An Acoustic and Electroglottographic Study of the Aging Voice With and Without an Open Jaw Posture

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Summary: Objectives. This study aimed to determine if the use of an "open jaw" posture in healthy aging adults would result in voice improvement detectable through acoustic and electroglottographic measurements.

Study Design. A convenience sampling strategy was used to recruit 85 participants, with at least five females and five males in each of four age groups, between age 35 and 50 years (35+), above 50 (50+), 60+, and 70+ years.

Methods. Participants sustained the vowel /a/ at three pitch levels (normal, low, and high) and repeated the test sentence "We saw two cars" in both a normal and an open jaw postures. A selection of acoustic and electroglottographic measures were derived from the steady midportion of the vowel segments extracted from the sustained and embedded vowels to identify measures sensitive to the effects of jaw posture, age group, gender, and pitch.

Results. Results from a four-way (two jaw postures × four age groups × two genders × three pitch levels) Mixed Model Multivariate Analysis of Variance showed a significant four-way interaction effect. For both genders, an open jaw posture led to an increase of fundamental frequency (F_0), formant one frequency, and vowel space area and a decrease of the amplitude difference of the first two harmonics and %Jitter. With an open jaw posture, speed quotient decreased for females and open quotient increased for females but decreased for males.

Conclusions. An open jaw posture was generally associated with positive changes in vocal behaviors, including higher F_0, improved phonatory stability, and voice clarity.

Key Words: Geriatric voice–Jaw posture–Pitch.

INTRODUCTION

The geriatric or aging voice is perceptually distinguishable from voices of younger adults. Studies have shown that an increase in the chronological age of an adult speaker would increase the likelihood of the speaker being judged by listeners to be older.[1,2] It appears, therefore, that the acoustic characteristics of the aging voice may reflect the effects various age-related anatomical and physiological changes have on the vocal system, including the respiratory system,[3–6] laryngeal structures,[3–5,7–11] and the vocal tract.[3] Because the temporal course of the normal aging process can vary among individuals, the degree to which this process affects phonatory characteristics may depend more on the general physical condition than on the chronological age of the speaker.[4,12] Nevertheless, acoustic studies of the aging effect on voice have often focused on comparing the broad categories of the aging continuum, ie, young and older adults.[13–21] In a survey of the voice research investigating the geriatric voice, the ages between 60 and 65 years were most often used as the cutoff age boundary for differentiating between "younger" and "older" adults.[12–14,22–28] In some studies, the elderly age group was defined as individuals aged 70 years and older.[8,19,29–34] Acoustic data obtained from individuals aged older than 60 years are often treated as data from one age group.[14,18,20] As the aging population is growing,[35] more studies are needed to investigate voice changes related to different stages of aging in the elderly.

Audible voice changes may be instrumentally monitored through acoustic analysis of the voice. The aging voice has been characterized by changes to acoustic measures. For example, age-related gender differences on voice include an upward shift in fundamental frequency (F_0) for men and a downward shift for women after the middle age.[4,10,13,16,28,31,34,36,37] Phonatory stability, which is often gauged through measures of jitter, shimmer, and signal-to-noise ratio (SNR), has been shown to deteriorate with aging.[19,34,37] In particular, shimmer[12,13,15] and SNR[19,34,38] have both been shown to better differentiate between young and elderly adults than jitter. Some studies failed to find jitter to be different between young and old healthy adults,[12,13,29,31,34] whereas other studies have reported a significant difference between young and older adult groups.[15,39] Studies have found a tendency for the frequencies of formants to lower in the speech of older individuals.[14,40–42] This tendency may be related to the increased flaccidity and atrophy of the cervical muscles in the elderly leading to a lowered larynx and thus an increase in vocal tract length.[3]

Gender differences in vocal fold physiology include the earlier ossification of cartilages in males than in females.[43] There is also a shortening of the vocal ligaments, thinning of the intermediate layer of the lamina propria, atrophy of the deep layer of the lamina propria in males, and a thickening of the mucosal covering of the vocal folds and loss of elastic fibers in females.[44] Other glottal gender-related changes, such as increases in vocal fold mass for elderly females and higher incidences of glottal gaps in elderly males, have also been found.[7,44] Given the reported gender-specific characteristics of vocal aging, it is not unlikely that the aging process would continue through to the very elderly and that different patterns of vocal aging may emerge at different stages of aging.

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The acoustic properties of voice are influenced by the dynamic changes to the contour and length of the vocal tract as a result of articulatory movement. Changes in jaw posture during phonation have the effect of changing these dimensions along the full length of the vocal tract. A lowered jaw has been shown to relieve muscular tension promoting more relaxed voicing patterns[10,45] resulting in improved approximation of the vocal folds[46] and increases in vocal fold adduction.[47] An open jaw posture is a technique used in voice therapy to relax the laryngeal musculature, eg, the yawn-sigh approach and the Froeschels chewing method, and as a technique commonly used by professionally trained opera singers.[48] Tense phonation on the other hand is associated with elevation of the hyoid bone and along with it, the larynx. In contrast, when the jaw is lowered, the hyoid bone is depressed, leaving the lowered larynx in a more relaxed position. As the larynx has been found to lower dramatically in a true vegetative yawn,[49] jaw widening may lead to a lowering of the larynx and a reduction of vocal fold tension. Vocal exercises focusing on the relaxation of oral-facial musculature have been shown to produce positive phonatory outcomes in singers[50] and in patients with Parkinson's disease through the Lee Silverman Voice Training where, when the jaw lowers as a natural consequence of increasing phonatory effort, there is a reported reduction in vocal fold bowing and improved loudness levels.[51] Increases in jaw opening have been associated with increases in F_0[52,53] and a lowering of formant two (F_2) frequency.[54] In addition, formant one (F_1) has been shown to vary with the degree of jaw opening[55] and increasing jaw opening is used as a singing technique for some vowels to increase pharyngeal constriction to raise F_1.[48] The relative frequencies of the first two formants, F_1 and F_2, provide acoustic information to the listener about the degree of jaw opening.[56] The magnitude of jaw opening has been found to be inversely related to the natural F_0 of individual vowels.[57]

An increase in jaw opening has also been associated with increases in vocal intensity,[58–61] which may be explained by greater vocal fold adduction when the jaw is lowered[46,47] coupled with an increase in radiated acoustic energy as a widened jaw further opens the vocal tract. Lower SPLs have been associated with higher measures of percent jitter and percent shimmer in healthy adults.[62] It could therefore be expected that as SPL increases in an open jaw posture, perturbation measures may also be expected to improve.

This study investigated the effects jaw posture has on a selection of acoustic and electroglottographic (EGG) voice measures over the course of aging in healthy older females and males. One hypothesis of this study is that an open jaw posture will be shown to improve voice quality, and that differences in acoustic and EGG parameters will be found between vowels produced using a normal and an open jaw postures even in consideration of the factors of age, gender, and pitch levels. Studies have reported differences in physiological gender aging patterns in the way it affects the structures of the vocal tract[7,43,44] and therefore, a second hypothesis is that acoustic and EGG measures will reflect these gender differences.

METHODS

Participants

Participants were recruited from the Canterbury region of New Zealand through personal contacts and advertisements in a community newspaper. Participants were 85 adults (56 females and 29 males) aged between 38 and 93 years. Table 1 shows the gender and age information for each of the four age groups. All participants were native English speakers who were healthy, active, noninstitutionalized members of the community with no history of speech, voice, or severe hearing problems, no history of neurological disorders or surgery involving the head and neck area. Twenty-seven participants reported some hearing loss, with none indicating that their hearing was either problematic or interfered with daily living activities including interpersonal social interaction. All participants received a written description of the study and signed the consent forms approved by the institutional human subject ethics review board.

Participants' tasks

Participants were instructed to sustain the vowel /a/ at a constant comfortable intensity level for approximately 3 seconds in three different pitch levels: normal, low, and high. To calculate a quadrilateral vowel space area (VSA), participants were asked to repeat the sentence "We saw two cars" containing the corner vowels /i/, /ɔ/, /u/, and /a/. These four vowels represent vertical and horizontal positioning of the tongue in vowel production and thus allowed for an investigation on the effect of jaw opening on VSA and the interaction between jaw opening and vowel height or forwardness on the acoustic representation of the vowels. Each task was performed in five random trials using

TABLE 1.
Descriptive Statistics for the Age (in Years) of the Female and Male Participants in the Four Age Groups (n = Number of Participants)

	Female					Male				
Age Group	n	Min	Max	Mean	SD	n	Min	Max	Mean	SD
35–59 (35+)	14	38	56	49.4	6.2	5	42	57	49.0	5.7
60–69 (60+)	17	61	69	65.4	2.8	7	61	69	66.1	3.0
70–79 (70+)	14	70	78	74.1	2.4	8	70	78	75.0	2.6
≥80 (80+)	11	80	91	83.5	3.1	9	80	93	85.4	4.2