SOME ASPECTS OF SPEECH AND VOICE IN HEALTHY AGEING PEOPLE

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ABSTRACT - Changes to aspects of speech and voice in ageing people are widely reported, but the reports are sometimes contradictory, perhaps because the samples surveyed vary greatly in size and their health status is not always clear. The tasks vary too, and methods of measurement, both of which are known to affect results. Reported here are data on rate of utterance and fundamental frequency from a sample of healthy ageing people, all native-born speakers of general Australian English.

INTRODUCTION

There are good reasons to expect that changes will occur in the production of speech by old people, and indeed, age is one of the attributes of a person that others can judge with reasonable accuracy, just from a sample of speech. Speech is a highly skilled act requiring simultaneously the careful management of airflow and very precise adjustments of the articulators, the whole being performed in a rapidly changing dynamic pattern, co-coordinated within an expressive intonation contour. Even at usual rates of utterance, as many as a dozen or more speech sounds will be produced in one second. Normal breathing is suspended to allow an out-going airstream sufficient to maintain the flow of speech, the larynx is positioned, the vocal folds are tensioned, and with tongue, lips, jaw and velum, are in constant motion, as needed to effect the different sounds of speech. So speech segments are produced by these means, of airflow management, of voicing, and of varying the resonators of the supralaryngeal vocal tract. But in addition, and somewhat independently, the pitch, stress and length of each segment must also be controlled, since these variables contribute importantly to contrasts of meaning in the spoken language. The whole complex system is one in which very fine adjustments must be made and coordinated at a rapid rate, and a decrement in the performance of any part, including the feedback circuits which are also, presumably, involved, must be expected to bring about changes in the articulated sounds themselves and in the pitch and voice quality with which they are made.

From about the beginning of the fourth decade of life there is a decrement in performance of all the body's systems, with changes to the respiratory, neurological and muscular systems being of particular significance for speech. Additionally, anatomical changes and changes to the structure of tissues (due to atrophy, calcification of cartilages and a general loss of elasticity) may be expected to bring about changes to the quality of sounds produced. Changes to the temporal organisation of speech might be expected because control at this level is multiply governed, and depends on the efficiency of the programming of articulatory movements, their execution, and the properties of the structures involved in carrying them out. Since normal ageing involves a slowing of neural processes it may be expected that speech segments will take longer to produce although a possible strategy to overcoming increased time necessary to complete a task may involve a trade-off in accuracy. Most studies on motor skills find that old people prefer accuracy in an accuracy-time trade-off, when decline in performance prevents the maintenance of both at the skill levels of a younger age. It could be predicted therefore that rate of utterance should increase with age, providing that accuracy is preserved. There is some evidence that accuracy in at least some aspects of temporal organisation (voice onset time) is preserved in very old women (Penny, 1995). The present study therefore looks at the global measure, rate of utterance, in an ageing population.

Fundamental frequency is known to follow a general decline with age although the extent of this decline and any sex differences in it are open to question. It has been suggested that men over the age of about 80 may show an increase in Fo, while women continue to show a decline, thus in old age the fundamental frequencies of men and women start to approximate each other (the coalescence hypothesis). This study examines the evidence for this hypothesis.

Both progression in rate of utterance and fundamental frequency are of interest to clinicians in speech pathology, and are of significance also to biological medicine, since these factors may contribute to an index of physiological ageing. We all might be interested in knowing just what we are responding to when we identify a voice as aged - is it voice or an aspect of articulation or perhaps both?

SUBJECTS

The subjects in this study were those taking part in the Australian Longitudinal Study of Ageing (ALSA). They were a random sample of 3,263 people drawn with the assistance of the Australian Bureau of Statistics from people over the age of 70 years living in the Adelaide metropolitan area. From this large sample we drew a sub-sample of 20 men and 20 women in each of five-year age groups, (70-74, 75-79, etc). according to certain criteria. There was, in addition, a sub-sample of people 65-69 years who were the spouses of people over 70 who had been drawn in the original sample. All these people were women (ie. there were no women in the primary sample over the age of 70 who had husbands younger than 70) This younger age group was retained for within-sex age comparisons but was not used for the across-sex comparisons. For inclusion in the present study people had to be Australian born, never to have smoked, nor to have any neurological disorder, any speech or hearing disorder nor any respiratory disorder nor any condition at all that would affect the speech mechanism. In the lower age groups there were more people than needed who met these criteria, and so subjects were drawn randomly from those available, but in the oldest age groups there were insufficient people to make full groups, so people over 90 were grouped together. The age range was from 65-103 for women and N=103, while for men the figures are age range 70-93 and N=78.

METHOD

People performed two tasks, one comprised a free speech response to the question,

> As you get older, what aspects of your life are the most important to your happiness and well-being. Would you like to tell me that in your own words?

The interviewer encouraged people to talk for at least a minute.

The other task comprised the National Adult Reading Test (NART) which required subjects to read a set of words, thus providing tokens in citation form which could be used for some acoustic measures. (The responses could also be scored to yield a measure of cognitive performance).

The responses were recorded on commercial quality cassette tape recorders, in the subjects' own homes. The interviewers were trained in interviewing and recording techniques. Transcriptions of the interviews were made and all transcripts were checked by at least two other people.

Rate of utterance measures were taken from counting the syllables on the transcripts while listening to the tapes. Times were taken with a stop watch. The number of 'conversational turns' taken by each person to provide the free speech sample were also taken as this reflects the number of prompts the person required. It might be the case

that older people require more support, in a sense, to produce their free speech and this may or may not be reflected in actual rate of utterance.
Fundamental frequency data were extracted from the steady portions of vowels in stressed position on the NART responses, using the Kay DSP5500 Spectrograph.

RESULTS

Rate of utterance.

Table 1: Rate of utterance (syllables per minute) and Conversational turns (C.T.) - women's data

Age group	N	Mean age	Mean rate	SD rate	Mean C.T.
65-69	20	67.9	164.8	28.14	3.00
70-74	20	72.3	167.9	42.35	3.85
75-79	20	77.0	161.6	31.88	2.40
80-84	20	81.1	164.0	30.02	2.15
85-89	18	86.6	160.2	32.37	2.59
90+	5	95.8	180.8	18.24	3.60

The data for the very oldest sample are based on very few subjects and cannot be included in any further statistical analysis. A one-way analysis of variance (done for completeness since the result is obvious) reveals no difference across the age groups in mean rate of utterance or in mean conversational turns required to produce the sample.

Table 2: Rate of utterance (syllables per minute) and Conversational turns (C.T.) - men's data

Age	N	Mean age	Mean rate	SD	Mean C.T.
70-74	21	72.5	164.4	50.4	2.33
75-79	16	77.5	154.2	57.6	2.31
80-84	19	81.5	165.6	32.4	2.42
85-89	18	86.3	157.8	37.2	2.5
90+	4	91.3	132.0	43.2	1.8

As with the women, the oldest age group has been excluded from further analysis because of the very small numbers. A one-way analysis of variance reveals no differences across the age groups in either rate of utterance or conversational turns.
A two-way analysis of variance shows no difference between the sexes in rate of utterance nor in conversational turns required, and there are no interaction effects.

Fundamental frequency

Table 3: Fundamental frequency in women.

Age	N	Mean age	Mean Fo	SD Fo
65-69	20	67.7	183.22	26.29
70-74	20	72.3	194.83	38.16
75-79	20	77.0	188.53	23.29
80-84	20	81.1	202.62	23.19
85-89	18	86.6	173.33	11.9
90+	4	95.8	187.04	32.52

A one-way analysis of variance showed a significant main effect of age, at better than 5% confidence level while Bonferroni tests showed that this was due to significant differences between age groups 1 and 2, 2 and 3, 3 and 5 and 4 and 5.

Table 4: Fundamental frequency in men.

Age	N	Mean	Mean Fo	SD Fo
70-74	21	72.5	141.94	24.91
75-79	16	77.25	138.67	23.99
80-84	19	81.47	147.31	33.00
85-89	18	86.33	119.63	31.72

The values for the oldest group were not reliably obtained.

A one-way analysis of variance showed a significant main effect of age, with the differences between age groups 1 and 3 and 1 and 4 and 2 and 4 being significant at better than 5% level of confidence.

A two-way analysis of variance showed a significant difference between the sexes (a trivial result in itself) but no interaction effects of age and sex suggesting no strong support for the coalescence hypothesis.

DISCUSSION

The strong finding that age does not change rate of utterance is perhaps surprising, but it must be remembered that the subjects of this study are all healthy and living independent lives in the community, and generally reporting a high level of satisfaction with their lives. Studies of their cognitive functioning also show a rather unexpected retention of abilities well into old age (Luszcz et al, 1995).
The finding that fundamental frequency changes significantly with age and the actual levels found must be related to the method of extraction. The Kay DSP5500 was used to extract Fo from words in citation form because it was decided not to employ any automatic extraction device because of the possibilty of error, especially as the recordings were made in home situations. The mean frequencies reported are the means of vowels over which there was some (as expected) variation, with low vowels resulting in lower values than high vowels. In a sense this validates our measures, but it must also be recognised that all our values are to some extent elevated because they are based on prominent segments.

It would appear that when we identify a voice as 'old' we are responding to fundamental frequency differences and possibly also bandwidth differences, due to changing damping characteristics of the vocal tract. Some preliminary work extending the present study suggests that this is so.

It must also be remembered that this is a cross sectional study and needs to be supported by longitudinal studies, to avoid confusion with the effects of different educational histories of the subjects, and even of changing fashions in speech habits in the history of the community. The ALSA study does offer the possibility of follow-up, and indeed a second wave of recordings has already been made, two years after the ones analysed here

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SPEECH IN ALZHEIMER'S DISEASE

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ABSTRACT

This paper describes the quantification of physical characteristics of Alzheimer's patients' conversational speech. The study was conducted on a total of eight probable AD patients and eight normal controls. For each group, a total of five measurements were made from their conversational speech recordings which depended on verbal fluency and pauses in speech. The paper discusses statistical results obtained with these parameters and explains their usefulness for quantifying speech deficits in Alzheimer's disease.

INTRODUCTION

It has been found, especially in aphasia studies, that physical characteristics of speech, such as speech rate, speech tempo, pauses, etc. can be used for characterizing speech and language disorders. Feyereisen, Verbeke-Dewitte and Seron (1986) describe the process of measuring speech tempo and mean length of utterances for differentiating between Broca's, Wernické's, mixed, and recovered Broca's aphasics. They note that by making use of such physical rather than linguistic measurements, conversational performance and picture description stand out as two different tasks, which suggests that the results on one cannot be used for generalization on the other. Similar work, carried out earlier by Deloche, Jean-Louis and Seron (1979), also showed that by making use of complex measurements on speech fluency, it was possible to differentiate between aphasics and normal controls and that conversational performance is quite different from description tasks. These differences have also been pointed out by many other authors using linguistic measurements in aphasia (e.g. Benson, 1967; Kertesz and Poole, 1974; and Singh, 1996).

Although the concept of analyzing temporal variables in spontaneous speech of patients has been tested in aphasia for some time, we undertook this study with the following aims: to develop similar techniques in the case of Alzheimer's (AD) patients; to evaluate which variables are specifically important for AD patients and to understand what they represent; to compare AD and normal performance using selected parameters; and finally to discuss how this method can be used for testing the effectiveness of drug-related strategies.

SPEECH ANALYSIS

In order to evaluate patients on the basis of their conversational performance, it was decided to work on the physical characteristics of their speech. The overall procedure consisted of two steps: data collection, and data analysis. These are explained below.

Sample

A total of eight patients with a diagnosis of probable Alzheimer's disease (pAD) were recorded by a trained researcher (JG): (4 females and 4 males; age range 57-77, mean age 67.8, sd. 6.2, duration of disease 31-70 months, mean duration 48.1 months, sd. 13.2). All subjects had attended the Bristol Memory Disorders Clinic at the hospital and were diagnosed following an extensive assessment within the clinic including: medical interviews, physical examinations, neuropsychological testing, laboratory investigations and computerized tomography scanning of the head. All diagnosis were made using the DSM-III-R and NINCDS-ADRDA criteria (American Psychiatric Association, 1987; McKhann et al., 1984). The Mini mental test scores showed that subjects were suffering with a range of cognitive impairments, i.e. mild to severe (Folstein et al., 1975): patients scored in the range 3-24 (mean 15, sd. 6.8). An

additional set of eight normal controls were recorded by author (SS), who were matched in terms of their age and educational background.

Each subject was recorded in a conversational setting for a period of 20-45 minutes to give a sample of roughly 1000 words. It has been noted by Andreason and Pfohl (1976) that samples below this level are usually inadequate for a reasonably valid analysis. The recording was carried out on a one-to-one basis using a clip microphone and tape-recorder. Subjects were asked to describe their hobbies, experiences and various other activities. These recordings were then used for calculating a set of speech parameters which are described below.

Method

A total of five variables were selected in this study after experimentation in order to quantify both speech fluency and planning aspects in speech. Some of these have been used in aphasia studies, and others were considered important to our understanding of speech behaviour in AD. These are:

- Verbal Rate (VR) = Text length / Total locution time (TLT), measured in words per minute including pauses
- Transformed Phonation Rate (TPR) = arc sin(PR) where PR = Total Phonation time/ Text Length where PR is phonation rate and the total phonation time (TPT) is the time spoken without pauses
- Mean Duration of Pauses (MDP) = Average pause-length in seconds = Total Pause Time/Total pauses
- Standardized Phonation Time (SPT) = Text Length/ Total Phonation Time, measured as number of words per minute, not including pauses.
- Standardized Pause Rate (SPR) = Text Length/ No. of Pauses, measured as the average number of words uttered between two pauses.

It can be observed from Table 1 that there is a considerable range of performance on most variables both in the Alzheimer and normal group. In order to establish the utility of our five measurements for discriminating between AD patients and NC subjects, it was proposed to use a non-parametric test (Mann-Whitney U test in this case) keeping in view the small sample size and no previous knowledge of the population distribution. The results are shown in Table 1, marked with asterisks, which illustrate the relative importance of variables for discriminating between AD and NC measurements. Although SPR and TPR were not found to be significantly important discriminators, at this point in our analysis it was decided to retain them for further analysis as they represent important variables in terms of their explanatory power for helping our present discussion. Their usefulness will become more evident when we discuss our PCA analysis.

PRINCIPAL COMPONENTS ANALYSIS

PCA is one of the multivariate methods of analysis for identifying a set of principal components which explain the variance in data (see Jollife (1986) for details). The results showed that the first principal component PC1 contrasts variables VR, SPT, SPR and TPR against variable MDP. This implies that a high PC1 score can be obtained through low scores on all variables except MDP. All measurements except SPT depend to some extent on pauses, however, MDP is the only variable that quantifies their average duration. The MDP measurement quantifies the time taken to re-plan sentences rather than their fluency (a large number of short pauses or a small number of large pauses will both yield equivalent pause time, however, in the latter case more subconscious effort goes into the planning aspect of speech). All other measurements quantify the fluency aspect of speech, namely the speech rate. In summary, PC1 contrasts variables that depend upon the planning aspect of language with those that depend upon its fluency (speech rate in some form) and explains 66.9% of variation in the original data.

PC2 contrasts variables VR and SPT against variables MDP, SPR and TPR. A high PC2 measurement will be obtained through high VR and SPT measurements and low MDP, SPR and TPR