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Listener estimates of talker age in a single-talker, 50-year longitudinal sample

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ABSTRACT

Purpose: While many studies have shown that listeners make relatively accurate age judgments from hearing talkers' voices, most have used just one age per talker. The present study evaluated listeners' age estimation abilities for a longitudinal sample: a single talker recorded over nearly five decades.

Method: We extracted 60 samples from addresses given by a male talker over 48 years. For each sample, listeners gave a direct estimate of his age. We also asked listeners if they could identify the talker, who was known locally, from the recordings.

Results: While correlations between the talker's chronological age and direct estimates of age were generally strong, the relationship was particularly strong when the talker was older than 68 years, although listeners underestimated chronological age by approximately 5 years. When the talker was between 49 and 68 years, direct age estimates were less accurate and less strongly correlated with chronological age. Additionally, direct age estimates were more accurate when listeners recognized the talker.

Conclusions: Corroborating cross-sectional studies, our listeners overestimated the talker's age when he was younger and underestimated it when he was older. However, the crossover between overestimation and underestimation, the point where estimated and chronological ages were equal, occurred at a later talker age for this longitudinal study than in previous cross-sectional studies. Additionally, listeners who recognized the talker made more accurate age estimates when the talker's chronological age was near the age where they would have known him. We propose future studies explore the relationship between familiarity and estimated age.

1. Introduction

As the Baby Boom generation has gotten older, more research has focused on age-related health issues. Age-related changes to the laryngeal system, while not typically life-threatening, have become increasingly important. Beginning in the fifth decade, specific degenerative processes affect the speech production system. These physiological changes (e.g., atrophy of muscles, dystrophy of nerves and cells, edema) cause speech production to deteriorate, affecting quality of life. Such deterioration includes dysphonia; slower speech and elongated words (Harnsberger, Shrivastav, Brown, Rothman, & Hollien, 2008; Ramig, 1983a); tremor, instability, and aspiration (Harnsberger, Brown, Shrivastav, & Rothman, 2010; Linville, 1988; Ramig, 1983b); reduced loudness. Further, decreased pulmonary function may cause a weaker voice and shortened phrase lengths.

Previous studies have examined whether listeners can perceive these age-related speech changes in physiology and production, as

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well as whether they are capable of making accurate judgments of age from hearing a talker's voice. These studies have varied in terms of both talker characteristics (e.g., gender, age range) and listener characteristics (e.g., gender, age, number) as well as in the speech materials the talkers produced (e.g., sustained vowels, spontaneous speech) and the perceptual tasks the listeners performed (e.g., category judgments, direct age estimates). Among studies in which listeners made category judgments, designs have ranged from two age categories (under 35 and over 65; Ptacek & Sander, 1966) to six age categories each spanning 5 years (Neiman & Applegate, 1990). Despite this, category judgments of age consistently have been more accurate for connected speech materials than for vowels. Furthermore, most category judgment studies (e.g., Goy, Fernandes, Pichora-Fuller, and van Lieshout, 2016; Linville & Fisher, 1985) have shown that listeners tend to underestimate the age of older talkers, with few exceptions (i.e., Ptacek & Sander, 1966). Caruso, Mueller, and Xue (1994) also found that their two older talkers were much more likely to be judged as young or middle-aged than to be judged as old.

Age underestimation for older talkers has also been evident in direct age estimation studies, most of which have covered several decades of talker ages (Hartman, 1979; Huntley, Hollien, & Shipp, 1987; Harnsberger et al., 2010 Ryan & Capadano, 1978; Shipp & Hollien, 1969). Hunter, Ferguson, and Newman (2015) conducted a retrospective data analysis of direct age estimate studies of English-speaking talkers and listeners. First, they identified seven studies that provided data in tables or scatter plots rather than just reporting means. They then used MATLAB to capture, verify, and recreate data provided in scatter plots from digital scans of the articles and pooled them with data provided in tables. In this *meta*-analysis, which yielded 530 data points for from at least 443 talkers (some of the studies had overlapping talker databases) aged 10–90 years, listeners seemed to overestimate age by about 5–7 years until talkers reached age 40. After talkers reached age 50, listeners underestimated age by about 5 years. This underestimation gradually increased until about age 80, at which point listeners underestimated talker age by 12 years.

Nevertheless, results varied among individual studies. For example, for talkers aged roughly 70–80 years, listeners underestimated talkers' age by about 8 years in Huntley et al. (1987) and by about 11 years in Moran, McCloskey, and Cady (1995), but by only about 5 years in Ryan and Burk (1974).[1] Eppley and Mueller (2001) explored possible causes of this underestimation by including both younger and older listeners but only older talkers. Since both listener groups underestimated the age of these older talkers by nearly 17 years, they concluded that the underestimation seen in other studies did not result from including only young listeners, nor was it due to regression to the mean. This suggested that the age underestimation of older talkers is a real phenomenon and not an artifact of experimental protocols or analysis techniques.

For all of the methodological variability among the previous studies, in nearly all of them the listeners were asked to identify each talker's age based on a single age sample (i.e., they used a cross-sectional design). While such designs enable general trends to be observed, longitudinal studies allow us to track age-dependent characteristics without the effects of talker variability (Linville, 1988). After a detailed search, only two age estimation studies which included longitudinal elements were found. In Brückl (2007), listeners heard recordings of 9 talkers who had been recorded on two occasions separated by 5 years; they were able to discriminate between samples produced by the same talker 5 years apart about two-thirds of the time. In another study, Reubold, Harrington, and Kleber (2010) used phrases extracted from broadcast recordings of two prominent individuals as well as manipulated, resynthesized versions of these phrases to assess the effects of age-related speech fundamental frequency and first formant changes on age estimation. For both individuals (Queen Elizabeth, recorded at ages 46 and 57 years, and Alistair Cooke, recorded at ages 39, 62, and 82 years), listeners underestimated the talkers' ages when they were older. These studies went beyond the traditional cross-sectional report of changes with age and added valuable within subject age changes, though the time points were limited to just a few ages.

The dearth of longitudinal age estimation studies is not surprising given that there have actually been very few longitudinal speech-related studies of any sort. A rare exception to this is an early speech aging study which tracked the vowel formants of seven talkers over as many as 29 years (Endres, Bambach, & Flosser, 1971). One barrier to such studies is the limited availability of longitudinal speech databases. Harrington, Palethorpe, and Watson (2000) addressed this dilemma by using 50 years of recorded Christmas broadcasts given by Queen Elizabeth II to examine age-related changes in the voice. Reubold et al. (2010) revisited these data, adding recorded broadcasts from four additional well-known speakers. However, the brief length of the broadcasts (1 m 16 s to 13 m 24 s) limits their usefulness: it is unknown whether such brief segments would be representative of longer speech samples or whether they might reflect warm-up effects. Further, with such well-known figures as Queen Elizabeth or Margaret Thatcher, listeners' familiarity may affect their age estimates.

Building on these previous attempts to use prerecorded public addresses as a listening database, the present study used recorded addresses given by a single talker over a period spanning nearly 50 years (ages 48–97). The goal was to examine listeners' ability to perceive within-talker age-related speech production changes. We then compared the accuracy with which listeners were able to estimate the talker's age to that observed in the cross-sectional age perception literature. Additionally, because the talker was a known individual to a significant proportion of the population local to the location of the experiment (as discussed in more detail in the Methods section), we were also able to discuss the potential effects of talker recognition on age estimation. The public addresses used here have been described in Hunter, Kapsner-Smith, Pead, Engar, and Brown (2012) and in Hunter and Titze (2016), both of which examined changes in vocal characteristics with age. Additionally, the public addresses were 25 to 50 min in length, allowing us to extract multiple samples from each recording.

The research questions for the current study were, "How accurate are chronological age estimates in a longitudinal sample?" and, "To what degree does familiarity with a talker affect chronological age accuracy?" Assuming that, on average, a single talker recorded

[1] We note that the original articles did not segment the results by age range. These estimates were approximated from tables and figures provided in the original articles.