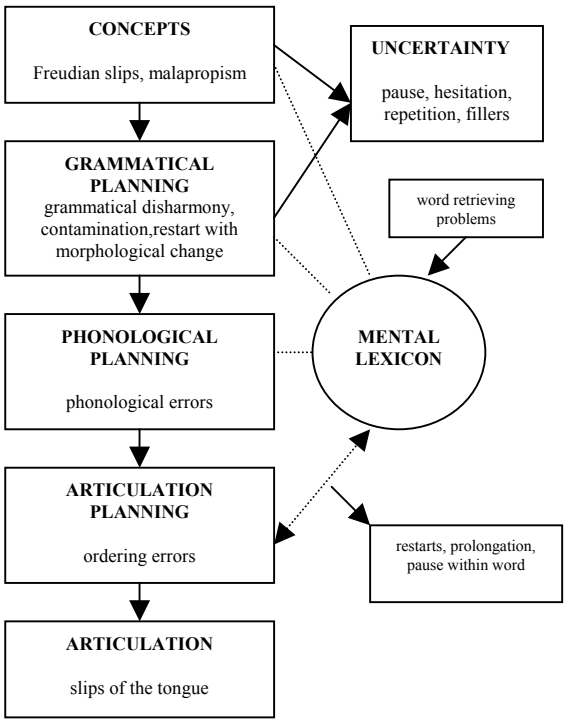

Figure 1: The process of speech production and sources of disfluency phenomena.

In adulthood, the quality of spontaneous speech depends on a number of factors that may be rather individual-bound. Such factors are genetic endowments, soundness of articulation, size and activatabilty of word stock, mother tongue awareness and practice in speaking, the topic itself, as well as the current mental state of the speaker.

In old age, a number of physiological changes occur. For instance, lung capacity decreases, forcing old speakers to breathe in more often. The ageing of the cavities influences voice quality, whereas due to changes in neurological

functions speech becomes monotonous and broken, and articulation becomes inaccurate. The time required for activating lexemes grows. These factors heavily influence the time structure of old persons' speech and the disfluency phenomena occurring in it.

The topic of the present paper is an investigation of disfluency phenomena in the spontaneous Hungarian speech of three age groups: children, adults, and old persons. The research objective is to trace invariable features of speech production and its changes across ages. Our hypothesis is that permanent changes are going on in the operation of speech production processes from early childhood up to old age, and that those changes can be studied via observing disfluency phenomena.

2. Method and material

We have conducted a series of experiments with the participation of 30 subjects, 15 of them females and 15 males. They constituted three age groups – children, adults, and old persons. The number of males vs. females was equal in all three groups.

The children were schoolchildren between 9 and 12 years of age, their mean age was 10;5. The adults were university students and teachers aged between 22 and 45, their mean age was 32 years. Old persons were aged between 60 and 90, their mean age was 77 years; all of them had had either secondary school or university education.

The participants' spontaneous speech was recorded and sampled. The children had to tell a continuous story on the basis of a series of four pictures, whereas adults and old persons were interviewed on various topics (work, hobby, career). The stories/interviews were tape recorded and faithfully transcribed. The measurements were done by CSL-4300B digital signal processor (with respect to the duration of speech samples, pauses, and hesitations).

The duration of the full recorded material was an hour and 10 minutes, or approximately 2.5 minutes per person (the samples ranged between 1 and 7 minutes). The number of words analysed was 7642, an average of 255 words per subject.

Disfluencies were studied at eight different levels:

1. the conceptual level;
2. the level of grammatical planning;
3. the level of lexical access;
4. the level of phonological planning;
5. the disharmony of lexical access and articulatory planning;
6. the level of articulatory planning;
7. the disharmony of articulatory planning and execution;
8. disfluencies involving several levels of planning.

We have summarised the numbers of occurrence of the various types of disfluency, the number of words per instance of disfluency, as well as discrepancies between male and female speakers. We also investigated the time structure (articulation rate, speech rate) of the speech of the participants. We have also performed statistical analyses (ANOVA, at a 95% level).

3. Results

3.1. Temporal relations in speech

Since disfluency phenomena show a correlation with speech rate [7], we have analysed the temporal features of the speech of the three age groups (see Figure 2). The data are given in sound/s.

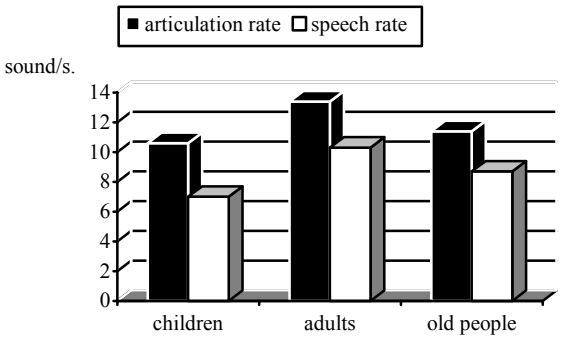

Figure 2: The articulation rate and speech rate of the subjects.

The data show that children speak the most slowly, old persons speak less slowly, and the members of the adult group are the fastest speakers. This result was to be expected as speech rate is known to correlate with age or rather, with speech experience. The differences are significant in each case (see Table 1) except that between the articulation rates of children vs. old persons.

Table 1: Significance of temporal relations of speech ($p<0,05$).

Age group	Articulation rate	Speech rate
Child vs. adult	$p<0.001$	$p<0.02$
Child vs. old	$p<0.2703$	$p<0.013$
Adult vs. old	$p<0.017$	$p<0.008$

Inexperience at articulatory movements in childhood, respectively their inaccuracy in old age, result in diminishing differences between the two groups in terms of articulation rate. Males and females did not exhibit significant differences either in articulation rate or in speech rate ($p < 0.855$; $p < 0.659$).

The deviation parameters of our data are close to one another; we have not found extreme differences among subjects in any of the groups (see Table 2).

Table 2: Standard deviation of data obtained.

	Articulation rate		Speech rate	
Age group	mean	std. dev.	mean	std. dev.
Children	10.56	1.1	6.99	1.88
Adults	13.35	1.256	10.31	0.898
Old persons	11.41	1.606	8.72	1.34

3.2. An analysis of disfluency phenomena

In the full sample, a total of 2177 instances of disfluency have been found. Compared to the total number of words, this means that 35% of children's utterances were characterised by disfluencies, whereas for adults and old persons, this figure was 25% and 27%, respectively.

The distribution and frequency of occurrence of disfluencies was quite variable. Table 3 shows the various types of disfluency, their numbers, and proportions across speakers.

As can be seen from the data, only silent pauses occurred with all speakers; this was, at the same time, the disfluency phenomenon occurring the most often. The reason for that can be found, primarily, in the physiological function of silent pauses: breathing. Most subjects also exhibited hesitation, repetition, the use of fillers, prolongation, and various grammatical errors.

Table 3: The number of disfluencies and their distribution across speakers.

Disfluency type	Occurrence across speakers (%)	Number of disfluencies (total material)
silent pause	100	1368
hesitation	93.3	331
repetition	73.3	77
filler	66.6	107
syntactic error	73.3	61
contamination	10	3
restart with morpho-logical change	50	24
false word activa-tion	13.3	6
change of word	13.3	5
phonological error	3.3	1
restart	53	26
prolongation	73.3	82
silent pause within the word	30	34
false start	43.3	37
serial order error	16.3	8
slip of the tongue	6.7	5

The percentages of disfluency phenomena for the three age groups are shown in Table 4. Irrespective of age, the percentages of the various types of disfluency were roughly the same, significant differences were not found in any case ($p < 0.9$). The largest proportion of occurrence is shown by silent pauses, and especially with old people. The highest numbers of hesitations and grammatical errors were found with adults; children repeated things proportionately the most often, whereas fillers were found in large numbers with old people. Prolongations occurred roughly equally with children and with old people.

Table 4: Percentages of disfluency phenomena.

Disfluency type	Children (%)	Adults (%)	Old persons (%)
silent pause	65	59.4	67.6
hesitation	13	18.2	11.3
repetition	7	3.5	2.8
filler	3	4.4	6
syntactic error	3	4.2	2
restart with morpho-logical change	3	0.7	1.3
problems of lexical access	0	0.9	0
restart	1	1.5	1.1
prolongation	4.5	3.3	4.1
silent pause within a word	0	2.2	1
false start	0.5	1	2.3
other	0	0.98	0.1

We have also investigated at which level of planning/execution (see section 2 above) the members of the three age groups exhibited the highest number of disfluencies (see Table 5). Our data show that, irrespective of age, the highest number of problems (uncertainties) occurred at the conceptual level (level 1), i.e., at the very beginning of the speech planning process. This is in accordance with results of earlier studies (cf. [7]). Relatively many problems occurred at the level of grammatical planning (level 2), or were due to a disharmony between lexical access and articulatory planning (level 5). At the other levels, either no disfluencies occurred at all, or – as with adults – their numbers were insignificant.

Table 5: The distribution of disfluencies by level (%).

	level 1	level 2	level 3	level 4	level 5	level 6	level 7
Children	88	6	0	0	6	0	0
Adults	85	4.2	0.9	0.08	8	0.58	0.4
Old persons	88	3.4	0	0	8.5	0.1	0

We have also calculated the ratio of words per disfluencies (see Table 6). We can see that children exhibited a disfluency phenomenon of the uncertainty type (including silent pauses) every three words, whereas the other two groups did that every five words. That difference is significant ($p < 0.01$; $p < 0.03$), that is, children's speech contained a lot more uncertainties. If that ratio is recalculated as number of disfluencies per 100 words, we can see that children exhibited 29 instances of uncertainty, whereas adults and old persons exhibited 21.2 instances, in the course of uttering a hundred words.

Table 6: The frequency of disfluencies in terms of number of words (word/disfluency).

Type	Children	Adults	Old persons
Uncertainties	3.4	4.7	4.7
Errors	36.4	32.9	42.6
Total (excluding silent pauses)	8.35	14.8	13.9

The ratio of occurrence of errors was a lot smaller, and the differences across groups were not significant. Every 100 words, children committed 2.7 errors, adults committed 3, whereas old persons committed 2.3 of them. At the level of all disfluencies (where, for better comparability, we have ignored silent pauses), 12 instances were found with children, 6.8 with adults, and 7.2 with old persons. These results are in accordance with those of both the Hungarian and the international literature [1, 7, 9].

On the basis of deviation data we can establish that the least deviation was found in children's data (st. deviation: 4.2), whereas the results of the other two groups covered a somewhat broader range (adults: 7.832, old persons: 6.162).

Table 7: Differences between male and female subjects.

	mean		std. deviation	
Disfluencies	females	males	females	males
Uncertainties	4.54	3.94	0.9612	1.062
Errors	37.35	30.42	23.824	14.290
Total	12.06	12.17	6.45	5.46

We compared the distribution of disfluency phenomena exhibited by male vs. female subjects, irrespective of age differences (see Table 7). In a hundred words, female subjects produced 27, and male subjects produced 21.3 instances of uncertainty, a significant difference ($p < 0.035$). For errors, these figures were 3.3 (females) and 2.2 (males); and for all disfluencies (excluding silent pauses), they were 8.2 (females) and 7.9 (males). No significant differences were found in this respect ($p < 0.128$; $p < 0.886$). That is, in women's speech there were somewhat more disfluencies, and their data also showed larger deviation than those of men.

4. Discussion

The hypothesis stated in the introduction – that speech undergoes permanent changes as the speaker gets older – has only partially been confirmed.

With respect to temporal features of speech, we have demonstrated that the child's slower articulation rate and speech rate get faster by adulthood, and then slow down again, albeit to a lesser extent, as the speaker gets old. The

articulation rates of children and old persons were rather close to one another; it can be seen that diverse causes – lack of experience, respectively the ageing of the organism – led to similar results.

With respect to disfluency phenomena, we have seen that problems always show up at the same levels, irrespective of age. The hardest task is to formulate what we are going to say; this can be seen in the number of uncertainties at the conceptual level. It is relatively difficult to assign the appropriate linguistic form to the contents we wish to communicate; this is what causes disfluency phenomena at the level of grammatical planning. Finally, it is not easy to harmonise lexical access with articulatory planning, a fact resulting in prolongations or false starts.

We have not found age differences in the numbers of occurrence of disfluencies – all three groups produced silent pauses in the largest numbers, followed by hesitations, fillers, repetitions, prolongations, and grammatical errors. That order is corroborated by other data from the literature (cf. [7]). The highest number of silent pauses were produced by old people; this is a result of the ageing of the organism, in view of the function that silent pauses have in facilitating breathing.

An overwhelming majority of disfluency phenomena we registered were uncertainties appearing at the conceptual level (87% of all the data); errors amounted to a mere 13% on average.

We found a difference between children and adults/old people in the number of disfluencies per 100 words with children producing significantly more instances of disfluency than the other two groups. The reason for that, undoubtedly, is lack of experience, which is partly due to age and partly to the peculiarities of the school system (the fact that schools provide little opportunity to practice speech).

The number of disfluencies per 100 words shows a correlation with data in the Hungarian, as well as the international, literature.

We have not found significant differences between male and female subjects in terms of articulation rate and speech rate; however, there was a difference with respect to disfluency phenomena. Women exhibited somewhat more instances of disfluency than men did.

On the basis of the results obtained, we can conclude that speech production and its disfluency phenomena change with age quantitatively rather than in qualitative terms. In view of the fact that the number of subjects participating in the present experiment, as well as the amount of spontaneous speech investigated, were rather limited, a more exact exploration of the tendencies found here requires further research.

5. Acknowledgements

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