

The word chain - on the effect of hearing impairment on duration

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Abstract

In an experimental task was tested the ability of ten year old hearing impaired subjects to preserve the phonological and acoustic form of actual words and nonsense words. One of the changes the words were undergoing was a great variation in duration of different sub morphemic segments.

1. DURATION AND HEARING IMPAIRMENT

The aim of this paper is to draw attention to a probable effect of hearing impairment on duration. Hearing impairment is known to effect the perception of different phonetic aspects of the speech wave. It functions as a filter reducing the detectability of certain frequencies. This effect is what is measured and used as a basis for the fitting of hearing aids. In congenital hearing impairments its often higher frequencies which are difficult for the impaired to detect. This makes for instance /s/ difficult to hear.

It is also known that frequency resolution is poorer in hearing impaired subjects. This causes general difficulties in the discrimination speech sounds. To discriminate between similar speech sounds which differs only in place of articulation is especially difficult (Bamford & Saunders 1985)

It is also known that so called gap detection is reduced in the hearing impaired (Bamford & Saunders 1985). The effects of this on the perception of the phonetic properties of speech is not clear.

One important aspect of the speech wave which has not been considered to be affected to any important degree by hearing impairment is duration. To put it oversimplified, even if you cannot hear whether something is an /a/ or an /e/ you are supposed to perceive the correct duration of it. This assumption is, as far as I have been able to find out, based on the lack of evidence of the contrary. That is, no one seems to have investigated it and thus no one has shown any effects.

The experiment here described was originally designed for other purposes than the investigation of duration but when the data were analysed they seemed to show rather big deviations of duration in the perception and production of the hearing impaired subjects. Since this was something of a surprise for me I would like to point it out for discussion.

2. THE EXPERIMENT

Data and results here presented are from a project: SAHS, "Semantic and pragmatic aspects on the language of the hearing impaired", financed by the Swedish Tercenary Fund grant nr. (for a more detailed presentation of the project see Strömquist and Nelfelt 1991).

In an experiment, seven ten year olds transmitted in pairs between them, two existing and well known Swedish words and two non existing words. The non existing words were in accordance with Swedish phonotactic rules. The subjects were all members of the same special education group for the hearing impaired and thus knew each other well and were used to co-operate. They were encouraged to use all available means to make the transmission as effective as possible. In this case that meant they could use speech only, speech and sign or speech and the manual alphabet. The activity was recorded on video and audio tape.

2.1 Analysis

I will here in some detail describe the fate of two of the words. One existing word and one none existing. The real word is "glassbil" (= Eng. "ice cream van"), a well known concept for Swedish children and, likely, a well known word for the subjects. The non existing word was /knäffdön/.

The other two words and also other phonetic aspects than duration will be described in a forth-coming report.

Every token of the actual word chain words were transcribed in phonetic transcription and the word chain activity as a whole was transcribed in normal orthography as narrowly as possible mirroring the phonological and grammatical form of the utterances. The words were analysed directly from the acoustic signal by means of the program "SounEdit". This program was chosen because it gives a good AT diagram which makes it easy to segment and measure duration manually. Nevertheless some utterances turned out to be extremely difficult to segment. Especial those of most gravely hearing impaired pupils. The AT diagram was segmented in periodical and non periodical segments which were numbered: periodical segment 1,2 etc. and non periodical segment 2,1 etc. For "glassbil" it should have been relatively easy to assign phonemes or features to the segments, for "knäffdön" it was often impossible.

Glassbil

Speaker	Db	Np1	P1	P2	Np2	T	Np3	P3	P4	P5	Np4
S1	0	4	9	13	28	2	-	22	14	15	-
D1	56	2	4	5	20	12	2	-	33	16	-
D2	56	-	61	40	58	72	2	-	25	-	-
F1	96	2	7	7	20	20	-	-	22	10	-
F2	96	7	19	19	13	-	3	-	29	18	-
A2	9	1	2	11	10	15	4	-	10	6	-
B1	48	9	-	7	14	9	7	-	16	-	-
B2	48	1	6	14	14	9	6	-	8	16	-
E2	98	7	25	8	10	6	12	-	22	-	10
G1	40	4	4	10	9	*	*	*	*	*	*

Table 2. "Glassbil". Duration in hundreds of seconds of the different segments for different speakers. The columns show from left to right: Speaker, hearing impairment in Db for each speaker, periodic segments =P, non periodic segments Np and silent segment T, in order of appearance. Rows shows the order of transmission. S is the normally hearing adult and starts the chain by passing the word on to D. S1 can be seen as a norm for the word. The utterance nr 1 of each speaker is directed to the former speaker and each speakers utterance nr. 2 is the transmission to the next subject in turn. All speakers do not have both an utterance nr. 1 and 2. Some speakers have utterances which are not included in the table, in between nr 1 and 2. * not analysable, very silently pronounced.

This word is a well known one for the children and it preserves its duration pattern rather well, although there are changes. To get back to the conventional pattern is, of course, possible for familiar words. In spite of some extreme durations in some nr 2 utterances, the original proportions are restored in the following nr 2 utterances. Compare for instance D2 and F1. F1 is more close to the pattern of S1 than D2 and the final /l/ which has been lost in D2 is restored in F1. If we look at E2 and G1, E2 has some rather prolonged segments which are back to more standard length in G1 but here the /l/ remains lost and the inserted final noise is kept in G1.

The intra-speaker variation in especially the pairs F1-F2 but also in B1-B2 looks a bit high, considering the familiarity of the word.

There is also inter-speaker variation which seems a bit high.

Knäffdön

	dB	Np1	P1	P2	P3	Np2	T	Np3	P4	P5	P6	Np4
S2*	0	10	-	10	10	28	12	4	24	-	29	-
D1*	56	10	-	6	3	20	11	2	11	15	16	-
S2*	99	9	-	4	7	18	9	3	16	-	15	-
D1*	56	10	-	6	3	20	11	2	2	-	17	-
D2	56	9	-	13	7	20	23	3	125	-	-	-
G1	40	7	-	13	6	49	1	1	31	-	-	-
G2	40	8	-	11	6	39	-	3	34	-	-	-
A2	9	8	-	12	-	20	-	-	6	-	-	-
F1	96	8	-	25	12	51	-	-	14	-	31	-
F2*	96	2	-	6	16	32	-	1	5	-	44	15
E1*	98	-	-	10	9	9	-	2	31	-	-	1
F2*	96	3	-	12	8	19	-	2	2	-	28	-
E1*	98	-	-	13	4	16	6	6	13	-	12	4
E2	98	-	61	31	43	44	-	6	4	13	20	18
B1	48	12	-	4	31	23	-	6	15	-	9	23

Table 1. "Knäffdön". Duration in hundreds of seconds of the different segments for different speakers. The columns show from left to right: Speaker, hearing impairment in dB for each speaker, periodic segments =P, non periodic segments =nP and silent segment =T in order of appearance. Rows shows the order of transmission. * means that there are more than one utterance of transmission and more than one utterance of feed back in the same pair of transmitter-receiver.

We here find a phenomenon not in the "glass"-chain. The transmitting and answering is repeated in the transmission between S and D and between F and E. This of course is an effect of the 'strange' word transmitted. The participants feel a need for extra feed back. There are also many utterances between the nr 1 and nr 2 utterances of the same word. In F's case as many as 9.

In this chain the duration pattern of the word is far more transformed during the chain than in the "glassbil"-chain. Some segments disappear, i.e. gets duration zero. Other segments are added during the chain. The word is totally unrecognisable when the chain ends. The phonemic structure has changed which shows in the disappearance of some segments and appearance of other. The phonemic quality of remaining segments has also changed. The stress pattern. has changed considerably. The pattern word has the primary stress on the second syllable and strong stress on the first syllable. From G and on the stress has changed to a strong primary stress on the first syllable. This shows in the table as more or less complete disappearance of the silent segment and a total shortening of the second syllable

There is very great inter-speaker and intra-speaker variation. Compare for instance E1 and E2. This is probably a sign of the problems the speakers have with assigning a phonological structure of the word. In the "glassbil"-chain the speakers had some concept of the structure beforehand. Here their task is to extract phonological structure from the auditive perception directly.

3 CONCLUSIONS AND DISCUSSION

One must of course be very careful to draw conclusion from a small material like the here presented. Also, the lack of normally hearing controls is a great drawback. I would guess though that the variation should not be as big in a group of normally hearing ten years old. A colleague of mine, Johan Hagman, made a cluster analyses, of the chains (the analysis cannot for reasons of space be presented in more detail here). This analysis

showed that greater variation was related to higher degree of hearing impairment and this is an indication that some of the variation is due to the hearing impairment of the subjects.

High intra-speaker variation is probably a sign of unstable word form patterns in the speaker. It is therefore interesting that there is noticeable intra-speaker variation also in the "glassbil"-chain. It might be a sign of less stable phonological patterns in the hearing impaired.

The intra-speaker variation seems to be large both for the existing word and the non existing. The differences between, for instance, B1 and B2, and F1 and F2 seem very big. If it is abnormally is not possible to say without controls. It is interesting though to follow up on this.

We saw that the changes in duration was of magnitude to severely transform the rhythmic structure of the non existing word. When listening it even seems to turn to monosyllabic. This can make us suspect that the hearing impaired subjects have a big problem with perceiving both syllabic structure of new words and stress patterns. If this is so, it is a very big problem in their language acquisition. For instance Peters and Strömquist has pointed out that stress and prominence are important clues for the child's segmentation of linguistic input. There is no reason to assume that it is not also important for sub-morphemic segmentation.

My conclusion is that the very tentative results here presented is an indication of the importance of duration in the study of hearing impairments. The transformation of duration properties in nr 1 type utterances is an indication that the perception of duration is affected, these type of utterances being more or less a direct repetition of what is heard. The transformations between utterances of nr 1 and nr 2 types are an indication of difficulties with analysing and assigning duration patterns to unknown words. The traces of similar problems even with the well known word might indicate a more general problem with analysing and storing duration patterns.

To sum the data give intriguing hints but no clear results and are an impetus for further research.

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