Effets of age on the amplitude, frequency and perceived quality of voice

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Introduction

The manner and extent to which voice amplitude and frequency control mechanisms change with age is poorly documented. The question of whether the perception of one's voice evolves with age, concomitant with acoustical changes, also remains unanswered. In the present study, we characterized the aging of voice production mechanisms (amplitude, frequency), compared the aging voice in different experimental contexts (vowel utterance, connected speech) and examined the relationship between self-perception of voice quality and voice acoustics.

Method

Table 1 Participants' characteristics

	Age		Education (in years)		HAD		MMSE		ECVB		VHI		CAPE	
N	mean ± SD	range	mean ± SD	range	mean ± SD	range	mean ± SD	range	mean ± SD	range	mean ± SD	range	mean ± SD	range
80	54.63±17.6	20-75	17.76±3.5	12-29	6.04±4.29	1-33	29.39±.88	25-30	60.3±4.56	42-66	3.85±6.48	0-47	9.11±6.56	0-32.4

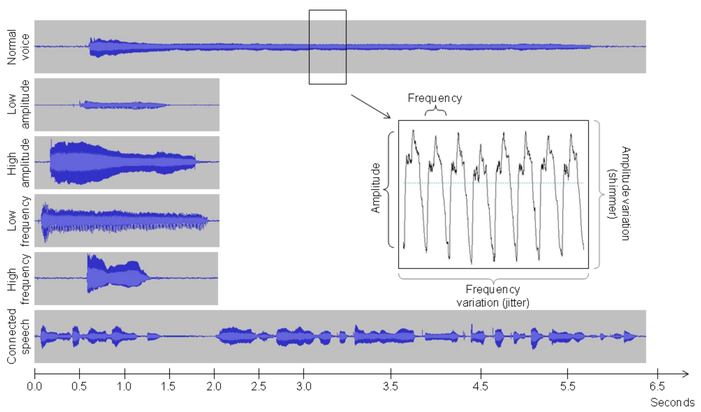
Participants' characteristics, for each age group and overall. HAD = Hospital Anxiety and Depression Scale. MMSE = Mini Mental State Examination. ECVB = Bordeaux' Verbal Communication scale, VHI = Voice Handicap Index, CAPE = Consensus Auditory-Perceptual Evaluation of Voice. HAD scale ranges from 0 to 42. For this test, scores between 0 and 16 are considered normal. The MMSE score ranges from 0 to 30 and a cut-off score of 23 optimizes sensitivity and specificity of detection of impairment

Questionnaires

- Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V)
- Bordeaux' Verbal Communication scale (ECVB)
- Hospital Anxiety and Depression Scale (HAD)
- Voice Handicap Index (VHI-30)

Procedures

Figure 1 Voice recording



Examples of sustained vowels /a/ produced under normal voice, lowest amplitude (without whispering), highest amplitude (without yelling), lowest frequency and highest frequency, and connected speech. Are also illustrated aside representations of some acoustical measures extracted from the voice samples.

Table 2 Acoustic measures extracted with Praat

Measure	Definition
Minimum f0 (Hz)	Minimum fundamental frequency (i.e., number of glottic cycles per second)
Maximum f0 (Hz)	Maximum fundamental frequency
Mean f0 (Hz)	Mean fundamental frequency
F0 SD (Hz)	Fundamental frequency standard deviation
Mean amplitude (dB)	Mean sound pressure level
Amplitude SD (dB)	Sound pressure level standard deviation
Duration (MPT; seconds)	Duration of the voiced utterance
Jitter local (%)	Absolute mean difference between consecutive periods, divided by the average period
Shimmer local (dB)	Average absolute base-10 logarithm of the difference between the amplitudes of consecutive periods, multiplied by 20.
Harmonic-to-noise ratio (HNR, dB)	Degree of acoustic periodicity, in other words the ratio between periodic (vocal fold vibration) and aperiodic (glottal noise) voice components (harmonicity of the voiced parts only)

Analyses

For each participant, data from the 2 trials and 2 stories were averaged together for each acoustical measure

Connected speech

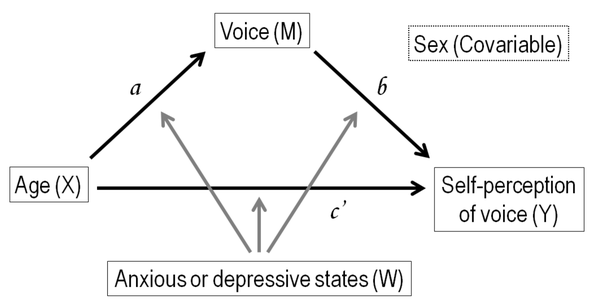
Spontaneous story telling.
Measures extracted: minimum, maximum, mean f0 and SD (Hz), minimum, maximum and mean amplitude (dB), and HNR (dB)]

Sustained vowel (/a/)

1) Longest and most stable central segments of each vowel, manually selected: minimum f0, maximum f0, mean f0 and f0 SD (Hz). Min and max f0 target values were adjusted (men 65-300 Hz; women 80-550 Hz)

2) Whole voice sample, manually selected: mean amplitude and SD (dB), duration (sec), relative jitter (%), shimmer (dB), and HNR (dB)

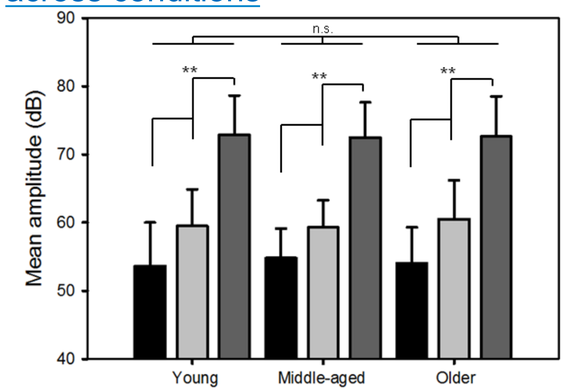
Figure 2 Moderated mediation model



A series of moderated mediations was conducted for each acoustic measure (M; n=10), self-perception measures of voice (Y; n=2) and anxious and depressive states (W; n=2), for a total of 40 moderated mediation analyses performed. The dependant (Y) variable was the self-perception measures of voice, while the independent (X) variable was the continuous variable Age. One covariate (Sex) was included in the model. Voice acoustics were used as the mediator (M) and anxious or depressive states as the moderator (W).

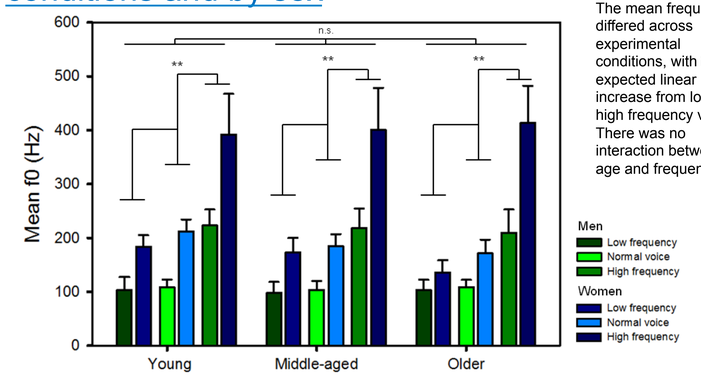
Results

Figure 3 Main effect of amplitude across conditions



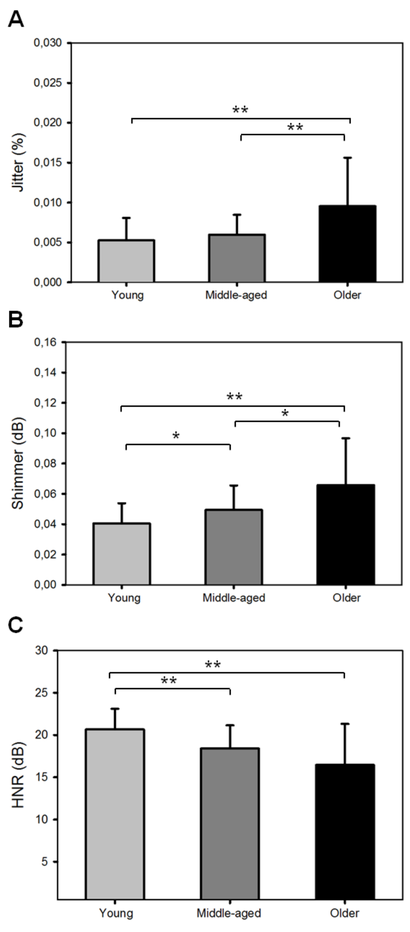
Mean amplitude significantly differed across the experimental conditions, with amplitude in the low amplitude condition being the softest, followed by normal and high amplitude voice. There was no interaction between age and amplitude.

Figure 4 Main effect of frequency across conditions and by sex



The mean frequency differed across experimental conditions, with the expected linear increase from low to high frequency voice. There was no interaction between age and frequency.

Figure 5 Main effect of age on voice stability measures

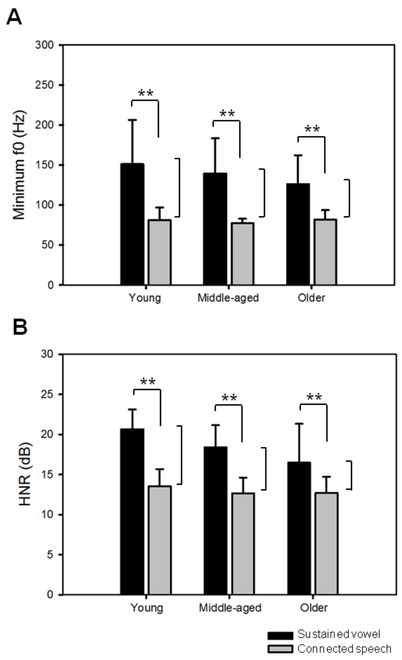


The voice of the older group voice had higher jitter and shimmer values than middle-aged and young voices. Furthermore, the young adults displayed higher HNR values than the middle-aged and the older adults.

Figure 7 From the left: f0 minimum, maximum, mean and HNR are negatively associated with age, while f0 SD is positively associated with age. Amplitude SD and MPT are positively associated with VHI while jitter is negatively associated with VHI. Finally, interaction between anxious states and f0 minimum, maximum, mean and SD, amplitude SD, MPT and HNR is negatively associated with VHI, while interaction between anxious states and both jitter and shimmer are positively associated with VHI. The size of the arrows corresponds to the quantity of acoustic measures involved in that relationship.

Figure 8 From the left: Age is positively associated with f0 SD, jitter, and shimmer, and negatively associated with HNR. Then, amplitude SD is positively associated with VHI while shimmer is negatively associated with VHI. Finally, interactions between depressive states and both MPT and HNR are negatively associated with VHI, while the interaction between depressive states and shimmer is positively associated with VHI. The size of the arrows corresponds to the quantity of acoustic measures involved in that relationship.

Figure 6 Interaction between age and context on voice



Results showed that while there are significant differences between contexts (sustained vowel, connected speech) for all age groups on minimum f0 and HNR, context effects are stronger for the young adults compared to the middle-aged and older groups.

Figure 7 Relationship between age and voice perception mediated by acoustic measures and moderated by anxious states

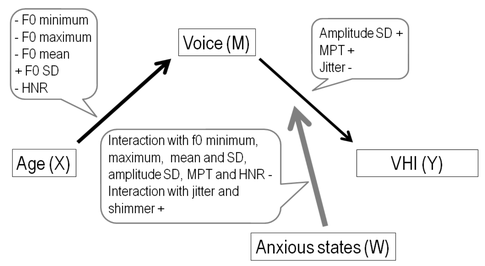
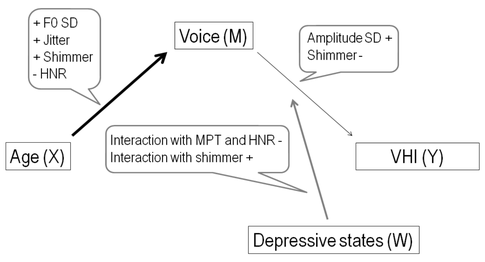


Figure 8 Relationship between age and voice perception mediated by acoustic measures and moderated by depressive states



Conclusions

- ★ The results of the present study confirm that the aging voice is less stable and noisier.
- ★ Our results suggest that older adults (up to 75 years) are equally good than younger adults in modulating the amplitude and the frequency of their voice, at least within the age range that we studied (20-75 years)
- ★ Comparison of conversational voice in different contexts (steady vowels and connected speech) revealed an age-related decline in the effect of context on voice production. Thus, age seemed to have a smaller effect on connected speech than on vowel utterances.
- ★ Our results show, for the first time, that anxious and depressive states moderate the relationships between age and voice production and self-perception of voice quality.

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