The Routledge Companion to Interdisciplinary Studies in Singing
Volume III: Wellbeing

Edited by Rachel Heydon, Daisy Fancourt, and Annabel J. Cohen

THE ROUTLEDGE COMPANION TO INTERDISCIPLINARY STUDIES IN SINGING VOLUME III: WELLBEING

The Routledge Companion to Interdisciplinary Studies in Singing, Volume III: Wellbeing explores the connections between singing and health, promoting the power of singing—in public policy and in practice—in confronting health challenges across the lifespan. These chapters shape an interdisciplinary research agenda that advances singing's theoretical, empirical, and applied contributions, providing methodologies that reflect individual and cultural diversities. Contributors assess the current state of knowledge and present opportunities for discovery in three parts:

- Singing and Health
- Singing and Cultural Understanding
- Singing and Intergenerational Understanding

In 2009, the Social Sciences and Humanities Research Council of Canada funded a seven-year major collaborative research initiative known as Advancing Interdisciplinary Research in Singing (AIRS). Together, global researchers from a broad range of disciplines addressed three challenging questions: How does singing develop in every human being? How should singing be taught and used to teach? How does singing impact wellbeing? Across three volumes, *The Routledge Companion to Interdisciplinary Studies in Singing* consolidates the findings of each of these three questions, defining the current state of theory and research in the field. *Volume III: Wellbeing* focuses on this third question and the health benefits of singing, offering a resounding chorus for its effects on wellbeing.

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Volume III: Wellbeing

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In memory of
Benjamin Leske PhD (1980–2018),
musician, composer, researcher,
community singing advocate, conductor and choir leader,
inspirational believer in the power of group singing.

9

THE IMPACT OF SINGING ON HUMAN COMMUNICATION IN AGING

From Protection to Rehabilitation

Pascale Tremblay and Julie-Anne Veilleux

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Several studies have shown that speech production can deteriorate significantly with age. Results demonstrate strong sex-specific changes in speaking fundamental frequency (f_o), whereby the pitch of a woman's voice becomes lower with age and the pitch of a man's voice becomes higher (e.g., Honjo & Isshiki, 1980; Ramig, 1983). Other age-related changes include a decline in vocal stability (e.g., Lortie, Thibeault, Guitton, & Tremblay, 2015; Wilcox & Horii, 1980) and loudness (Baker, Ramig, Sapir, Luschei, & Smith, 2001). Decreased speech rate (Fozo & Watson, 1998 ; Wohlert & Smith, 1998), increased duration of speech sounds (Ryan & Burk, 1974 ; Smith, Wasowicz, & Preston, 1987), and changes in speech timing (e.g., Tremblay & Deschamps, 2016 ; Tremblay, Sato, & Deschamps, 2017) have also been reported, as well as a decline in articulation accuracy (Bilodeau-Mercure et al., 2015; Bilodeau-Mercure & Tremblay, 2016). Though limited, a few studies suggest that these changes originate, at least in part, in the central nervous system, suggesting a decline in motor control (e.g., Tremblay & Deschamps, 2016; Tremblay et al., 2017). Understanding changes in human communication and their impact on everyday situations is crucial, given that communication difficulties can negatively affect quality of life.

One promising strategy to maintain communication skills in normal and pathological aging is singing. Singing is a universal human activity that offers a broadly applicable low-cost strategy to protect against the negative effects of aging. Indeed, singing can easily be integrated into the daily routine of most adults at home, in rehabilitation centers, in retirement centers or in recreational facilities. Importantly, it is universal: everyone can sing, regardless of their age, sex, socioeconomic and cultural backgrounds. Identifying whether singing can positively affect voice, articulation, prosody, and quality of life is important, as a variety of professionals including speech pathologists, gerontologists, family doctors, and educators, but also families and caregivers, can develop or implement low-cost interventions tailored to individual needs and characteristics, which, ultimately, could improve quality of life of the elderly.

The fact that singing has an impact on speaking is consistent with the Integrative Model of Speech Motor Control (Ballard, Robin, & Folkins, 2003). This model postulates that speech and non-speech orofacial functions are controlled, at least in part, through domain general brain networks, and that working on one behavior (e.g., singing) might have beneficial effects on another (e.g., speaking).

Given that singing and speaking share the same apparatus, which includes the respiratory system, the vocal tract, and the articulators (e.g., the tongue, soft palate, and lips), the impact of one behavior on the other is perhaps not surprising, but the potential clinical applications of this phenomenon have not been fully exploited. Importantly, singing also engages affective, motivational and memory systems and, therefore, could have broad applications.

In this chapter, we review the impact of singing on voice and speech production in normal and pathological aging. For the sake of brevity, here we focus on two common age-related disorders: non-fluent post-stroke aphasia and dysarthria. We also provide a brief discussion of future directions in this area of research.

The Protective Effect of Singing in Aging

Several studies have examined the positive impacts of singing on the human voice. Specifically, it is well established that singing has a huge impact on vocal quality and stability (e.g., Brown, Morris, Hicks, & Howell, 1993; Pabon, Stallinga, Sodersten, & Ternstrom, 2014), phonatory range (Åkerlund, Gramming, & Sundberg, 1992), and respiration (e.g., Mendes, Brown, Sapienza, & Rothman, 2006; Stegemöller, Radig, Hibbing, Wingate, & Sapienza, 2017). But can these benefits have long-lasting effects and outweigh the strong impact of age?

In a recent study on 47 professional singers, it was found that, with age, the highest frequency as well as the frequency range, measured from the sustained phonation of a vowel, decline significantly (Berghs, Creylman, Avaux, Decoster, & de Jong, 2013). No significant age-related voice improvement was found. This suggests that the voice of a professional singer may undergo the negative effects of aging in the frequency domain (pitch); however, the absence of a control (non-singing) group makes it difficult to determine whether the intensity and the trajectory of these age-related changes is different across professional singers and non-singers. Importantly, another study reported that older singers can benefit from a short vocal training program (Tay, Phyland, & Oates, 2012). In that study, the impact of a 7-week vocal training program, the Vocal Function Exercise (VFE) developed by Stemple (1993), on the voice of healthy nonprofessional older choral singers (68 to 83 years) was examined. A control group of singers was included which did not receive the VFE. The results show that the voices of the VFE group were perceived as less rough. The data also revealed longer phonation times, lower jitter, lower shimmer, and lower harmonic-to-noise ratio (HNR) in the VFE group. These results suggest that voice acoustic and perceptual features can be rapidly improved in older singing adults.

A growing number of studies have examined the benefits of singing on vocal aging, in amateur and professional singers. Interestingly, some studies have shown that, in professional singers, the normal changes that occur in the human voice do not occur, and that the Speaking f_o of professional singers remains stable over time (e.g., Brown, Morris, Hollien, & Howell, 1991; Brown, Morris, & Michel, 1990; Morris, Brown, Hicks, & Howell, 1995). Voice parameters other than pitch also appear to benefit from singing. For example, Brown and colleagues found a faster speech rate in older female professional singers compared to older female non-singers (Brown et al., 1990), which suggests that the decline in speech timing that is observed in normal aging is reduced in older professional singers. This could indicate an experience-dependent preservation of speech motor control in singers, though additional data are needed to evaluate whether the neural networks involved in speech motor control are preserved in older singers.

Prakup (2012), in an elegant study, found that the voices of 30 older female and male amateur choral singers aged between 65 and 80 years old were more stable in the frequency domain (measured as a lower jitter) compared to a group of 30 older non-singers. Vocal stability in the frequency domain is a measure of the synchrony of vocal fold vibrations. Lower stability is perceived as harshness. In the same study, it was also found that singers had an overall higher mean vocal intensity compared to non-singers. No difference was found in vocal f_o. Interestingly, it was also found that male and female singers were perceived as younger than non-singers. Jitter was correlated to perceived age in male and female singers and male non-singers. These data provide important cues into the impact of amateur singing on the human voice, at the physical and perceptual levels. However, the finding of a positive impact of singing on jitter is at odds with the results of earlier studies (Brown et al., 1990; Maruthy & Ravibabu, 2015). Specifically, Brown and colleagues (1990) found no difference in jitter ratio between older female non-singers and professional female singers aged 63 to 85 years old. Participants in the Brown et al. study were slightly older than in the Prakup study, and, importantly, they were *professional* rather than *amateur* singers, which might account for the divergences. A lack of age difference in jitter was also reported by Maruthy and Ravibabu (2015) who compared two groups of 15 young and older female professional Carnatic classical singers to two groups of 15 young and older female non-singers. The results revealed an interaction between group (singers and non-singers) and age on maximum f_o but not jitter. Maximum f_o was significantly higher in older singers compared to older non-singers, though the group difference was higher for the younger singers, suggesting that the benefit of singing on maximum f_o might decline with age.

In sum, though most studies document some form of age-related benefit of singing on voice production (see Table 9.1), there is some variability in terms of the specific impact of singing. These partly discordant findings could be related to the type of singers that were recruited (amateurs vs. professionals) or to other characteristics of the singers such as how often people sing, how long and intense their average singing sessions are, but also general health factors, including respiratory health and weight. While one might have expected a strong positive moderation effect of professional singing on vocal aging because of greater vocal control and better vocal technique compared to amateur singers, it is possible that the positive impact of professional singing on vocal aging declines gradually with age. Potential explanations include more frequent and probably more intense vocal activities, which might have a deleterious effect on the vocal folds. Research comparing vocal aging in amateur and professional singers is needed to identify potentially specific impacts of different singing profiles.

A related concern is that, in most studies in the literature, singers' personal characteristics (beyond the amateur/professional dichotomy), such as respiratory health and weight, are not reported or not integrated to experimental designs. Singing-related factors are also largely ignored, such as the number of times per week one sings, the context (e.g., group or solo singing) as well as the duration and intensity of singing sessions. This is potentially an important limitation because the impact of singing might vary as a function of both personal and singing-related characteristics, and singing might be an effective strategy against normal vocal aging only under certain circumstances. We started addressing this question in a recent study in which we examined whether the frequency of singing moderates the effect of age on several voice parameters in a group of 72 healthy adults (20–93 years) (Lortie et al., 2017). Our results suggest that the number of times per week one sings moderates voice stability in aging, with frequent singers maintaining a more stable voice in the frequency domain (measured as f_o standard deviation). An interaction between age and singing frequency was also found on f_o, with frequent singers showing a more stable voice than occasional singers and non-singers. Some of the effects of singing, however, were found to be detrimental at younger ages, such as voice amplitude variability, though this effect normalized later in life.

In sum, though a certain degree of divergence is noted, globally the studies suggest a positive (mitigating) impact of singing on vocal aging. Taken together, these studies indicate a positive effect of singing on the aging voice. However, the results appear quite variable across studies, which might be due to the small and not fully characterized samples. Thus, while this is a promising area of research, additional studies are necessary to fully understand the benefits of singing in the aging of voice but also articulation and prosody, taking into account the diversity of singing profiles. Understanding the impact that singing has on normal aging is necessary to fully take advantage of its positive impact in pathological aging.

Table 9.1 Normal aging articles reviewed (full references provided in the main text)

#	*References*	*Sample*	*Outcome measures*	*Main findings*
1	Morris et al. (1995)	Young (25–35): 18 non-singers, 5 tenors, and 9 bass/baritones; Middle-aged (49–55): 14 non-singers, 5 tenors and 6 bass/baritones; Older (65+): 18 non-singers, 5 tenors, and 4 bass/baritones	SFF, frequency range, intensity, intensity range, and average peak vocal intensity	Singing benefit on SFF and frequency range in aging
2	Prakup (2012)	65–80(M=N/A): 30 singers and 30 non-singers	f_o, pitch stability, intensity, intensity stability, and perceptual ratings	Singing benefit on jitter and intensity in older singers Older singers perceived as younger
3	Lortie, Rivard, Thibeault, & Tremblay (2017)	Young (20–39, M=28): 12 non-singers, 8 occasional singers, and 6 frequent singers; Middle-aged (40–65, M=56): 13 non-singers, 8 occasional singers, and 5 singers; Older (66–93, M=75): 14 non-singers, 2 occasional singers, and 4 frequent singers	f_o, frequency range, pitch stability, intensity, intensity range, intensity stability, and HNR	Singing benefit on f_o, SFF, f_o variability and amplitude variability in aging
4	Brown et al. (1991)	Young (20–35, M=26): 20 professional singers and 35 non-singers; Middle-aged (40–55, M=44): 20 professional singers and 35 non-singers; Older (65–85, M=76): 20 singers and 34 non-singers	SFF	Singing benefit on SFF in aging
5	Berghs et al. (2013)	Young (21–30, M=N/A): 13 professional singers; Middle-aged a (31–30, M=N/A): 9 professional singers; Middle-aged b (41–50, M=N/A): 12 singers; Older (51–60, M=N/A): 13 professional singers	Frequency range, pitch stability, intensity range, vibrato parameters, MPT, and DSI	Age-related decline in highest frequency overall and DSI For additional female decline in f_o range and SD vibrato amplitude
6	Brown et al. (1990)	25 young non-singers (20–32, M=27), 19 older singers (63–85, M=73), 25 older non-singers (75–90, M=79)	f_o, frequency range, intensity, pitch stability, reading time	Singing benefit on SFF and reading time in aging
7	Sundberg et al. (1998)	20 professional singers (20–70, M=N/A)		Rated age correlates with real age

			Rated age, vibrato rate, and vibrato extent	Vibrato rate and extent correlate negatively with rated age
8	Tay et al. (2012)	22 singers (68–83, M=76), half received a voice treatment (VFE) and the other half did not	f_o, frequency range, pitch stability, intensity stability, HNR, maximum phonation time, perceptual parameters of the voice, perceived effectiveness of the program, and compliance with home practice	The VFE is associated with lower perceived roughness, lower shimmer, and lower HNR
9	Hazlett & Ball (1996)	1 young singer (20) and 1 older smoking singer (60)	f_o, f_o range, pitch stability, intensity, intensity stability, HNR, maximum phonation time, voice onset time	No statistics reported Tendency for a benefit of singing on jitter and frequency range and HNR
10	Maruthy et al. (2015)	15 young non-singers (19–48, M=28), 15 older non-singers (51–68, M=59), 15 young singers (19–48, M=28), 15 older singers (51–72, M=59)	f_o maximum, lower intensity, jitter, MPT, DSI	Singing benefit on f_o maximum and DSI in aging

Legend:
f_o = fundamental frequency
DSI = dysphonia severity index
HNR = harmonic-to-noise ratio
MPT = maximal phonation time
SD = standard deviation
SFF = Speaking f_o

The Therapeutic Effect of Singing in Non-Fluent Aphasia

Singing has been used as an intervention in different types of age-related diseases, including aphasia. Aphasia is an acquired, non-degenerative, language disorder often resulting from a cerebrovascular accident or a traumatic brain injury (TBI). Brain lesions resulting in aphasia are generally located on the left hemisphere (Verstichel & Cambier, 2005). Patients with *fluent aphasia* can produce sentences and speak spontaneously. In contrast, patients with *non-fluent aphasia* (NFA) are unable to produce sentences: they use a limited vocabulary and speak slowly (Hallowell & Chapey, 2008). Spontaneous speech is either completely absent or severely limited and prosody is altered (Verstichel & Cambier, 2005). Aphasia recovery is variable.

The capacity of NFA patients to sing has been reported by clinicians since the earliest published studies on the topic in the mid-19th century. In one of the first group studies on singing (Yamadori, Osumi, Masuhara, & Okubo, 1977), 24 patients with moderate to severe NFA were asked to sing known popular songs. For 21 of these patients, the capacity to sing was partially or totally preserved, suggesting that the capacity to sing is, at least in part, independent from the capacity to speak. This suggests partly distinct control systems, with the dominant hemisphere for singing being the intact right hemisphere, while the dominant hemisphere for speaking is the left (which is damaged).

Melodic Intonation Therapy (MIT) was developed by Albert, Sparks, and Helm (1973), as a treatment for patients with severe chronic NFA.[1] MIT uses melodic intonations (not songs) which represent an exaggeration of natural prosody and is usually referred to as "intoning." MIT uses a hierarchy of difficulty levels: (1) the patients begin by humming a melody; (2) then they intone sentences, first as a repetition (3) and then in response to a question; and finally (4) the patients use a spoken prosody without melodic intonation. MIT also involves a hierarchy of facilitation. The clinician always starts by singing alone, then the patients and the clinician sing together. The clinician gradually stops singing to let the patients finish the melody alone. Throughout MIT, the patients are required to tap the rhythm using their left hand, first with the help of the clinician, then by themselves (Sparks, 2008). MIT was first tested on three patients with NFA who did not respond to other treatments; their speech production was found to improve following MIT (Albert et al., 1973).

Several studies have been conducted to test the effectiveness of MIT. Cortese, Riganello, Arcuri, Pignataro, and Buglione (2015) tested it in six Italian-speaking NFA patients who received four 40-minute sessions per week for 16 weeks. At the end of the intervention, patients showed improved spontaneous speech (semantic-lexical structure, phonemic structure, speech automatism, prosody, and communication). Schlaug, Marchina, and Norton (2008) compared MIT with another commonly used type of therapy, Speech Repetition Therapy (SRT), in two NFA patients. Both interventions were organized around five 90-minute sessions per week combined with home exercises (total of 75 sessions). The only differences between the interventions were the melodic intonation and the hand tapping of MIT. After the initial 40 sessions, both patients improved on naming and speech rate, but the patient who received MIT showed larger improvements. After 75 sessions, naming and speech rate were further improved. Moreover, the patient who completed MIT showed evidence of a reorganization in the right hemisphere, as revealed by functional magnetic resonance imaging (fMRI), while the patient who completed SRT showed evidence of a reorganization in the left hemisphere. Since the melodic intonation and the hand tapping were the only elements that differed from the SRT, the authors concluded that these elements contributed the most to the effectiveness of MIT by activating right-hemisphere brain regions more strongly. Wan and colleagues (Wan, Zheng, Marchina, Norton, & Schlaug, 2014) observed that intensive MIT (five 90-minute sessions per week for 15 weeks) was associated with changes in the right hemisphere. They compared 11 NFA patients who underwent MIT sessions with nine NFA patients who did not receive any treatment. Changes in the right hemisphere only occurred in the treatment group and were associated with improved fluency.

To determine whether rhythm or melodic intonation contributes more to the effectiveness of MIT, two studies (Stahl, Henseler, Turner, Geyer, & Kotz, 2013; Zumbansen, Peretz, & Hebert, 2014) compared three types of therapy: melodic or singing therapy (MT), rhythm therapy (RT), and standard spoken therapy (ST). The MT included melodic intonation and rhythm, the RT only included rhythm and the ST included neither melodic intonation nor rhythm. In both studies, participants underwent three one-hour individual sessions per week. Stahl et al. (2013) included 15 NFA patients assigned to one of the treatment groups (MT, RT or ST). Left hand tapping was not allowed, to facilitate the comparison of the interventions. All participants improved their production of stereotyped phrases (e.g., "hello, everything alright?") but the participants who underwent MT or RT showed greater improvements. However, only ST patients showed improvements on non-stereotyped phrases and generalization effects. Zumbansen et al. (2014) included three NFA patients who underwent all three therapies (MT, RT, and ST) each for six weeks in different order. Patients practised 20 sentences of different lengths per session. Half of the sentences were practised every session, and the other half were new. The results showed improvement on trained sentences in all interventions, but a generalization effect was only observed for MT. This difference might be due to the presence of untrained sentences, which promote generalization and are a feature of the original MIT, but was absent in Stahl (2013).

MIT was originally developed for patients with chronic aphasia, but it was adapted for subacute (i.e., two to three months post-stroke) NFA patients by Van der Meulen and colleagues (2014). In this study, 24 subacute NFA patients underwent a randomized controlled trial. The control therapy consisted of linguistics tasks not involving speaking, such as writing or oral comprehension. The experimental and control groups received five hours of therapy per week for six weeks and were asked to complete exercises at home. Similar to Schlaug et al. (2008), van der Meulen et al. (2014) observed that the MIT group improved their speech production more than the control group in language repetition, in the Amsterdam Nijmegen Everyday Language Test, which measures verbal communication in daily life, and in trained and untrained sentences. Furthermore, the authors observed that the sooner the treatment is started in the subacute phase, the larger the improvements.

In sum, the MIT seems to have the potential to rehabilitate, at least to some extent, NFA patients at both the chronic and subacute phases. All the studies reviewed here found a positive impact of singing on at least one measure of speech production (e.g., naming, fluency repetition). The unique elements of the MIT are the rhythm, the melodic intonation, and the tapping, but it is unclear whether one of these elements is most beneficial. Finally, while some researchers have examined the generalization effect of MIT on untrained sentences (Stahl et al., 2013; Zumbansen et al., 2014), no study thus far has examined the generalization to everyday life situations, which is the ultimate goal of any intervention targeting human communication.

The Therapeutic Effect of Singing in Dysarthria

In addition to being used as a treatment for aphasia, singing-based interventions have also been used as an alternative treatment for dysarthria. Dysarthria refers to a group of neurogenic acquired speech disorders characterized by altered speech movements. Depending on the lesion site, dysarthria might involve one or several pathophysiologies (e.g., spasticity, flaccidity, or rigidity), which can impair speech processes (e.g., respiration, phonation [pitch, intensity, voice quality], articulation, resonance or prosody [stress, rate of speech]) to different extents (Yorkston, Beukelman, Strand, & Hakel, 2010). Most studies on singing intervention in dysarthria have focused on patients with Parkinson's disease (PD). However, few studies have also explored singing interventions in patients with dysarthria in non-degenerative brain diseases, such as stroke or TBI. In this section, we first review studies of PD patients and then we discuss other kinds of dysarthria.

PD is a neurodegenerative disorder associated with hypokinetic dysarthria, which is characterized by reduced respiratory function, altered articulation, reduced speech intelligibility, prosody, and pitch (f_o), and changes in voice quality and intensity (Yorkston et al., 2010). The Music Therapy Voice Protocol (MTVP) was one of the first singing-based interventions for PD patients (Haneishi, 2001). The protocol was first introduced as an individual treatment (Haneishi, 2001), and then it was adapted as a group intervention (Yinger & Lapointe, 2012). Both individual and group interventions reported gains in vocal intensity (Table 9.2). Another intervention, the Voice and Choral Singing Treatment (VCST), which involves weekly choral sessions as well as two, one-hour speech therapy sessions, was also found to have positive outcomes (respiratory function, maximum phonation time, and speech prosody) (Di Benedetto et al., 2009). In a more recent study using a similar choral intervention, Evans and colleagues reported improvements in respiration, vocal intensity, and f_o but not intelligibility (Evans, Canavan, Foy, Langford, & Ruth, 2012). Other studies, however, have failed to find positive outcomes following singing interventions in PD patients (Elefant, Baker, Lotan, Lagesen, & Skeie, 2012; Shih et al., 2012), but also found no deterioration, despite the degenerative nature of PD (Elefant et al., 2012; Evans et al., 2012), even after two years (Evans et al., 2012). This lack of deterioration was considered a positive outcome (Yinger & Lapointe, 2012). However, none of these studies mentioned the typical rate of speech deterioration in PD patients, and the only study that investigated longitudinal changes, to our knowledge, reported that the speech of patients with no or mild cognitive impairment did not deteriorate over a period of one year (Ash et al., 2017). Thus, it is not clear whether interventions in these studies were effective at all. Importantly, these studies used a less intense protocol (see Table 9.2), involving only one session per week, which might account for the discrepancy. However, Stegemöller et al. (2017) compared two choral treatments differing only in intensity and found no difference, suggesting that intensity might not be the key factor.

Contrary to PD patients, patients with non-degenerative brain damage, such as TBI or stroke, usually suffer from a combination of two or more types of dysarthria (Yorkston et al., 2010). Two individual singing-based therapies have been developed specifically for patients with dysarthria following TBI or stroke (Kim & Jo, 2013; Tamplin, 2008). Both therapies are similar to the one used with PD patients and include vocal exercises and singing familiar songs. In the first study, patients improved in speech intelligibility, rate, and speech naturalness (Tamplin, 2008), while in the second, patients improved mostly on voice measures including vocal intensity, f_o, stability, maximum phonation time, and speech rate in a phoneme repetition task (Kim & Jo, 2013).

Two other singing therapies have been developed for neurological patients with various speech disorders, including dysarthria, following TBI (Baker, Wigram, & Gold, 2005) or other neurological conditions (Cohen & Masse, 1993). In an individual singing therapy for TBI patients, participants improved their voice range and their emotional prosody (the ability to change intonation patterns with emotions) (Baker et al., 2005). In a group singing therapy targeting patients with neurogenic communication disorders, such as cerebrovascular accident, multiple sclerosis, cerebral palsy, or PD, an improvement in speech rate and intelligibility was found (Cohen & Masse, 1993). An important limitation of these two studies is that the number of dysarthric participants was not specified and the positive outcomes were not reported as a function of whether the patients had a diagnosis of dysarthria.

In sum, singing might be beneficial to dysarthric patients but the results are less consistent than for aphasia. One potentially important limitation is that disease and speech severity is

Table 9.2 Aphasia and dysarthria articles reviewed (full references provided in the main text)

#	*Reference*	*N*	*Age*	*Diagnosis*	*Intervention*	*Outcome measure*	*Main findings*
1	Albert et al. (1973)	3	48–67 (M=60)	NFA	MIT (N/A)	Speech fluency	Improvement (speech fluency)
2	Yamadori et al. (1977)	24	21–74 (M=48)	NFA	Singing or humming	Capacity to sing popular song	Preserved on 21/24 patients
3	Schlaug et al. (2008)	2	47–58 (M=53)	NFA	MIT (individual, five 90-minute sessions/week for 15 weeks) and SRT (individual, five 90-minute sessions/week for 8 weeks)	Structural brain changes and speech fluency	Improvement (speech production measure) for MIT and SRT, but greater improvements for MIT Structural brain changes (right hemisphere for MIT and left hemisphere for SRT)
4	Stahl et al. (2013)	8	40–72 (M=56)	NFA	Melodic therapy, rhythmic therapy or ST (individual, three 60-minute sessions/week for 6 weeks)	Speech accuracy	Improvement (speech accuracy) for singing and rhythmic therapy
5	van der Meulen et al. (2014)	23	18–80 (M=53)	NFA	MIT (individual, five 90-minute sessions/week for 15 weeks) and SRT (individual, five 90-minute sessions/week for 8 weeks)	Verbal communication, repetition, and semantic association	Improvement (verbal communication, repetition, semantic association)
6	Zumbansen et al. (2014)	3	48–57 (M=52)	NFA	Melodic therapy, rhythmic therapy or ST (individual, three 60-minute sessions/week for 6 weeks)	Speech fluency and speech accuracy of trained and untrained material	Improvement (speech fluency and speech accuracy of untrained material) for melodic therapy Improvement (speech accuracy of trained material) for all the therapies

(*Continued*)

Table 9.2 (Cont.)

#	*Reference*	*N*	*Age*	*Diagnosis*	*Intervention*	*Outcome measure*	*Main findings*
7	Wan et al. (2014)	20	45–70 (M=56)	NFA	MIT (individual, five 90-minute sessions/week for 15 weeks)	Structural brain changes and speech fluency	Structural brain changes (right hemisphere) and improvement (speech fluency)
8	Cortese et al. (2015)	6	53–71 (M=60)	NFA	MIT (individual, four 40-minute sessions/week for 16 weeks)	Semantic-lexical structure, speech accuracy, speech automatism, prosody and communication, repetition, naming, comprehension, and speech fluency	Improvement (semantic-lexical structure, speech accuracy, speech automatism, prosody and communication, repetition, naming, comprehension, and speech fluency)
9	van der Meulen et al. (2016)	17	N/A (M=60)	NFA	MIT (individual, 5 hours/week for 6 weeks)	Verbal communication, repetition, naming, auditory verbal comprehension	Improvement (repetition of trained and untrained items)
10	Haneishi (2001)	4	67–77 (M N/A)	PD	MTVP (individual, three 60-minute sessions/week for 4 weeks)	Speech intelligibility, vocal intensity, and voice parameters	Improvement (speech intelligibility and vocal intensity)
11	Yinger & Lapointe (2012)	10	59–84 (M=72)	PD	Group MTVP (group, two 50-minute sessions/week for 6 weeks)	Vocal intensity and voice parameters	Improvement (vocal intensity)
12	Di Benedetto et al. (2009)	20	N/A (M=66)	PD	VCST (one 120-minute session/week, N/A) with speech therapy (two 60-minute sessions/week)	Respiratory function, voice parameters, and speech prosody	Improvement (respiratory function, some voice parameters, and speech prosody)
13	Evans et al. (2012)	10	48–81 (M=67)	PD	Choral (group, one 120-minute session/fortnight for 2 years)	Speech intelligibility, respiratory function, vocal intensity, voice parameters, and facial musculature	Improvement (respiratory function, vocal intensity, voice parameters, and facial musculature)
14	Shih et al. (2012)	13	54–79 (M=66)	PD	Singing in groups (group, one 90-minute session/week for 12 weeks)	Vocal intensity and voice parameters	No improvement

15	Elefant (2012)	10	55–84 (M=64)	PD	Choral (group, one 60-minute session/week for 20 weeks)	Vocal intensity, voice parameters, and singing components	Improvement (singing components)
16	Stegemöller et al. (2017)	27	N/A (M=67)	PD	Choral (group, one or two 60-minute session/week for 8 weeks)	Respiratory function, vocal intensity, and voice parameters	Improvement (respiratory function, voice parameters
17	Tamplin (2008)	4	19–51 (M=28)	Dysarthria	Singing therapy (individual, three 30-minute sessions/week for 8 weeks) and speech therapy	Speech intelligibility, rate of speech, communication efficiency, and naturalness of speech	Improvement (speech intelligibility, rate of speech, and naturalness of speech)
18	Kim and Jo (2013)	6	52–65 (M=59)	Dysarthria	Accent-based Music Speech Protocol (individual, 5 sessions/week for 2 weeks)	Vocal intensity, voice parameters, and articulation	Improvement (vocal intensity, voice parameters, and articulation)
19	Baker et al. (2005)	4	24–29 (M=27)	Unspecified speech disorders following TBI	Singing therapy (individual, three 45-minute sessions/week for 5 weeks)	Prosody and voice parameters	Improvement (prosody and voice parameters)
20	Cohen and Masse (1993)	32	N/A	Speech disorders following brain damage	Singing or rhythmic therapy (group, two 30-minute sessions/week for 9 weeks)	Rate of speech and speech intelligibility	Improvement (rate of speech) for singing and rhythmic therapy Improvement (speech intelligibility) for singing therapy

Legend:
Diag. = diagnostic
M = mean
MIT = Melodic Intonation Therapy
N = Sample size
NFA = Non-fluent aphasia
PD = Parkinson's disease
Voice parameters: Fundamental frequency (f_o), f_o variability, vocal range, maximum phonation time, jitter, and shimmer.

rarely reported. Those two important limitations render between-study comparisons difficult and make it hard to interpret null findings. Finally, very few studies used conversational speech as an outcome measure (Di Benedetto et al., 2009; Yinger & Lapointe, 2012), which makes it difficult to determine whether post-singing-intervention improvements can be generalized to everyday conversation. Hence, though singing interventions appear to have a positive effect in some dysarthric patients on some outcome measures, future research is needed to evaluate the effectiveness of singing therapy on dysarthria symptoms as a function of patients' characteristics (e.g., severity).

Conclusions

In this chapter, we provide a non-exhaustive overview of the scientific evidence for a beneficial impact of singing in normal and pathological aging, focusing on NFA and dysarthria. The results of our review suggest that singing can improve communication-related outcomes in both clinical populations, but that it might be more effective in aphasic patients, as the results appear to be more consistent across studies. However, the outcome measures vary significantly across studies and often are not detailed. Moreover, the outcome measures are usually not selected based on clear hypotheses about underlying mechanisms. Given the various types of dysarthria, and also aphasia, it is possible that singing-based interventions are most effective either at certain severity levels, or for certain types of disorders. Importantly, we also found that singing has a protective impact on different aspects of human communication, particularly on voice production, though the voice parameters most sensitive to singing remain to be identified, and the potential impact of singing on speaking has been largely ignored. While benefits are reported in all studies, there is divergence in terms of the nature and extent of these benefits. Here again, a lack of proper characterization of participants, particularly the singers, prevents the identification of the most robust singing-related outcomes in the elderly. Understanding normal aging as well as the impact of singing on normal aging will provide a better baseline against which to examine the clinical impact of singing in age-related diseases such as NFA and PD. It will also inform the development of science-based singing interventions. Thus, while this field of research is still emerging and much work is needed to fully understand the protective and curative effects of singing on communication, the available evidence shows promising results.

Glossary

Carnatic classical singing A traditional South Indian classical singing style.

Fundamental frequency (f_o) A measure of how high or low the frequency of a person's voice sounds. It is the frequency of vocal fold vibration. f_o can be measured using a sustained vowel or connected speech (which is considered more representative of everyday voice usage), in which case it is referred to as Speaking f_o or S f_o.

HNR An assessment of the ratio between periodic component and non-periodic component comprising a segment of voiced speech. A normal voice is characterized by a high HNR. A low HNR denotes an asthenic voice and dysphonia.

Jitter The amount of instability in vocal pitch, with a higher jitter value indicating a higher vocal instability in the frequency domain.

Jitter ratio A measure that takes into account the relationship between jitter and f_o: mean jitter (in milliseconds)/mean period (in milliseconds) * by 100.

Shimmer The amount of instability in vocal intensity, with a higher shimmer value indicating a higher vocal instability in the intensity domain.

Note

1 Tanner also mentions Melodic Intonation Therapy in Chapter 10.

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