Ageing and Speech Prosody

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Abstract

Ageing is part of the normal evolution of human beings. Demographic projections to 2030 indicate that more than 60 countries will have at least 2 million people age 65 or older¹. Yet knowlegde about speech in the elderly is still dispersed and incomplete, in particular in the area of normal ageing.

Prosody within a linguistic community is triggered by a number of parameters which are investigated (see this conference). Yet, little is currently known about the longitudinal evolution of this speech component.

This paper is a first state of the art about speech prosody and ageing, with the hope that more researchers in speech sciences will investigate this domain.

Introduction

From birth to death, human beings are in constant evolution, reorganising their brains, developing new abilities and loosing some others (Snowdon, 2001, Goldberg, 2005). Speaking does not escape from this general trend. Understanding how human communication proceeds, involves taking account of this evolution. When speaking, children and adults activate different functionnal regions as demonstrated for example by Brown et al. (2005) in their comparative fMRI study of word generation. Prosody is triggered by a number of parameters, among others the speech task and the individual style, for example the intonational style (Zellner Keller, 2005). Little is currently known about the longitudinal evolution of prosody.

To start with the notion of ageing, it is important to underline that ageing is often associated with dementia. Dementia describes a syndrome associated with a range of diseases which are characterised by the progressive impairment of brain functions, including language, memory, perception, personality and cognitive skills. The prevalence of dementia tends to increase with ageing. Life expectancy is growing and the part of the elderly of the world's population is increasing, especially among females. Nearly all European countries will have elderly support ratios that will be greater than 40 by 2030^{1} . The Canadian Study of Health and Ageing reports that one third of people older than 84 suffer from dementia. In other words, it is crucial to study speech communication in normal ageing in order to better apprehend speech communication in pathological ageing, although the fuzzy boundary between "normal" and pathological cognition raises important methodological issues (Bäckman et al, 2000).

So far research of the influence of ageing on speech has been mostly performed in North America and in the United Kingdom by colleagues working in departments entirely dedicated to the study of ageing. A few European colleagues work in a rather isolated context. The research in this area is published in various journals of neurophysiology psychology, psychiatry, and gerontology. Very few are published in journals dedidated to the study of speech and language. This paper is a condensed overview of what is known about ageing and its impact on language and speech, in particular in speech prosody. Speech and prosody production, perception and its contributions to conversational speech will be our main focus.

1. Ageing: a Physiological Process

Despite tremendous variations between subjects in the speed of the ageing process due among others to genetics and life conditions, it is important to briefly underline how a number of changes characterizing the process of ageing may have important effects on speech communication (Caruso et al., 1994), even if the "preservation in many important areas of language knowledge helps most elderly adults maintain a very high level of functionning in day-to-day discourse processing" (Wingfield, 2000, p.374).

Structural noticable tissues changes such as bone tissue demineralization is often accompanied by bone deformations and remodelling. Also, the facial bones have been reported to continue to grow slightly into old age (Linville, 2001). Some laryngeal cartilages ossify. Neurological tissues are also concerned throughout ageing. By the age of 90, it is expected that brain weight has decreased by ca.10% in comparison to young adults (Xu et al, 2000 in Linville, 2001, Snowdon, 2001, Goldberg, 2005, Raz et al., 2005). The brain is nowadays considered as a device merging information from different modalities (Pullvermüller, 2002). The nervous tissue loss requires various adaptations and compensations that might have an impact on its multimodal functioning such as speaking. Another important aspect is that part of the neurological tissue modifications are intertwined with hormonal functionning² which triggers modifications of the vocal folds (Linville, 2000). Changes of the structure and the length of the vocal folds are documented and muscles, in particular facial muscles and respiratory muscles, loose elasticy and strength (Linville, 2001).

¹ This ratio indicates the number of people aged 65 or older per 100 people aged 20 to 64 in a given population. Source: Global Ageing: The Challenge of Success. A publication of the Population Reference Bureau. <u>http://www.prb.org/pdf05/60.1GlobalAgeing.pdf</u>

² <u>http://www.lecerveau.mcgill.ca/</u>

The neuromuscular control of voice production depending among others on the balance of pulmonary, lanryngeal, and articulatory elements is consequently affected (see below section 3.2 and 3.3; Martin, 1997). One major effect of these changes is the slowing-down of the speech rate (Linville, 2001; see below section 3.2).

Apart from motor functions, the auditory system is also often affected either at the peripheric level because of transmission loss in the middle ear and loss of hair cells in the basilar membrane, and/or a deficit in central auditory processing. In that case, older adults often experience hearing loss in high-frequency sounds and deficits in frequency and temporal resolution (Wingfield et al., 2005). The frequency deficit renders the separation difficult of speech from noise. The deficit in temporal resolution causes troubles with discriminating silent gaps, blurring words together. Yet the perceptual process is still most often correctly achieved thanks to the expert language knowledge the speakers have developped. However, the ressources engaged in the effortful perceptual process can thus not be dedicated to the comprehension and memory operations (Wingfield et al, 2005).

The relationship between physiological changes and cognition is not straightforward. Declines in memory and cognitive abilities are a normal consequence of ageing in humans (e.g., Craik & Salthouse, 1992). Normal cognitive ageing appears to be rather heteregeneous and varies tremendously. However, the literature documents abilities that are more susceptible to decline: fluid intelligence³, inductive reasoning, episodic and working memory and processing speed (Bäckman et al., 2000). The decline of the working and episodic memory in normal ageing is commonly reported and discussed (Craik & Salthouse, 1992, Light and Burke, 1988). In a study of the relationship between measures of frontal lobe functioning and verbal memory performance among healthy old adults, Simenski and Abeles (2002) suggest that frontal lobe functioning contributes significantly to the verbal memory abilities of ageing speakers.

Age-related changes in physiology and cognition have various impacts on language, as summarised in the following section.

2. Language and Normal Ageing

In a study of language change over life, Pennebaker and Stone (2003) developped the "Linguistic Inquiry and Word Count" software with which they compared 3000 language samples obtained from participants with excerpts from ten well-known novelists. They found that with increasing age, speakers tend to use more positive and fewer negative emotion words. Also, aged people appear to be more anchored in the present and future with regards to their use of verb tense, a result that is unexpected in terms of the stereotypes of ageing in our societies. In the same study, a drop in the use of the firstperson singular was found, suggesting that aged speakers tend to be more detached from themselves. Finally, looking at the linguistic markers⁴ of cognitive complexity, aged speakers demonstrate a general pattern of increasing complexity.

Aged people often report more word-finding failures than younger people, whereas the semantic processes seem to be well-maintained (Burke and Shafto, 2004). The decline in word-retrieval is manifested for example by reformulations, filled pauses, slips of the tongue and tipsof-the-tongue. Burke and Shafto (2004) have reviewed the relevant literature on this issue and they conclude that normal ageing selectively impairs certain language functions more than others. Although old speakers maintain or even improve their knowledge of words and word meanings, those production language deficits might be explained by weaker connections in the phonological system.

In the following section, the impact of ageing on speech production and perception will be summarized.

3. Speech and Normal Ageing

3.1 Lexical Access and Syntax

Speech production involves the ability "on the fly" to access the lexicon and to organise words into a coherent utterance. This ability can be experimentally controlled. For example, Kemper et al. (2004) asked young and old participants to memorize sentence stems differing in syntactic complexity and to produce afterwards a complete sentence with this stem. When placed in such controlled situation, older speakers tend to produce less complex utterances than younger speakers (Kemper et al., 2003, 2004; Wingfield, 2005). Kemper suggests that the competence for syntactic processing per se might not be concerned in ageing, but rather that there are the working memory limitations on the ability to produce long and complex utterances. Also, I wonder if the time pressure due to certain tasks such as in Kemper's and / or the motivation to perform well in such types of experience is not perceived as more stressful by old people since the slowdown process by aged people is well-established nowadays.

3.2. The slowdown process

The slowdown process has indeed various impacts on speech production. For example, David et al. (1988) placed young and old subjects in a delayed pronunciation task to trace the time course of lexical access and a semantic priming task to determine the time course of spreading activation. They found from the delayed pronunciation task that older adults benefited more than the younger adults from a preview of the word to-bepronounced; there was little evidence of age-related differences in the rate at which activation builds up in semantic memory; but the analyses of the production durations indicated that there was a large age-related

³ Fluid intelligence is defined as our "on-the-spot reasoning ability, a skill not basically dependant on our experience." in Belsky, J. (1990, p. 125): The Psychology of Ageing Theory, Research, and Interventions. Pacific Grove: Brooks/Cole Publishing Company.

⁴ According to the author, these are words that reflect how much people are actively thinking about their writing topic. Examples include: thinking, wonder, because, knowledge.

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difference in the duration from onset to offset to pronounce a visually presented word.

3.2. Articulation and Tempo

Evidence of slower articulation has been found for the laryngeal functionning, the oral muscles and lip activity (Linville, 2001). Smith et al (1987) asked 10 normal, elderly adults and 10 young adults to produce a variety of words and sentences at both normal and fast speaking rates. Segment, syllable, and sentence durations of older adults were 20 to 25% longer than those of the young adults at both speech rates. Greater variability in speech rate for older speakers is also reported (Linville, 2001). However, Brückl and Sendlmeier (2003) in a study of aged female voices found that if the tempo in read speech is slower with increasing age, articulation rate cannot be considered as correlated with chronological age.

The perception of fast speech rate is not easily processed by elderly subjects. As pointed out by Wingfield et al. (2005) and Vaughan et al. (2002), it is not likely that older speakers loose speech recognition because of a slowing in their processing speed. Instead, it is the loss of the consonant acoustic cues that affects recognition of rapid speech.

The importance of linguistic prosody for older listeners was demonstrated by Wingfield et al (1999). Older listeners performed better on speech recognition when silences were inserted in sentences at natural phrase boundaries than when silences were simply added at regular intervals. Relevant silences helped to build semantically coherent units.

3.3 F0 and Intonation

The impact of ageing on fundamental frequency affects women and men. In female ageing voices, F0 decreases by ca. 30 Hz with a strong drop around the menopause. Men show a slightly decreasing curve followed by a strong increase by ca.30 Hz starting around the fiftyth year (Linville, 2001; Martin, 1997; Brückl & Sendlmeier, 2003). A number of studies have investigated the perceived aged voice and its acoustic correlates. Brückl & Sendlmeier (2003) found that the correlations between the perceived or the chronological age and the average fundamental frequency in spontaneous speech are stronger than in read speech. In agreement with Linville (2001) and Baken (2000), their various measures of F0 stability did not show any systematic strong correlations. F0 stability seems to be more affected by physical health, which is quite variable among speakers of the same age.

3.4 Intensity

Maximum vowel intensity decreases with age in both men and women (Linville, 2001). This is likely due to the changes that occur in the respiratory and phonatory systems. Yet this lowering is not discernible in normal conversational speech (Linville, 2001). According to Brückl & Sendlmeier (2003), a raised frequency tremor intensity index is on the basis of sustained vowels, the best predictor of increased chronological and perceived age. The authors also found that spectral noise is more related to fitness than to chronological age.

3.5 Voice Quality

The speed of the changes in the vocal tract of elderly adults varies from one speaker to another. Linville (2001)

reports from the literature a tendency for old men to centralize vowels because of a less accurate tongue command. In her own study based on an LTAS analysis, she retrieved this tendency of centralization which is more pronunced for men than for women.

3.6. Linguistic and Emotional Prosody

Baum (2003) tested the hypothesis that elderly listeners may rely to a greater extent than young subjects on contextual cues to aid in phonetic identification. Her findings suggest that for older listeners, both lexical and prosodic context make independent contributions to phonetic identification, with the influence of metrical stress proving to be quite strong.

Since Jackson (1915), it has been speculated that the linguistic and emotional components of intonation were functionally differently distributed in the brain: the right hemisphere being more concerned with the emotional part and the left hemisphere with the linguistic part. However Snow (2000) in an extended review of clinical and neurobehavioural studies of patients adults and children - with brain damages and results from dichotic listening, neuroimageing or ERP studies with normal speakers concludes that there is no evidence of this dichotomy. Furthermore, these two components in intonation share actually a common neural basis in the right hemisphere for speech production as well as speech reception. The right hemisphere seems to be specialized in emotional communication via the prosodic, gestural and facial channels. In the same review, Snow states that there is clear evidence of a left localization for processing the temporal structure of speech and that the loudness in speech seems also to be processed differently from pitch. In other words, the neural basis of linguistic and emotional prosody is multichannelled in different areas of the two brain hemispheres.

Orbelo et al. (2003) have evaluated the ability to produce and grasp affective prosody through the ageing process. Their results show that the production of affective prosody, measured by variation of F0 on various stimuli, does not change significantly through ageing but that comprehension of affective prosody shows a negative correlation with age. Older participants manifest a decline in grasping prosodic affects. This is in agreement with Thompson et al. (2001) who conducted a study based on the perception of videotaped scenes. Emotional nonverbal information was conveyed at the end of each scene at low, medium, and high intensities. Older adults' ability to differentiate levels of emotional intensity was not as strong compared to younger adults.

In summary, aged people tend to hypoarticulate at a slower speech rate, with a higher or lower F0, and a quivering and rougher voice. Compared to younger speakers, they tend to experience more word-finding failures, to use less complex sentences and compensate various perceptual failures by a greater use of prosody.

4. Ageing and conversational interactions

People interacting with the elderly may feel unconfortable in this type of interaction where they would like to express care. They tend to use alternatively two styles of speech which might be maladjusted in a balanced interaction.

4.1 Elderspeak

Elderspeak is a style of speech, adults - in particular caregivers - tend to use spontaneously with elderly. William et al. (2004) consider this style close to the motherese style. This style is characterized by a slower speech rate, an exagerated intonation with a higher pitch and a higher loudness. Utterances are shorter and the lexicon is simplified. There is moreover a tendency to use affective diminutives, closed questions and an irrelevant use of "we". This patronizing style is technically and psychologically damageing (William et al., 2003). Higher and slower speech for example introduce severe acoustic distorsions that are difficult to resolve for people having a reduced auditory ability (Kemper, 1999). Elderly often perceive this style as humiliating, denigrating their speaking ability and it is not uncommon that they react by social withdrawal and self-depreciation.

4.2 Oldiespeak

This style of speech has not yet been reported in the literature. I found its use in the frame of conversations between psychologists and old residents in nursing homes. Psychologists questionned the erlderly about their quality of life and used from time to time "oldiespeak". This style is somewhat opposed to the elderspeak. Based on an impressionist analysis of various speech samples, I found that oldiespeak consists in imitating old person's prosody to express empathy or to reestablish the communicative interaction. It is characterised by slurred or hypoarticulated speech, reduced loudness, quivering intonation and shimmer. This style is much often used in very short reformulations (one to two words) or requests of confirmation.

5. Speech Prosody, an interactional tool

Various experiments to enhance care-workers' communicative skills with old people have been successfully proposed. For example, Kemper et al (2004) and Bryan et al. (2002) found that short training sessions focused on communicative strategies give rapidly encourageing results. Care-workers feel more successful and old people feel more respected. Part of this training is related to an adapted use of speech rate, loudness and pitch.

Conclusion

The objective of this condensed overview was to give account of the current knowledge on speech and ageing, in particular in the area of speech prosody. There is much to do yet and I hope I have convinced my colleagues that one way to respect our elderly is to better understand their communicative needs.

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