Normal changes in the speech of older adults. You've still got what it takes, it just takes a little longer!

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Abstract:

The authors reviewed the changes in speech production as a result of aging, including changes in structure and function as well as changes in motor control for speech. The following speech production processes in normal or typical aging were reviewed: breathing for speech, phonation, resonation, articulation, and fluency. Different theories of the role of motor control were reviewed, including more recent conclusions that cognition influences speech motor behavior throughout the lifespan. There are many speech changes in the communication of an older adult, but most are adaptive and do not affect good conversational speech.

Keywords: speech | gerontology | motor control | aging | speech motor behavior | older adults | communication

Article:

Speech-language pathologists and audiologists are well aware that older adults comprise our fastest growing segment of the population, with adults over age 85 appearing more frequently on our caseloads. These facts reflect the general increase in the number of older adults worldwide and, as such, have prompted what some refer to as the "graying of the planet" (Sowers & Rowe, 2007). As biological, psychological, and physiological changes occur in all adults over time, changes in speech production occur as well, even in relatively healthy adults. As Pankow and Solotoroff (2007) pointed out, aging is not a disease!

Changes in speech production occur throughout the lifespan as a result of changes throughout the speech and language processing system, including changes in the anatomy, physiology, sensory feedback, motor control, and central processing of speech (Kahane, 1981; Liss, Weismer, & Rosenbek, 1990; Lowit, Brendel, Dobinson, & Howell, 2006; Torre & Barlow, 2009). This review will examine the typical and expected changes that occur in speech production with aging, within the context of a reduced sensory and sensory integrative system (Hooper & Dal Bello-Haas, 2009).

The older speaker constantly changes and monitors speech production in light of reduced or altered sensory feedback and adjusts his or her speech to meet environmental demands. Warren and colleagues (1985) succinctly described this process as the collective influence of change across the entire speech production system (including changes in respiration, phonation, articulation, resonation, and fluency) that affect the integrity of the speech production processing system (Laine & Warren, 1995; Warren, 1964; Warren, Dalston, Trier, & Holder, 1985). Warren (1975) described the phenomena of holistic speech performance as a system that is affected by "concurrent activity in other speech structures" (p. 11). Thus, as we look at changes in the speech of an older adult, and artificially separate voice or articulation for discussion purposes, or separate anatomical changes from neurosensory changes, we must remind ourselves that we are dealing with a continuous speech production processing system. We must also remind ourselves of a basic tenant of aging research: in any given physical measure, if the system is stressed, the older organism is less likely to adapt. Thus, a healthy speaker can appear to be disordered if stress is put on the speech production system, either by experimental design, or by internal or external environmental forces.

Finally, as we examine the body's structural changes and the functional changes in speech production that occur with age, we must remember the classic words of Edward Sapir (1921):

If, then, these and other organs are being constantly utilized in speech, it is only because any organ, once existent and in so far as it is subject to voluntary control, can be utilized by man for secondary purposes. Physiologically, speech is an overlaid function, or, to be more precise, a group of overlaid functions. It gets what service it can out of organs and functions, nervous and muscular, that have come into being and are maintained for very different ends than its own. (p. 8)

Terminology

In this review, the authors have chosen to use the terminology of Nation and Aram (1977) and others, who describe the speech production processes and their age-related changes, as follows:

1. Breathing for speech, or the respiratory process as it functions during speech production.

2. Phonation, the process that produces voice, including normal changes in the behaviors of pitch, loudness, and quality.
3. Resonation, the process that results in oral or nasal air flow.
4. Articulation, the process of shaping and configuring the oral cavity and surrounding structures to produce consonants and vowels and related behaviors.
5. Fluency, the process of the rate and rhythm of speech production.

Please note that this choice of terminology, employed to relate the speech system as a series of interconnected processes, does not separate the term “speech” from “voice.” Thus, in reviewing normal changes in the speech of older adults, the authors refer to “speech,” not speech and voice, in order to avoid artificially separating phonation from other speech production processes. Further, these systems share a common mucosal tissue, are contiguous, and are highly interdependent relative to their growth, development, and deterioration throughout the lifespan. Any divisions for discussion purposes are artificial.

The challenges inherent in defining “normal aging” influence our research. Many of our texts in communication sciences and disorders are replete with developmental charts that describe speech and language. These texts, however, tend to only cover age-related changes up to adulthood. A few authors include information about normal changes that occur with age, but many studies that employ healthy speakers as participants have only included speakers with a mean age of 65-70 (Lowit et al., 2006). The majority of investigators have examined younger and older adults at the same point in time for the purpose of cross-sectional research. This particular method is much easier, faster, and cheaper and affords the opportunity to compare younger and older participants on any given speech measure. Far fewer researchers, and almost none in communication sciences and disorders, engage in longitudinal research, or research that examines data collected on the same individuals over time, sometimes for decades. This particular type of research can produce more sophisticated data analyses by permitting the examination of trends or changes in cohort groups, as well as the exploration of cause-and-effect relationships (Menard, 2002). Most of the data reviewed in this article are the product of cross- sectional research that has compared younger adults to older adults. Further, the majority of these studies did not examine a significant number of participants over the age of 80. Nevertheless, there are some interesting yet normal changes in speech that occur with age. And remember, aging is not a disease!

Breathing for Speech

Typical aging comes with changes in respiratory structure and function (Rochet, 1991). Since speech is an overlaid function, “breathing for speech” is intricately related to respiration. In a clear review of the differences between “breathing for speech” and respiration, Corballis (2002) reminds us that respiratory muscles keep air pressure just below the level of the larynx for speech production. This enables speakers to control exhalation for control of purposeful speech production. Speech breathing depends on adjustments within the thoracic cavity, with the abdomen usually compressed more inwardly for speaking (Hixon, Mead, & Goldman, 1976). In their review of speaking and breathing under increased demands, Bailey and Hoit (2002) observed that participants found speaking to be more difficult than breathing. These results are in accordance with previous research that has explored the competition between breathing and speaking, wherein speech is the more difficult of the two processes (Solomon & Hixon, 1993).

In a classic study of age-related changes in speech breathing, Hoit and Hixon (1987) examined three different groups of healthy men at ages 25, 50, and 75 and found many age-related differences. They examined normal differences and changes in respiratory function, including changes in the structure, lung volume, mechanics, ventilation, and gas exchange, as well as changes in the respiratory nervous system. They found that participants in the age 75 group adjust their linguistic performance by using fewer syllables per breath during extemporaneous speaking. They also observed that this particular group also could be expected to have a higher and larger lung volume and rib cage volume during initiation for speech, fewer syllables per breath, and greater average lung volume expended per syllable.

More recently, investigators also have found higher lung volumes in the speech breathing of older adults, and of note, have found these age-related changes to be more pronounced in men than in women (Huber & Spruill, 2008). They also discovered similar results relative to greater respiratory volumes per breath group, in accordance with previous research, and further observed differences in utterance length and loudness (Huber, 2008). Huber (2008) found that older adult speakers exhibited greater difficulty relative to utterance length and loudness and planned in advance for these difficulties by using processes associated with pre-motor speech planning.

In essence, clinicians, in their evaluation and treatment of older adults, need to adjust expectations for normal performance and look critically at normative data, particularly when the data do not include older participants. Normal changes in the respiratory system that occur with aging may or may not constitute a true disorder, depending on the older individual. As such, there are clinical implications for those clinicians who treat older adults with respiratory problems such as chronic obstructive pulmonary disease.

Phonation

The process of phonation, resulting in voice, in the older adult appears to remain functional for conversation throughout the lifespan. Although most listeners can identify the voice of an older adult, good communication appears to be maintained throughout the lifespan (Linville & Fisher, 1985; Shipp & Hollien, 1969; Ramig, Scherer, & Titze, 1984). As such, age-related changes in the vocal mechanism frequently have been documented in previous research. For example, Sato, Hirono, and Nakashima (2002) observed that the layers of the vocal structure display some deterioration during the aging process. Other researchers have documented bowing and atrophy of the vocal folds, as well as calcification of the laryngeal cartilages in conjunction with age-related changes in the laryngeal musculature (Mueller, Sweeney, & Baribeau, 1984; Takeda, Thomas, & Ludlow, 2000). Collectively, these changes result in a structure that has been called the “presbylarynx” by voice scientists, with the resulting voice of the older adult referred to as “presbyphonia.” As with other changes that occur during aging, there is great heterogeneity in the voice of an older adult. Further, environmental influences, such as smoking and occupational toxins, can greatly affect the “normal” aging voice.

For many years, scientists have examined acoustic and perceptual correlates of the aged voice in effort to identify those characteristic changes in men and women. Yet, there remains a collective disagreement regarding the degree of change that occurs, as well as the potential underlying causes of this change. In comparison to younger adults, the voices of older adults may differ in pitch, loudness, and quality, but there are conflicting reports amongst researchers. For example, some researchers have documented that fundamental frequency, an acoustic measure of pitch, appears to lower with age, and then rise again in very old age, with some notable differences in gender (Hollien & Shipp, 1972; Linville, Skarin, & Fornatto, 1989; McGlone & Hollien, 1963; Mysak, 1959; Mysak & Hanley, 1958; Ramig & Ringel, 1983; Saxman & Burk, 1967). Recent work by Makiyama, Yoshihashi, Hirai, Kodama, and Asano (2007), employing aerodynamic phonatory function measures, revealed no age-related changes in pitch except in women over the age of 70. Relative to loudness, listeners perceive older adults as less loud, and older adults themselves often report using greater effort in order to be heard during vocalization (Caruso & Mueller, 1997). These observations likely reflect changes to the respiratory system that have been described previously, concomitant with additional articulatory and voice quality changes.

As a person ages, changes in voice quality have been described perceptually, by listeners, as tremor, hoarseness, voice breaks, breathiness, and a variety of other vocal quality descriptors

(Benjamin, 1981; Ptacek & Sander, 1966; Ryan & Burk, 1974). As such, there is much disagreement in the literature as to whether these vocal quality changes are, in fact, normal and frequently occurring changes in older adults. Of note, some researchers have found no difference in perceived hoarseness or breathiness in older adults (Gorham-Rowman & Laures-Gore, 2006).

Resonation

The ability to have respiratory air efficiently flow through the oral or nasal cavities, and the coordination of this resonance behavior, depends on complex motor skills that involve the collective coordination of muscles in the aerodigestive track. Yet, the oropharygeal system in the healthy, older adult appears to have remarkably little functional change across the lifespan. The movements that are integral to adequate velopharyngeal closure during speech production have been examined by a few researchers, with no differences observed in the nasal air flow dynamics of older adults (Hoit, Watson, Hixon, McMahon, & Johnson, 1994). Although age-related differences in intraoral air pressure may exist, these differences do not appear to affect the speech production abilities of the older adult (Sonies, 1991; Zajac, 1997). The reviews of the structural and functional changes in the oral and pharyngeal systems, including changes in gustation, olfaction, somesthesis, and kinesthesis, indicate that the older adult maintains adequate palatal skills for functional speech production, even in the presence of sensory decline (Hooper & Dal Bello-Haas, 2009; Sonies). Although some of the pleasures of tasting and smelling may be diminished, air flow from the nose or mouth for adequate speech resonance appears to be maintained in healthy aging.

Aging, Articulation, and Fluency

Articulation and fluency are frequently considered concomitantly in the speech production of older adults, as these behaviors are intricately joined. Relative to the production of vowels and consonants, researchers have examined these speech products in terms of rate, rhythm, and accuracy. Older adults may exhibit impairments in hearing, perceiving, and comprehending speech secondary to deterioration of the auditory system. However, they appear to demonstrate adequate speech production for conversation relative to articulation and fluency, even when a reduced rate of speech is employed.

Jacewicz, Fox, O'Neill, and Salmons (2009) examined articulation rate across dialect, age, and gender and observed both regional and gender variations in speech rate during reading tasks and in informal conversation. For example, speakers from Wisconsin spoke significantly faster than speakers from North Carolina, and young adults read aloud faster than did older adults in both regions. In informal speech, however, only the young adults from Wisconsin spoke faster than older adults. In addition, the variables of dialect and gender, coupled with age, influenced the speaking rate in both regions of the country. For instance, younger and older adults from the Southern region of the United States did not exhibit an age-related effect relative to overall speaking rate. These observations are particularly noteworthy for the clinician who works with older adults. The diagnosis of a speech rate disorder, such as dysarthria, in the older adult should be considered in light of regional and geographical differences that suggest that appropriate rate may be greatly influenced by these parameters.

Yet, there are some discrepancies in the literature relative to the measurement of speech rate. For example, previous studies that examined speech rate in older adults failed to screen for overall cognitive abilities. Other studies employed reading tasks that may have skewed (negatively impacted) the results reported for speech rate differences amongst older adults (Lowit et al., 2006). For example, Lowit and colleagues (2006) compared a group of healthy, older adults and a group with Parkinson's disease on tasks of articulation rate and found that the groups performed similarly. The authors concluded that adequate cognitive skills might influence speech performance. In another study, Goozee, Stephenson, Murdock, Darnell, and Lapointe (2005) assessed the lingual kinematic strategies used by younger and older adult speakers to determine whether they employed different strategies to cope with increased tongue rate movements. Both groups demonstrated a speech-accuracy tradeoff, with older adults increasing their speech monitoring skills and employing slower speaking rates, an observation that was anticipated under a stress-induced response setting. However, the authors did not control for participants who wore dentures. Their results may have been confounded by this omission, given that artificial teeth are well regarded in the literature for contributing to diminished speaking rate (De Souza, Marra, Pero, & Campagnoni, 2007; Price & Darvell, 1981).

Both the Lowit et al. (2006) and the Goozee et al. (2005) studies reflect the relationship between speaking rate and fluency. Although both studies used tasks of increasing speed (either reading or syllable repetition) and likely reflect neuromotor control of the tongue, the resulting speech behavior can also be considered a form of speech fluency, a behavior that combines rate and rhythm. In some speakers, adaptation to a slower speech rate may result in perceived dysfluency, but most studies are in agreement that fluency does not deteriorate with age until over the age of 100 (Caruso & Mueller, 1997; Searl, Gabel, & Fulks, 2002). However, some investigators have described fluency differences that occur with increased age, with a few studies reporting that older, non-stuttering adults are more dysfluent than younger adults (Duchin & Mysak, 1987; Manning & Monte, 1981; Yairi & Clifton, 1972). In a separate study, Pindzola (1990) examined older participants between the ages of 65 and 85 during dyadic conversation tasks and obtained similar results. Specifically, the group of participants as a whole demonstrated a mean total percentage of dysfluency of 6.95%, with interjections, revisions, and word repetitions reported as the most frequently observed dysfluent behaviors. When the group was divided by ethnicity, no differences in overall dysfluency rates or behaviors were observed. Although the literature suggests that speech fluency remains a well-preserved feature of speech production throughout the lifespan, few studies have explored the potential relationship between gender and fluency (Caruso, McClowry, & Max, 1997; Leeper & Culatta, 1995).

Studies that have examined the accuracy of speech production, or the accurate production of consonants and vowels produced in the oral cavity, have observed differences with age, with both speech products approaching a schwa or neutral vowel in the very old (Liss et al., 1990). The cause of this behavior may be attributed to several factors, including the presence of a longer vocal tract, an increase in self-monitoring skills, or the modification of speaking rate (Amerman & Parnell, 1992). As with other speech behaviors that have been observed in older adults, the accuracy as well as the rate of production, are two behaviors that are typically measured on many motor speech evaluations. As such, age-related differences may need to be considered.

Speech Motor Control

Changes in the speech production skills of older adults must always be considered within the context of a motor speech skill, with the transference of language to a speech code that can be understood by the listener serving as the ultimate goal. Many good models of speech motor control vary in their approach. For example, some models espouse a linguistic context for motor control, while others advance a neurophysiological or cognitive science framework (Kent, 2004; van der Merwe, 2009). Even within the many motor control theories, there is a paucity of research that focuses on older adults, except for their inclusion as age-matched controls. Rather, research in this area has largely focused on the developmental aspects of speech motor control, including the linguistic, neural, and sensorimotor development of infants and young children (Locke, 2004; Moore, 2004; Barlow, Finan, & Park, 2004).

A second category of motor speech control research has included participants with specific motor control disorders, such as dysarthria, stuttering, or apraxia of speech. In part, these studies have provided the basis for the development of theories that attempt to explain the potential role of cortical control in speech, as well as its relationship to cognitive abilities.

The complexity of the speech production process can be more clearly understood by examining the theoretical framework set forth by van der Merwe (2009). In her review of the phases in the transformation of the speech code, she differentiates linguistic-symbolic planning from phases of sensorimotor control. The motor control components include the planning, programming, and execution phases of speech movements. Although this model was designed as a template for the examination of the pathological speech motor control system, it could also provide guidance for future research that may explore the relationship between the nervous system of the older adult and the age-related demands of speech production.

In his review of the models of speech motor control, Kent (2004) examined the neurophysiological and neurobehavioral data, as well as the theoretical history behind speech motor control theories. He guided us from the earlier research of "coordination dynamics," or dynamic systems that do not include a role for cognition, to more recent theories of cognitive-motor performance (Ackermann, Riecker, & Wildgruber, 2004; Guenther & Perkell, 2004; Kent, 2004; van Lieshout, 2004). He concluded that motor behavior is directly affected by cognition and that cognition, in turn, influences speech motor behavior (Kent, 2004).

The construction of internal models representing speech movements, aided by observation and imitation of speech behavior, are supported by recent work in cognitive science (Callan, Kent, Guenther, & Vorperian, 2000; Perkell et al., 1997). As with other motor behaviors, such as new learning in an exercise class, the speaker observes and constructs an internal model and then imitates the behaviors (Perkell et al.).

Conclusion

It is indeed fascinating to note that, over time, a healthy, older adult can successfully modify his or her speech behaviors as their speech production system ages, relative to its structure and function. Certainly, the plasticity of the motor system continues throughout the lifespan. Most researchers in motor speech disorders note that healthy, older participants produce intelligible and largely error-free speech, evidence of adaptation within our motor performance over the lifespan (Hooper & Dal Bello-Haas, 2009). It is likely that changes within the sensory and motor systems, concomitant with adaptive changes in cognitive skills, combine to produce distinct, yet functional speech for us as we age.

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