The Moderating Effect of Frequent Singing on Voice Aging

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Summary: The effects of aging on voice production are well documented, including changes in loudness, pitch, and voice quality. However, one important and clinically relevant question that remains concerns the possibility that the aging of voice can be prevented or at least delayed through noninvasive methods. Indeed, discovering natural means to preserve the integrity of the human voice throughout aging could have a major impact on the quality of life of elderly adults. The objective of this study was therefore to examine the potentially positive effect of singing on voice production. To this aim, a group of 72 healthy nonsmoking adults (20–93 years old) was recruited and separated into three groups based on their singing habits. Several voice parameters were assessed (fundamental frequency [f0] mean, f0 standard deviation [SD], f0 minimum and f0 maximum, mean amplitude and amplitude SD, jitter, shimmer, and harmonic-to-noise ratio) during the sustained production of vowel /a/. Other parameters were assessed during standardized reading passage (speaking f0, speaking f0 SD). As was expected, age effects were found on most acoustic parameters with significant sex differences. Importantly, moderation analyses revealed that frequent singing moderates the effect of aging on most acoustic parameters. Specifically, in frequent singers, there was no decrease in the stability of pitch and amplitude with age, suggesting that the voice of frequent singers remains more stable in aging than the voice of non-singers, and more generally, providing empirical evidence for a positive effect of singing on voice in aging.
Key Words: voice–aging–singers–perturbation measures–fundamental frequency.

INTRODUCTION

The human voice is an important carrier of human emotions, and it is also the foundation of human verbal communication throughout the entire life span. Unfortunately, the human voice undergoes several important acoustical changes throughout aging.[1–5] For many individuals, age-related voice changes have a negative impact on communication and social participation,[6–9] and therefore on the quality of life. Age-related changes in voice production are widespread and appear to have a complex and multifactorial etiology. Indeed, multiple anatomical and physiological age-related changes affecting the vocal tract, the larynx, and the respiratory system have been documented.[2,10–19] These include the ossification of the laryngeal cartilages; atrophy of the laryngeal muscles, lamina propria, glands, and connective tissues; a loss of ligament elasticity; bowing of the vocal folds; changes in the innervation of the larynx; and neuromuscular degeneration. Changes in the amount and quality of secretions and changes in each layer of the mucosa also appear with aging.[11,20] These anatomical and physiological changes can lead to a reduction of the vibration of the vocal folds, a reduction of adduction of the vocal folds (ie, bowing in presbyphonia), and an increased laryngeal muscle tension (especially for men).[1,2,10,13,21] Hormonal changes in menopause can also contribute to increased vocal fold swelling and edema, which in turn can lower the fundamental frequency (f0).[22,23] Acoustically, the voice undergoes several important changes in aging affecting the pitch, amplitude, and quality of the voice. Changes in f0 have been most thoroughly investigated. In men, f0 declines until the fifth decade and rises gradually after.[2,21,24,25] In women, there appears to be a steady decline of f0 with age.[4,21,24–27] For both men and women, control over vocal pitch tends to decline with age as shown by an increase in the variability of f0 (measured in standard deviations [SDs]), meaning that f0 becomes less stable with age.[27–30] In contrast to the well-documented effects of age on f0, the relation between age and measures of voice perturbation is less clear. Yet perturbation measures are important because they can reveal instability of the vocal fold vibration (jitter), irregularity of glottic closure (shimmer), and loss of vocal fold adduction (harmonic-to-noise ratio [HNR]). Moreover, these measures are widely used in clinical settings. For jitter, the literature is not entirely consistent. Indeed, whereas some studies have shown an increase in jitter with age,[24,29,31,32] other studies report no effect of age.[4,30,33] It has been suggested that changes in jitter are related to physiological changes rather than to chronological age.[33] In sum, the effect of aging on jitter remains uncertain. For shimmer (ie, regularity of glottal opening, and particularly closure), there are also some inconsistencies. For example, although some studies have shown age effects on shimmer in both men and women,[1,24,34] others have found changes in men but not in women.[4] One factor that may account for some of the differences across studies in terms of measures of perturbation is the recording process. Control of recording amplitude and mean f0 have been reported to influence shimmer and jitter significantly.[35–37] Presbylaryngitis (vocal cord atrophy) is also frequent but not universal in aging, and can be confounded with certain characteristics of the normally aging voice.[38] Finally, because the gap between the vocal folds tends to increase with age, middle-aged and older adults tend to have lower HNR (ie, noise level in the voice) values compared with young adults.[24,34] However, others have found changes in women but not in men,[6] or did not observe age differences in HNR.[4] In

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sum, although some inconsistencies remain concerning measures of voice perturbation, it is clear from the literature that aging affects the production of voice at multiple levels.

Early reports have observed that the acoustics of singers' voices differ from that of non-singers, including greater amplitude achieved at various frequencies.[39,40] Singing is also known to be associated with increased voice stability,[41] wider phonation range,[40–43] and increased maximal phonation time.[43,44] Moreover, it has been shown that singing training has a positive and quantifiable effect on voice control in children and teenagers with normal voices.[45,46] Consistent with this idea, a few studies have examined the effect of aging on singers' voices, and observed that the voice of middle-aged and older singers is more stable and has greater amplitude compared with the voice of non-singers.[47,48] Older singers also showed significantly higher speaking fundamental frequency (SFF) than older non-singers during a standardized reading task.[48–50] Understanding the nature and extent of age-related voice decline, as well as vocal habits that may provide protection against negative age effects, is key to developing new interventions to delay the onset of—and potentially prevent—these difficulties, which could have a major impact on the quality of life of elderly adults.

The goal of the present study was to characterize the effect of aging on a large number of acoustical voice parameters in two different contexts (production of a sustained vowel, and overt reading of a standardized passage) in a group of healthy singers and non-singers. Although many studies have examined voice aging, as discussed in the previous paragraphs, the present study is unique in that we examined voice in both a standard (sustained vowel production with controlled amplitude) and a more ecological context (passage reading), and that we analyzed a large number of voice quality and stability measures (12 acoustical parameters were studied). Most importantly, we examined the potentially positive effect of singing on 12 acoustical parameters using a powerful moderation analysis. In line with the literature, we hypothesized that aging would affect most voice parameters but that singing would moderate this effect. Finding a positive effect of singing on voice production in aging could have immediate and broad practical applications for the growing population of senior citizens.

METHODS

Participants

The study comprised a total of 74 healthy nonsmoking participants recruited through email, as well as through posters and flyers distributed in the community. Of the original sample, two participants were excluded because of technical issues that rendered unusable their audio samples. The remaining 72 participants (28 men, 44 women; total mean age ± SD: 51.15 ± 20.05; range: 20–93 years) were included in the analysis. The sample was divided into three groups based on their age (young: 20–39; middle-aged: 40–65; and old: 66–93 years old; Table 1). All participants were native speakers of Canadian French; had normal or corrected-to-normal vision; no self-reported history of speech, voice, language, swallowing, psychological, neurological, or neurodegenerative disorders; and no self-reported history of drug or alcohol abuse. Participants were screened for depression using

TABLE 1.
Participants' Characteristics

	Men			Women			All					
		Age			Age		Education (in years)		GDS		MoCA	
Group	N	Mean ± SD	Range	N	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range
Young	12	29.08 ± 6.04	20–38	14	27.64 ± 4.25	23–37	17.9 ± 3.01	11–24	3 ± 2.43	0–8	28.73 ± 1.34	25–30
Middle-aged	9	56.78 ± 7.97	44–65	17	55.12 ± 7.98	40–65	16.98 ± 3.38	12–24	1.81 ± 2.67	0–10	28.04 ± 1.78	25–30
Older	7	72.71 ± 3.9	68–78	13	76.15 ± 8	67–93	15.8 ± 4.1	7–24	2.25 ± 2.77	0–9	27.3 ± 1.53	25–30
Total	28	48.89 ± 19.48	20–78	44	52.59 ± 20.05	20–93	16.99 ± 3.52	7–24	2.36 ± 2.63	0–10	28.08 ± 1.64	25–30

Abbreviations: GDS, Geriatric Depression Scale; MoCA, Montreal Cognitive Assessment.