Therapeutic singing protocols for addressing acquired and degenerative speech disorders in adults

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Abstract

The ability to communicate and make oneself understood is integral to a person's quality of life. It affects social interaction, educational and vocational opportunities, and ultimately independence and sense of self. Unfortunately, speech production is often impaired as a result of neurological damage (eg. traumatic brain injury, stroke) or disorders (eg. Parkinson's disease). There are many similarities and shared neural mechanisms between speech and singing. For example, both singing and speech utilize rhythm, pitch variation, tempo, dynamics, articulation, and respiratory support. Music therapists manipulate these elements of music when addressing therapeutic goals for people with neurogenic speech disorders. Many clinical protocols to address speech disorders in adults have now been published to guide clinical practice in music therapy. This paper summarizes existing music therapy and singing-based protocols used to address commonly occurring acquired or degenerative speech disorders, namely dysarthria, dysphonia, dysprosody and apraxia of speech. We examine individual and group therapy protocols used in medical and community settings for people with neurogenic speech disorders caused by traumatic brain injury, stroke, spinal cord injury, and Parkinson's disease. We highlight the strengths and limitations of these protocols and make recommendations for clinical practice.

Keywords: music therapy, singing, protocol, speech disorder, neurological

The connection between singing and speech

Speech production is often impaired as a result of neurological damage or disorders. This can significantly impact a person's quality of life as so much of human interaction relies on verbal communication. We use speech to communicate basic needs and emotions as well as to interact socially and in the workplace. Therefore, a sudden or gradual decline in speech production can have devastating effects on many facets of a person's life. Such functional communication deficits also have a subsequent negative impact on emotional wellbeing, self-esteem, and social connectedness.

There are many shared neural resources, physiological mechanisms, and structural similarities between singing and speech. From a neurological perspective, singing involves the activation of the motor cortex, basal ganglia, and cerebellum, regions that are also involved in the production of verbal intonation (Freeman, 2000). This supports the use of singing to activate and exercise the speech centres of the brain, which may reconnect or reawaken the necessary neural systems utilized in the production of intoned speech. Further, by repetitious engagement of the speech production networks via singing, it is possible to stimulate neuroplastic changes in the brain (Altenmuller & Schlaug, 2013; Baker & Roth, 2004).

The parts of the body that make up the speech apparatus and the physiological mechanisms used to produce speech are also used when singing (and often to a greater degree). For example, the respiratory system is used to provide the air support that drives both speech and singing; however, more air is required to sing than for conversational speech. The vocal folds (glottal valve) are needed to produce phonation, the soft palate (velum), back of the throat (pharynx), and tongue produce resonance and vowel qualities, and the teeth, tongue and lips are used to articulate sounds in both speech and singing (Baker & Tamplin, 2006).

From a structural perspective, speech and singing share many structural similarities such as rhythm, pitch variation, tempo, dynamics, articulation, and respiratory support. Singing involves the fusion of music and language along a continuous spectrum, with more rhythm-focused genres (eg. rap and recitative at one end and more melody-focused genres (eg. pop songs and arias at the other

(Brown, 2000). Music and language both utilize structured patterns of pitch (melody), timing (rhythm) and intensity (dynamics) (Patel, Peretz, Tramo, & Labreque, 1998). Therapeutic singing and vocal exercises can be used to build respiratory muscle strength and control. The key is emphasis on vocal technique and, as with any type of strength training, the principle of progressive overload. A muscle will only strengthen when forced to operate beyond its customary intensity. Neural adaptation is also possible as the movements involved in singing closely match the target movements for speech in direction, force, range and velocity (Van der Merwe, 1997).

Music therapy clinical protocols to address speech goals

Music therapy treatment protocols have been developed for many commonly occurring acquired or degenerative speech disorders, such as dysarthria, and dyspraxia, and voice disorders, such as dysphonia and dysprosody. A recent Cochrane review of music interventions in acquired brain injury (Magee, Clark, Tamplin, & Bradt, 2017) included only three studies on music-based aphasia interventions and found a moderate effect of these interventions on overall communication. No controlled clinical trials of the required standard were found for music-based interventions designed to address nondegnerative neurogenic speech impairments. However, several music-based speech protocols have been published for people with speech disorders caused by traumatic brain injury (TBI), stroke, spinal cord injury, Parkinson's disease, and other neurological conditions. Music therapy protocols that have been developed for neurological language disorders (such as aphasia), speech disorders resulting from congenital disorders (such as cerebral palsy), and non-neurogenic speech disorders (such as lisps and stuttering) will not be covered in this paper.

Studies using therapeutic singing protocols to address speech goals have demonstrated improvements in speech naturalness and intelligibility in dysarthria due to acquired brain injury (Tamplin, 2008) or Parkinson's disease (Elefant, Baker, Lotan, & Krogstie Lagesen, 2012; Haneishi, 2001), dyspraxia (Hurkmans et al., 2015), speech intensity and maximum phonation time following quadriplegia (Tamplin et al., 2013), and affective intonation following acquired brain injury (Baker, Wigram, & Gold, 2005). Most of the protocols we

reviewed use singing familiar songs (along with other vocal and respiratory exercises) to provide motivation for speech rehabilitation. Tables 1, 2 and 3 detail 26 publications that describe the use of music-based clinical protocols designed to treat speech disorders. Some of the publications only describe a protocol, others include case studies, and yet others have tested a protocol in a clinical trial (although many lack a control comparison). In this paper, we will highlight the strengths and limitations of these protocols and make recommendations for music therapy clinical practice.

Music therapy protocols designed to increase respiratory support for speech

We developed a therapeutic singing protocol designed to improve respiratory support for speech for people with quadriplegia and tested the effect of this intervention in a small randomised controlled trial (see Table 1, Tamplin et al., 2013). The 12-week protocol comprised one hour of therapeutic singing techniques three times weekly designed to holistically address all aspects of respiration for singing and speech. The vocal exercises included stretching, oral motor respiratory exercises and pitch and intensity exercises, and took approximately 20 minutes to complete (see Tamplin, 2012 for a more detailed protocol description). Sustained exhalation and phonation exercises were included to develop respiratory endurance and increase inspiratory capacity. A number of exercises targeted intensity variation, using crescendo, diminuendo, and accented rhythmic pulsing. Participants were guided to explore new ways to increase the recruitment of the spared accessory respiratory muscles in the neck and shoulders by bracing or pushing with the upper body to provide an increased support base for expiratory efforts. The song singing component of the intervention incorporated the techniques for improved breath support and control (practiced in the vocal exercises) into familiar songs. Each session concluded with a vocal improvisation focusing on maximum sustained phonation and exploration of vocal range. The outcomes of the study indicated that the protocol was effective in increasing voice projection over background noise and maximum phonation time.

Music therapy protocols designed to address nondegnerative dysarthria

Respiratory support is also often compromised in speech disorders such as dysarthria. Dysarthria is a term used to describe a group of motor speech impairments caused by nervous system damage. The type and severity of dysarthria depend on which area of the nervous system is affected, but it can cause impaired movement (weakness, paralysis, incoordination) of the muscles used for speech production, including the lips, tongue, jaw, vocal folds, and diaphragm (Duffy, 2013). Acquired dysarthria is common following stroke or TBI and is characterised by decreased intelligibility and loudness and abnormal speech rate and prosody. Dysarthric speech is difficult to understand as words often slur together due to weakness and imprecision of the articulators.

Several music therapy protocols have been designed to improve dysarthric speech (see Table 1). Some focus on rate control (eg. Cohen, 1988; Pilon, McIntosh, & Thaut, 1998; Thaut, McIntosh, McIntosh, & Hoemberg, 2001), others utilize rhythm to organise and improve word articulation (eg. Cohen, 1992, 1995; Cohen & Masse, 1993; Kim & Jo, 2013), some focus on prosody and phonation (eg. Magee, Brumfitt, Freeman, & Davidson, 2006), and others use a combination of singing strategies (eg. Cohen & Ford, 1995; Tamplin, 2008; Tamplin & Grocke, 2008).

Music therapy protocols designed to modify speech rate have used different forms of musical pacing and cuing with positive effects. Cohen (1988) found rate decreases when tapping during singing and speech, with greater decreases noted during speech. Pilon and colleagues (1998) found improvements in intelligibility secondary to rate change during three different pacing conditions: metronome pacing, board pacing, and singing for dysarthric speakers with PD. Similarly, Thaut et al. (2001) found improvements in intelligibility when imposing rate control strategies to decrease rate of speech for severely dysarthric speakers with PD. None of these studies examined carryover effects on speech following training using these pacing techniques however.

Kim and Jo (2013) developed an accent-based music speech protocol for

patients with mixed dysarthria[1], based on the Accent Method of voice therapy (Kotby, 1995). The protocol was administered daily for two weeks and included upper body warmup, respiratory exercises (abdominal breathing and scales), vocalisation (melodic and rhythmic), and melodic chanting. All six patients who trialled the protocol showed significant improvements in maximum phonation time, fundamental frequency and vocal intensity and also improvement trends in diadochokinetic rate. Cohen (1992) found improved speech outcomes following a music speech protocol that used both rhythmic exercises and singing. In a follow-up study, Cohen and Masse (1993) separated out a singing-based protocol from a rhythm-based protocol (involving articulatory drills of vowels, words and sentences in time with a metronome) to determine the relative benefits of each on speech production. Both protocols revealed similar significant speech-rate improvements, however, singing yielded significantly greater increases in intelligibility. Participants in the control group made no improvements.

Tamplin (2008) developed a music therapy treatment protocol for dysarthria and tested its efficacy in an experimental case study with four participants. Results suggested improvements in speech intelligibility, pause time, and naturalness following 24 sessions over 8 weeks. The protocol was designed to address respiration, phonation, articulation, resonance and prosody. A theoretical rationale was provided for the inclusion of each set of exercises and the detailed protocol was outlined clearly (Tamplin & Grocke, 2008) and described in line with standard Neurologic Music Therapy technique definitions (Thaut & Hoemberg, 2014). In summary: oral motor and respiratory exercises were used to develop respiratory control and support for phonation; rhythmic articulation and rhythmic speech cuing used the entraining function of rhythm to organise motor speech movements; melodic articulation and vocal intonation therapy used pitch variation in musical exercises to improve speech prosody and pitch range; and therapeutic singing (using appropriately chosen familiar and preferred songs) was used to coordinate breathing, pitch and rhythm together in a motivational and enjoyable activity. Clear recommendations for how to select

[1] Mixed dysarthria is a combination of two or more of the pure dysarthria types.

appropriate song material to address the therapeutic aims were also provided (Tamplin & Grocke, 2008).

Therapeutic singing protocols to address speech in Parkinson's disease

A number of singing-based protocols have been developed to address hypokinetic dysarthria, characteristic of Parkinson's disease (a degenerative neurological condition). This type of dysarthria involves deficits of respiration, phonation, and facial musculature movement, which result in reduced vocal loudness and pitch variation, short rushes of speech, breathiness, and imprecise articulation (Duffy, 2013). Respiratory muscle strength declines faster in Parkinson's disease than in typical ageing, and results in reduced maximum expiratory and inspiratory pressures (Sanches et al., 2014). Several studies have examined the effects of singing protocols designed to improve speech outcomes for people living with Parkinson's disease (see Table 2). Most of these protocols are based on the rationale that singing requires greater respiratory support and subglottal pressure than speech and thus can be used as enjoyable means of training to increase voice projection. Singing also uses greater variation in pitch than speech and thus can be used to address monotone speech production that is common following TBI (Baker et al., 2005) and also in Parkinson's disease. There are similarities between many of these protocols, such as the use of diaphragmatic breathing, humming, pitch glides, scalic exercises, consonant articulation practice, and song singing with focus on breath support, for phrase lengths and sustained phonation and pitch range.

Haneishi (2001) developed a music therapy voice protocol (MTVP), involving vocal exercises and singing in 1:1 sessions three times weekly for 4 weeks, and measured the effects of this protocol on voice, speech and mood in four participants with Parkinson's. Intelligibility was subjectively measured using the Speech Intelligibility Inventory Self-assessment Form (Kent, 1994) and acoustic speech data was analyzed from a recording of the participant's reading of the Rainbow Passage (Fairbanks, 1960). Though the study was too small to generalize findings (n=4), statistically significant improvements in carer-rated intelligibility and vocal intensity suggested benefits of the MTVP. Perez-Delgado (2007) adapted Haneishi's (2001) MTVP to include respiratory exercises, and

shorter, more frequent sessions and measured the effects of this adapted MTVP protocol on six participants with Parkinson's. Improvements in intelligibility were observed; however, this was subjectively rated by the researcher which may have biased the findings. Both participants and caregivers reported enjoyment of the MTVP sessions, which endorsed the motivational power of singing as therapy for people with Parkinson's. In some cases, gains were lost without continued MTVP instruction, suggesting a need for a longer, or ongoing, service delivery.

The therapeutic effects of singing on speech outcomes for people with Parkinson's disease have also been examined using group protocols. Several studies have explored various dosages and intensities of group singing protocols designed to address a range of speech, voice, and respiration parameters (Table 2). Yinger and Lapointe (2012) developed a detailed group protocol based on Haneishi's MTVP (2001). The group met twice weekly for 6 weeks and the G-MTVP consisted of: 5 minutes of opening conversation, 5 minutes of physical warm-ups, 5 minutes of breathing exercises, 5 minutes of speech exercises, 5 minutes of vocal warm-ups, 20 minutes of singing exercises and 5 minutes of closing conversation. They found significant improvements in vocal intensity during conversational speech and reading from pre to post intervention.

Elefant and colleagues (2012) describe a 20 session weekly group singing intervention that included abdominal breathing, vocal exercises, song singing and conversation. The 10 participants exhibited a significant increase in singing quality, voice range, and voiced sound. They also significantly improved in the physical subscale of the Voice Handicap Index and notably speech quality did not decline over the 20 weeks. Di Benedetto et al. (2009) examined the effects of weekly choral singing in combination with twice weekly group speech therapy designed specifically to prepare the participants for singing, ie. muscular, respiratory, laryngeal, oro-facial and prosodic exercises. They found significant improvements in respiratory muscle pressures and phonation time as well as improvements in prosody and fatigue during reading aloud. Similarly, Stegemöller et al. (2016) found significant improvements in respiratory muscle pressures and phonation time as well as improvements in voice-related and health-related quality of life following an 8-week group singing intervention for

people with Parkinson's. Interestingly they found no significant differences in outcomes between groups that met weekly or twice weekly. Further information about the music therapy protocol is detailed in the paper (Stegemöller et al., 2016) which included trunk, shoulder and neck exercises, abdominal breathing, lip trills, glissandos, messa di voce (intensity) exercises, pitch range and articulation exercises and popular song singing. Azekawa (2011) examined the effect of a group singing protocol using two NMT techniques (vocal intonation therapy and therapeutic singing). She found a decrease in pause time and an increase in fundamental frequency for five participants who completed the 6-week protocol. Evans and colleagues (2012) found significant improvements in phonation, respiration and facial musculature for 10 people with Parkinson's who participated in a fortnightly group singing intervention over 2 years facilitated by a professional singing teacher. In contrast, Shih et al. (2012) found no improvements (but also no decline) in speech and voice after a 12-week group singing intervention for 13 participants with Parkinson's. As can be seen there are several (similar) models of singing protocols designed to improve speech for people with Parkinson's, but research examining the efficacy of such protocols is still emerging.

Music therapy protocols designed to address prosody impairments

Difficulties with prosody indicate that a person has an impairment in the ability to inflect emotion in the voice. People displaying dysprosody are unable to make use of rises and falls in pitch, attack, and speaking tempo to communicate their most basic emotions leaving others unable to interpret the emotional meaning of what they are saying. Baker's protocol (2011a) incorporates singing a series of upward and downward intervals, and singing high and low notes (to develop pitch control and extend pitch range), as well as singing songs to develop and utilize increased pitch control and range. The songs selected for therapy (in addition to being patient-preferred) must also include a reasonable pitch range within the melodic phrases in order to extend vocal range. The protocol was effective in increasing pitch range, fundamental frequency, and fundamental frequency variability in four males with TBI (Baker et al., 2005, see Table 1).

Music Therapy protocols for Apraxia of Speech

Apraxia of speech (AoS) is a disorder of motor speech programming. A person with an acquired brain injury may have the language capacity and physical ability to produce speech, but cannot do so volitionally due to an impairment in the ability to select, program, and/or execute the positioning of the articulators and to sequence muscle movements (Baker & Tamplin, 2006). AoS may impair some or all of the following areas: 1) initiation of articulatory movements, 2) internal coordination of palate, tongue, larynx and pharynx, 3) coordination of the voice with articulation, 4) control of the rate of articulatory movement, 5) phoneme substitution, 6) sequencing of movements, and 7) abnormal prosody.

Singing and rhythm-based protocols to address AoS, although under-researched, have been described in the literature (see Table 3) by De Bruijn and colleagues (de Bruijn, Hurkmans, & Zielman, 2011; Hurkmans et al., 2015), Baker (2000, 2011a), and Baker and Tamplin (2006, 2011). De Bruijn and colleagues' (2011; Hurkmans et al., 2015) protocol for AoS involves a music therapist and speech therapist working together simultaneously, hence the protocol name: speech-music therapy for aphasia (SMTA). The speech-language therapy targets the sound, word, and sentence level, and the music therapy targets singing, rhythmical chanting, and speaking. The speech and music exercises are separated in the sessions but are matched according to level of skill achieved, so when the client is working on word-level exercises in the speech therapy component of the session, they also work at the word-level in music therapy exercises. SMTA is described as a rate-rhythm control strategy. A strength of this protocol is the consideration of tempo. Slow tempos can create a sense of relaxation so are important when introducing new or difficult exercises. However, if the tempo is too slow, the music lacks flow and may not be motivating for the client. Simple rhythms are also recommended and when syncopation is not part of normal speech, it should be avoided (de Bruijn et al., 2011). This protocol was implemented with a large sample of people with AoS (n=133) and found to improve language capacity and verbal fluency.

Baker (2000, 2011b) observed improvements in intelligibility following a modified melodic intonation therapy (MIT) program. Baker's modified version of

MIT uses melodic and predictable musical phrases that are meaningful and useful for the client. The protocol also involves collaboration with a speech pathologist whereby the client practices AoS drills and exercises in speech therapy sessions to compliment the music-focused approaches in music therapy.

Another singing protocol for AoS is designed to build skills in a gradual way by initially targeting less complex sound sequences and building to more complex sequences (Baker & Tamplin, 2006). Easier phonemes using bilabial sounds (lip closure), such as "m", "p" and "b", are practiced initially followed by linguadentals (where the tip of the tongue touches the inside of the front teeth, e.g. "d" and "t"). Songs that contain a significant number of words containing the identified target sounds are selected or composed for use in therapy. The protocol also considers the placement of the target sounds within words. For example, the "m" in "music" is easier to master than in "stem" at the end of the word, so clients are asked to focus on the words beginning with "m" before those ending with "m".

The Therapeutic Rhythmic Chanting protocol for AoS (Baker & Tamplin, 2006, 2011) aims to address impairments in oral motor control and coordination through the rhythmic chanting of various consonant-vowel combinations (e.g. "me-ma-me-ma" or "me-dah-me-dah"). To reinforce the rhythmic flow of the chanting, the therapist taps the client's arm or beats a drum while the client is chanting. As in the previous AoS protocol, when the client begins to improve, the task difficulty is increased. For example, chanting to simple rhythmic patterns rather than a basic pulse.

Singing protocols for dysphonia

To date only one study has outlined a singing protocol for dysphonia (Onofre, Ricz, Takeshita-Monaretti, de Almeida Prado, & Aguiar-Ricz, 2013, Table 1). The 12-session weekly protocol (consisting of breathing exercises and scales) was implemented with five total laryngectomees with tracheoesophageal voice prosthesis. Results suggested improvement (or persistence) of the general degree of dysphonia for emitted vowels and for the parameters of roughness and breathiness. Improvements were also noted in perceived pitch range and accuracy as well as legato phrasing. Further research into the use of singing

protocols for dysphonia is needed before conclusions around efficacy and clinical recommendations can be made.

Discussion

This review of music therapy or singing-based protocols for speech indicates a number of common features across the different protocols. This was to be expected, given the neurological, physiological and structural connections between singing and speech described earlier. Many protocols were based on a structure of vocal warmups, exercises (including physical stretching, breathing exercises and vocal/singing exercises) and song singing. The selection of exercises and therapeutic focus of the sessions varied depending on the presenting needs of participants and subsequent speech goals.

Protocol dosage

In general, the session length was shorter for protocols for individual therapy (mostly around 30-40 minutes), and longer for group protocols (mostly around 60 minutes, but up to 90 or 120 minutes for some protocols). The dosage was highly variable with some protocols requiring more frequent sessions, such as 2-3 times per week over a shorter time period, and others using weekly sessions over 8-12 weeks. This variation appears to have been based on both feasibility/practical issues and time since injury. Kim and Jo (2013) included five 30-minute sessions per week for 2 weeks for stroke patients in subacute rehabilitation. The rationale for more intensive therapy in the early phase of rehabilitation is to capitalize on naturally occurring brain recovery (neuroplasticity). Neural networks are more likely to be established or re-established when activation of these areas of the brain occur more frequently and intensively.

One of the main reasons for shorter sessions is fatigue. Singing requires significantly more physical effort than speech (hence it's potential for therapeutic application) and can be quite tiring, particularly for people with neurological speech impairments (Baker & Wigram, 2004). In an individual session, 30 minutes of intensive vocal exercises and singing is likely to be quite physically challenging. However, in a group context, where the focus is not on

just one person, there may be more opportunities to rest and therefore longer sessions are appropriate.

Travel time to attend face-to-face sessions can be significant for many people (if they are not hospital inpatients), therefore it can be difficult to commit to more than one session per week. With the emergence of telehealth modalities such as videoconferencing software and even virtual reality platforms, it is possible that in the future, distance will not be a factor preventing more frequent sessions.

Protocol content

Most protocols typically outlined a graded program where the level of speech production difficulty was taken as a starting point for intervention, and the level of difficulty of singing tasks gradually increased to encourage systematic improvements in voice and speech production. For example, when working with AoS, simpler phonemes were targeted first and more challenging sounds were not introduced or targeted until these simpler sounds were mastered (Baker & Tamplin, 2006). The strength of this approach is that it maximizes the participant's opportunity to succeed by focusing on targeted groups of sounds sequentially. Singing exercises specifically designed to address targeted deficit skills were embedded into most protocols. For example, singing melodic intervals to increase voice control is a technique that may extend pitch range and help with speech intonation and prosody.

Nearly all protocols included some form of physical warmup or stretching to prepare for the therapeutic voicework to follow. The vocal and breathing exercises varied between protocols exercises depending on the main goal for intervention (for example, respiratory function, vocal intensity, speech fluency, or intelligibility). High intensity breathing exercises were particularly targeted in protocols aiming to increase vocal intensity.

Integrating rhythm into the singing practice was a primary component of several of the protocols. Recent findings suggest that rhythm may be a crucial component of therapeutic singing interventions (Stahl, Kotz, Henseler, Turner, & Geyer, 2011). The entraining function of rhythm can be used to stimulate and organise motor speech movements. Clear rhythmic cueing primes and triggers

movement initiation and enhances the precision of timing in motor planning. Based on optimization principles in motor control, this rhythmic cuing enhances accuracy in the control of space and force dynamics of the entire speech movement pattern (Thaut et al., 2001). Thus, a focus on rhythmic speech production using cuing or during singing improves articulatory precision and rhythmic drills on consonants and consonant blends may improve phonemic accuracy. Rhythm in song acts as a timekeeper to organize breathing patterns and cue verbal output in phrases. Rhythm is also an important component of speech naturalness and intelligibility, as abnormal speech rhythms make it difficult to understand what a person is saying. For example, rhythmic articulation exercises and use of rhythm to structure phrase lengths and achieve stress when singing in Tamplin's (2008) dysarthria protocol assisted participants to improve the semantics and syntax of their speech, which also led to improved intelligibility. Unfortunately, none of the studies using rhythmic pacing protocols (Cohen, 1988; Pilon et al., 1998; Thaut et al., 2001) examined training effects of rhythmic cuing over time on speech rate and intelligibility, but only evaluated immediate effects in single sessions.

Several of the protocols recommended the careful selection of music material, ie. songs that are patient-preferred and with positive, meaningful and/or uplifting lyrics. It is also important that songs selected for therapy are not too difficult, in terms of pitch, tempo, rhythm, or lyrical complexity may impede patient progress and potentially decrease motivation for participation in therapy (Tamplin & Grocke, 2008).

There is currently no research (and little clinical description even) into the effects of singing protocols in progressive neurological disorders other than Parkinson's Disease. It is possible that the therapeutic singing protocols designed for Parkinson's dysarthria might be adapted for use in certain stages of Huntington's Disease or Motor Neuron Disease, although this has not yet been tested. It is possible also that the protocols for non-degenerative dysarthria be applied to degenerative conditions. It is interesting to note however, that most Parkinson's singing protocols were group interventions, while the majority of protocols designed for non-degenerative speech conditions were individual. This may reflect the homogeneity in speech goals or lack of it, for these groups

respectively.

Recommendations

Each of the 26 singing-based speech protocols reviewed in this paper were slightly different. Some of the protocols were based on adaptations of previously published protocols, for example MIT (Baker, 2000; de Bruijn et al., 2011; Hurkmans et al., 2015) or Haneishi's (2001) MTVP (Perez-Delgado, 2007; Yinger & Lapointe, 2012). However, these were still different to the original published protocols on which they were based. Given the increasing number of singing-based therapeutic speech protocols currently in the literature, it would be sensible for music therapists to test these existing protocols in replication studies to determine their effectiveness. It is imperative that research studies designed to test protocol efficacy are well-controlled and sufficiently powered, and ideally with random assignment, allocation concealment and assessor blinding.

The speech therapy field has a similar dilemma, with many protocols for dysarthric speech rehabilitation currently used in clinical practice not strongly supported by research evidence (Sellars, Hughes, & Langhorne, 2009). An exception to this is the Lee Silverman Voice Treatment (LSVT®) protocol, an intensive vocal-exercise protocol for people with Parkinson's disease based around "thinking loud" (Ramig, Fox, & Sapir, 2004). Sapir, Ramig, and Fox (2008) have acknowledged numerous studies demonstrating efficacy of LSVT® through long-term improvement of vocal quality, loudness, articulation, and prosody, as well as its suitability for telehealth, group applications, and less-intensive delivery. Although the LVST® protocol has also been critiqued, it has been used in many research studies and has demonstrated positive effects on speech production. Using LSVT as an example, we now need to build a body of research around specific music therapy speech protocols, rather than continuing to develop new protocols. The use of common terminology to describe techniques will assist in this process and the adoption and use of Neurologic Music Therapy terms (Thaut & Hoemberg, 2014) where appropriate is already apparent in the research literature.

This paper summarises 26 publications that describe singing protocols to address speech and voice goals. Music therapists working in speech

rehabilitation are urged to refer to the original publications cited for greater detail on each of the protocols discussed and to guide their clinical practice. As discussed, it is important for further research to be conducted on these existing protocols, to determine not only whether they are effective, but also to determine optimal dosage. The review of protocols in this paper suggest that singing is an ideal therapeutic medium through which to address speech and voice goals because of the impact of singing and rhythm on neural activation and motor programming, the engagement of the entire speech system during singing, and the significant motivational factors that music brings to the therapy context.

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