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Research Report

Introducing the Beatalk technique: using beatbox sounds and rhythms to improve speech characteristics of adults with intellectual disability

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Abstract

Background: Individuals with intellectual disability (ID) often demonstrate speech impairments and reduced intelligibility. However, traditional treatment methods, which involve using repetitive verbal and non-verbal exercises, may not be fully suitable for this population. As adults with ID tend to lose interest and motivation facing the demands of a typical speech therapy session, other intervention methods are needed. The current study tested a novel intervention technique, Beatalk, based on practising vocally produced sounds and rhythms, imitating the sounds produced by rhythm machines in an a cappella musical context (i.e., human beatboxing). Human beatboxing may be a particularly effective tool since it involves intense production of speech sounds (phonemes) that can be misarticulated in the presence of speech disorders; it is relatively easy to learn and practice, and is also considered 'fun'.
Aims: As many of the features of beatboxing make it a promising method for speech therapy, this pioneering study aimed to examine its effectiveness in comparison with a traditional speech therapy.
Methods & Procedures: Twelve adults with moderate ID and low speech intelligibility (age 24–48 years) participated in a speech therapy group for 6 weeks. Six participants were assigned to the Beatalk (study) group and six to a traditional (control) therapy group. Pre- to post-treatment changes in speech intelligibility and voice measures were assessed.
Outcomes & Results: The preliminary data demonstrate that both types of therapy groups resulted in improved performance in articulation accuracy and voice measures, yet the Beatalk technique yielded larger gains.
Conclusions & Implications: The results present initial evidence for the beneficial effect of the Beatalk technique as an intervention tool for adults with ID. It is an easy-to-use technique in the context of speech therapy, and may enhance verbal communication skills in this population.

Keywords: intellectual disability, speech impairments, speech intelligibility, human beatboxing, Isato Beatbox, Beatalk.

What this paper adds

What is already known on the subject

Speech impairments and reduced speech intelligibility are common among adults with ID. Yet, validated treatment methods for improving the verbal communication abilities of this population are lacking. The current pioneering study introduces a novel therapy technique, Beatalk, based on practising vocally produced sounds and rhythms—human beatboxing.

What this paper adds to existing knowledge

Following a 6-week group intervention, the Beatalk participants showed greater improvement (relative to controls, who participated in a traditional speech therapy group) in articulation accuracy and voice measures.

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What are the potential or actual clinical implications of this work?
These initial results suggest that the Beatalk technique may be suitable for promoting verbal communication of adults with ID. This technique involves relatively intense orofacial exercises, is easy to learn and enjoyable to practise. These features, along with the advantages of group music making, seem to enhance the effectiveness of speech therapy.

Introduction

Intellectual disability (ID) is characterized by below-average intellectual functioning and by significant limitations in adaptive behaviours, such as social and practical skills necessary for daily living (Harris 2006). It is a developmental disability that originates before the age of 18 years, and varies in the degree of cognitive impairment, from mild to moderate intellectual impairment (IQ scores of between 40 and 60), to severe cognitive impairment (IQ < 40). Many individuals with ID do not have specific syndromes but exhibit associated developmental disabilities that reflect central nervous system compromise (Evenhuis *et al.* 2000). These associated developmental disabilities may cause other diseases or impairments. Indeed, children and adults with ID often demonstrate related physical disabilities, such as vision problems, hearing impairments, seizure disorder and cerebral palsy (Harris 2006, Owens *et al.* 2006).

The current study focuses on speech impairments, which are very common among adults with ID (Harris 2006). Although reduced speech intelligibility is prevalent in this population, validated treatment methods for improving the verbal communication abilities of adults with ID are lacking (Terband *et al.* 2018). Given the need for suitable intervention tools, we tested a novel intervention technique, based on practising vocally produced sounds and rhythms: human beatboxing. We assumed that using elements of music-based interventions (Hooper *et al.* 2008) would increase the engagement levels of adults with ID, and thus enhance the effectiveness of speech therapy and treatment outcomes.

Speech impairments among adults with ID

Some individuals with ID fail to develop speech or develop only limited speech abilities (van der Meer *et al.* 2011). Others, with mild to moderate ID, exhibit speech difficulties and their speech intelligibility is low (Cheslock *et al.* 2008, Coppens-Hofman *et al.* 2016). For example, Shriberg and Widder (1990) reported high rates of articulation inconsistency, and reduced prosodic and paralinguistic competence in continuous discourse in a large sample of adults with ID. The rates of speech impairments are estimated at about 80% in institutionalized individuals with severe and profound ID. In non-institutionalized individuals with ID, prevalence of speech disorders is triple that of the general population (Harris 2006).

Speech disorders in ID may result from impairments in different systems required for intelligible speech production. Many individuals with ID present with anatomical characteristics that may adversely affect speech production, such as dysmorphic craniofacial features (Baker *et al.* 2002), malocclusions (e.g., Engleman's Class II and III), and musculoskeletal abnormalities (Winter *et al.* 2008). People with ID typically show poor motor functioning (Eichstaedt and Lavay 1992, Fernhall 1993), including motor control for speech production (Shriberg and Widder 1990). The increased incidence of hearing impairment in the ID population (approximately 10%, and even higher in severely to profoundly intellectually disabled individuals; Harris 2006) may also contribute to their speech problems. The prevalence of combined sensory impairment (both hearing and visual impairments) is also high, especially in adults with severe or profound ID (Evenhuis *et al.* 2001).

Speech intelligibility plays a key role in verbal communication. The low speech intelligibility that characterizes adults with ID has negative implications on the personal well-being of those individuals (Coppens-Hofman *et al.* 2016). Lack of verbal communication may impair social skills, leading to behavioural problems and isolation (Bott *et al.* 1997). As many people with mild to moderate ID integrate into the general society (e.g., the labour market by supported employment), their impaired and misarticulated speech constitutes a barrier that isolates them and limits their social participation (e.g., postsecondary education, independent living and employment settings). Consequently, promoting the ability to communicate verbally is one of the therapeutic goals in rehabilitation programmes of individuals with ID.

Speech therapy for adults with ID

The literature suggests that speech therapy for people with ID can be effective at adult age. For example, in a recent study, Terband *et al.* (2018) investigated the effect of speech therapy in a heterogeneous group of adults with mild and moderate ID with reported poor speech intelligibility. The participants received articulation training and showed a positive effect of treatment on speech intelligibility. The authors concluded that speech skills could improve through dedicated training,

using well-structured exercises (for a relevant systematic literature review, see Snell *et al.* 2010).

Yet, improving speech abilities for adults with ID presents a challenge for both patients and therapists. From the perspective of individuals with ID, improving speech abilities requires contending with cognitive limitations that are often accompanied by behavioural problems (e.g., high levels of frustration, mood swings and challenging behaviours such as aggression; Brown *et al.* 2013), which may reduce cooperation and attention. Take, for example, a traditional speech therapy session. It usually consists of modelling and repetitive verbal and non-verbal exercises, with feedback from the therapist. Clearly, an adult patient who does not have ID can understand the need for therapy and is self-motivated by the treatment results (Grossinho *et al.* 2014). In contrast, adults with ID tend to lose interest and motivation easily, especially when the task at hand is as demanding and challenging as speech production. Hence, many communicative programmes for adults with ID focus on improving language skills, rather than speech intelligibility (Snell *et al.* 2010).

From the therapist's perspective, the speech impairments are often taken for granted and viewed as characteristics of ID, and as such are considered more therapy resistant and less sensitive to treatment. As noted by Terband *et al.* (2018), 'it is often simply accepted that by adolescence people with ID have reached a plateau in learning and continued communication intervention is not seen to have any value' (p. 236). In light of the need for validated and effective tailored treatment methods for adults with ID, we aimed to test a new intervention tool called Beatalk. This music-based technique can be applied in a group setting (such as choral singing), and thus it presents many advantages.

Positive effects of music-based interventions

Musical training benefits have been reported for people with ID in the areas of cognition, physical, and emotional development and communication (Cameron 2017, Hooper *et al.* 2008). Actively making music has been shown to affect positively listening and aural processing skills, literacy skills, auditory memory, spatial reasoning and mathematical performance, intellectual development and creativity (e.g., Cross *et al.* 2012, Fujioka *et al.* 2004, Hetland 2000, Hutchinson *et al.* 2003, Jaschke *et al.* 2013, Roden *et al.* 2014). The benefits of active engagement with music on psychological well-being across the lifespan are also well documented. Music offers the potential for enhanced self-efficacy and self-esteem, improvements in mood and behaviour, reduced anger, and increased motivation (Hallam 2010).

Many adults with ID are socially isolated and have reduced access to community engagement and development of relationships (Walker *et al.* 2014). For these individuals, *group* music-based activities (e.g., playing a musical instrument in an ensemble or singing in a choir) can provide valuable advantages. Collective music-making has been shown to contribute to feelings of social inclusion, belongingness, group identity and solidarity. It supports cooperation, prosocial behaviour, relationships, collaborative learning, taking turns, teamwork and helping others (Hagen and Bryant 2003).

Singing is a type of music-based intervention, and the literature shows consistent support regarding its physical and psychological benefits (Hunter 1999). Relatedly, *choir singing* is a popular group music-based activity, with robust positive effects on various psychophysiological functions, for both professional and amateur singers (Dingle *et al.* 2013). Active participation in choral singing has been associated with benefits for breathing and posture, for the heart and the immune system, and for well-being and relaxation (Clift and Hancox 2001). In addition to these benefits, it has the social advantages of group music-making. Thus, choir singing presents an opportunity for meaningful activity and social connectedness for adults with ID (as well as other disabilities; Dingle *et al.* 2013).

Given these benefits, in the current study, a beatbox choir was designed. Namely, the participants formed a body of 'singers' who practised producing beatbox sounds and rhythms together, as a group.

Human beatboxing

Human beatboxing is an a capella art of producing vocal percussions and non-verbal sounds to emulate musical instruments (De Torcy *et al.* 2014). It is a relatively new urban artform belonging to hip hop culture, starting in the 1980s in New York City (Paroni 2014). Human beatboxing aimed to imitate the sounds produced by rhythm machines, as these machines were very expensive and unaffordable to most of the street artists. Beatbox artists started to reproduce those sounds using their mouths and vocal tracts when accompanying rappers.

The beatbox artist reproduces a variety of instrumental sounds (e.g., drum noises, guitars, trumpet and saxophone) with the vocal cords and mouth (lips and tongue). At the same time, the beatboxer produces a rhythm (by simulating the bass) and other sound effects. This sounds very similar to bands with instruments, although instrumental accompaniment is absent.

Interestingly, many beatbox sounds are speech sounds (phonemes) that can be represented by the International Phonetic Alphabet (IPA). For example, the *kick drum* sound is very similar to the voiceless bi-labial plosive [p]. The *hi-hat* corresponds to the articulation of the voiceless alveolar plosive [t] or the affricative [ts]. These sounds are produced to create musical rhythms, at

different levels of complexity. In the presence of speech production problems, these sounds may be omitted, replaced (i.e., consonant substitution) or distorted. For example, the sound [ts] is often replaced with [s] or [t] or is inaccurately produced (inter-dentally or laterally). The sound [t] may be replaced with [k] in the presence of an a-typical phonological process of backing (Coppens-Hofman *et al.* 2016). Thus, these sounds may serve as intervention targets in speech therapy (Shriberg 1997).

In recent years, beatboxing has gained considerable popularity (Thompson 2011). A variety of beatboxing performances can be found on YouTube and similar websites consisting of user-generated content. Online beatboxing communities (e.g., Humanbeatbox.com, the Beatbox Battle Network) are growing rapidly, serving as a place for beatboxers to share ideas and tips, as well as learn from video tutorials, and compete in international beatboxing competitions. Beatbox is fun to produce and relatively easy to learn (Thompson 2011). These characteristics have led us to consider it as a tool in speech therapy.

The Beatalk technique: using beatbox sounds and rhythms in speech therapy

The need for effective therapeutic tools that can be successfully implemented in speech therapy for adults with ID (and possibly other special populations) has led us to consider the use of beatbox sound and rhythms. Actually, many of the features of beatboxing make it a potential method for speech rehabilitation (as noted by De Torcy *et al.* 2014). For example, beatboxing involves relatively intense, yet safe and harmless, orofacial exercises. It has many of the physical advantages of singing, promoting speech-related skills (e.g., breathing). Beatboxing is easy to learn and enjoyable to practise, suitable for speakers of different languages and low cost. Let us now describe these advantages in more detail.

Intense orofacial vocal exercise

During beatboxing, the laryngopharynx structures move independently, in a flexible yet strong manner, adopting extreme behaviours. De Torcy *et al.* (2014) observed vocal tract behaviours of beatboxers by a fiberscopic imaging. The authors reported that the participants mobilized all their laryngopharyngeal structures separately, suggesting that their laryngopharyngeal system operated at full capacity. Video observations of the beatboxers' faces and necks have shown mobilization of all the facial and neck muscles. Specifically, the lips were constantly active, the cheeks participated very little but remain toned, and the mandible (once in position) was maintained in a fixed position, allowing other articulators to move freely. Similarly, Sapthavee *et al.* (2014) performed functional endoscopic evaluations of the anatomical structures involved in beatboxing and found that beatboxing uses the entire vocal tract (including the pharyngeal constrictors). Proctor *et al.* (2013) analyzed the coordination of glottic and supraglottic gestures in a beatboxer and observed the use of the full range of airflow mechanisms in human languages.

Promotion of speech-related skills

Beatboxing, as a kind of musical vocal art, shares many characteristics with singing. Singing has been recommended as a valuable therapeutic tool to improve speech production in the context of speech rehabilitation (Krauss and Galloway 1982, Lathom *et al.* 1965, Marsh and Fitch 1970, Michel and May 1974, Seybold 1971). It has been found to prompt a louder voice than does speech. Learning how to control the breath to sing a musical phrase may help patients improve their respiratory capacities (Decker and Kirk 1995). Practising songs at different tempos might also improve abnormal speech rates. In addition, exaggerating consonants while articulating song lyrics may help improve speech intelligibility (Cohen 1994). For example, Haneishi (2001) found increases in speech intelligibility and in vocal intensity following a music therapy voice protocol (MTVP), which focuses on vocal and singing exercises for individuals with Parkinson's disease.

Let us now return to beatboxing. Recently, Sapthavee *et al.* (2014: 330), who performed a functional endoscopic evaluation of beatbox artists, noted that 'singers and beatbox artists use similar mechanisms to alter sound'. Indeed, the anatomical structures and positioning involved in singing and beatboxing are comparable. In addition, vocal techniques and coordinated strategies have been found to be similar for both vocal activities (e.g., fine control of pharyngeal musculature to elongate the vocal tract and depress the larynx; Sapthavee *et al.* 2014; hypopharyngeal cavity involvement; De Torcy *et al.* 2014). Most sounds produced by singing (and spoken language) as well as the basic beatbox sounds (that were chosen for the current study) are exhaled sounds.

Clearly, there are some differences between singing and beatboxing. Singers primarily use the vibratory function of the true vocal folds, while many beatbox sounds are non-voiced percussive noises. The mechanisms involved in such sound production most likely rely on control of the oral cavity and oropharyngeal structures. The use of pharyngeal constrictors has been shown to create a longer closed phase, increasing subglottal pressure (Buescher and Sims 2011), which may affect voice characteristics such as loudness and quality. The hypopharyngeal cavity involvement (as a

resonator) also promotes harmonic resonance (De Torcy *et al.* 2014). Airflow production mechanisms also differ between singing and beatboxing, as the latter is characterized by using the full range of airflow mechanisms, including the non-pulmonary egressive (ejective) mechanism (a vacuum in the mouth cavity between the closed glottis and an upper articulation point; Proctor *et al.* 2013). Such behaviours, which characterize beatboxing, may also improve vocal loudness.

Safe and harmless exercise

Although producing beatbox sounds involves broad and intense muscular activity and extreme vocal behaviours, this does not lead to vocal pathology (among neither professionals nor amateurs), and thus it seems harmless. Bourdin and Navion (2013, cited in Paroni 2014) investigated professional and non-professional beatboxers (behavioural investigations and aerodynamic analyses) and reported the absence of chronic vocal pathology among their participants. Possibly this may result from the fact that the percussive sounds of beatbox performance rely heavily on voiceless mechanisms, using the pharyngeal constrictors to create a longer closed phase and increase subglottal pressure (Sapthavee *et al.* 2014). Furthermore, Sapthavee *et al.* (2014) claimed that beatboxing might even protect against glottic injury.

Easy to learn

Currently there is no official method to teach beatboxing, unlike other vocal arts (e.g., classical opera singing). In fact, beatboxers began to teach this new musical form without being formally educated. The lack of an accepted methodology led to learning achieved through imitation and example. Sharon and Bell (2012: 235) referred to beatboxing as 'an aural tradition, best learned and practiced by ear'. As learning to beatbox is based on imitation, it is simple, and can be successfully achieved even by children (e.g., Rodriguez 2016). We suggest that the fact that beatboxing has been successfully taught to laymen by sheer imitation demonstrates its potential as a simple tool in the context of speech therapy for special populations such as adults with ID.

Enjoyable to practise

Practising beatbox is generally considered fun and enjoyable (Thompson 2011). The participant can practice the songs she likes, and the rhythms she prefers, and thus engagement levels are high. As many participants (especially teenagers and young adults) may feel that beatboxing is 'cool' and personally rewarding, meaningful and effective learning can be achieved. Using music-based intervention elements may increase intrinsic motivation (Hallam 2010); that is, performing an activity for the pure enjoyment of the activity itself (rather than its rewarding value, or external stimulants; Ryan and Deci 2000). The Beatalk technique addresses intrinsic motivation by applying music making features to engage people with speech therapy (Hagen and Bryant 2003).

Practising beatbox sounds and rhythms can be done anywhere, anytime. As practice options are diverse (classroom-based, home-based, pull-out, etc.), generalization can be better achieved (Cirrin *et al.* 1995). In fact, much of the practice is achieved through peers in informal everyday settings. For example, a participant in the group (a practice beatboxing 'band' or 'choir') can seek the help of a friend who can make a certain sound that she wishes to be able to produce. Such practice has the abovementioned emotional and social benefits of group music making in general (Hagen and Bryant 2003), and choir singing in particular (Dingle *et al.* 2013).

Cross-cultural nature

An important advantage of the Beatalk technique is its cross-lingual and cross-cultural nature. As described above, beatbox sounds can be found in the sound systems of many languages (Proctor *et al.* 2013). In recent years, beatboxing has become a global phenomenon and is even considered 'a universal language' (De Torcy *et al.* 2014). Thus, learning the beatbox sounds and practising them may be appropriate for speakers of all languages. This is a key advantage in many multicultural and multilingual societies (e.g., Israel, due to its immigrant nature).

The economic viewpoint

Learning to beatbox does not necessitate any professional musical education, and it can be easily achieved via media (internet resources such as YouTube). Practice can be assisted by non-professional providers (e.g., trained volunteers, caregivers) with relatively brief training. Moreover, the required equipment is minimal, reducing possible costs. As practising beatbox can be performed in a group, it may be less costly than individual therapy, thus allowing more treatment to be offered from available staff resources and budgets.

Considering these advantages, we developed the Beatalk technique. This intervention tool is based on a special beatbox learning technique, formed by Isato Beatbox, a leading beatbox artist who has performed worldwide and taught beatbox to children, teenagers and adults for 10 years, and by Mr Elad Schreiber, a musical producer, entrepreneur and Isato's musical partner. In order to adapt the unique beatbox learning procedure to a therapeutic context, a speech–language pathologist (SLP) (the author) joined them. This team used some

beatboxing features (sounds, rhythms), and integrated them with speech therapy methods, creating a novel treatment tool.

The Beatalk technique has two stages: (1) acquisition: learning basic beatbox sounds; and (2) rehearsal: producing these sounds in simple and more complex rhythms. In the current study, we chose the following sounds: the *kick drum* [p], the *hi-hat open* [ts], *the snare drum* [k] and *the snare meshed* [kS], as they represent different articulation places (using different articulators) and different complexity levels (Icht and Ben-David 2015). All are easy to demonstrate by an experimenter and to imitate by a participant. The selected rhythms varied from repeating a certain single sound (simple rhythm, e.g., [p p p]), to repeatedly producing a pair of sounds (intermediate rhythm, e.g., [p-ts p-ts] or [k-kS k-kS]), to creating a sequence of three sounds (complex rhythm, e.g., [p-p-ts p-p-ts] or [k-k-kS k-k-kS]). We assumed that practising the beatbox sounds and rhythms would improve measures of speech production, namely articulation accuracy and voice.

The current study

As verbal communication is the main means of communication for people with mild to moderate ID (Roberts *et al.* 2007), improving their speech intelligibility is essential. This paper describes a pioneering study in which we evaluated the efficiency of the Beatalk technique to improve speech abilities in a heterogeneous group of adults with moderate ID of mixed aetiology. Twelve participants were divided into two groups: Six participated in the Beatalk group and the other six in a traditional speech therapy group. For each group, six weekly therapy sessions were conducted (about 40 min). Each therapy session (day 1) was followed by two short practice sessions (days 4 and 6). We evaluated pre- to post-treatment changes in speech intelligibility (via transcriptions of the practice sessions) and voice measures (by voice recordings of spontaneous speech, responses to simple questions and sustained phonation in the therapy sessions). The following is a detailed description of the study design (the intervention programmes and the assessment procedure) and its outcomes.

Materials and methods

Participants

This study was conducted at Beit Amichai, a modern adult daycare centre in the town of Hod HaSharon in central Israel. It provides comprehensive state-of-the-art, optimized and fully accessible facilities for adults with developmental disabilities of various types and levels. Beit Amichai's programme provides various rehabilitative activities, e.g., speech therapy (focusing on communication abilities, augmentative and alternative communication, feeding and swallowing), physical therapy, music therapy, occupational therapy, art therapy, behavioural management (behaviour modification), and multisensory therapy (a 'snoezelen' room). The work plan is governed by personal annual goals tailored to each individual according to his/her needs.

The daycare centre is operated by Amichai, a nonprofit Israeli association that provides services throughout the lifespan for the welfare of people with developmental disabilities. The recipients of the services of Beit Amichai are categorized by the Ministry of Welfare and Social Services as having medium to low functioning levels (moderate to severe mental retardation, coupled with physical disabilities). Currently, the daycare centre provides services for 42 adults.

The study was approved by the university ethics committee. Inclusion was based on the level of speech impairment. The main exclusion criterion was the presence of severe behavioural problems. The SLP of the daycare centre identified 17 participants as verbal, yet with low speech intelligibility. The parents or legal representatives of these potential participants received written information regarding the study, and 12 gave their written consent.

Twelve adults with ID (age range 24–48 years; mean of 30 years; five men) participated. The participants were given oral information about the study and invited to attend the intervention programmes. All the participants gave their oral consent. The participants formed six pairs, with pair members matched for functioning level (cognitive impairment severity) and speech abilities. One member of each pair was randomly assigned to the Beatalk group; the other member was assigned to the control group. A detailed description of the participants is provided in table 1. A paired samples *t*-test confirmed that the participants' age did not differ between the intervention groups ($p = .20$), and a pair of chi-square tests indicated that gender and ID severity did not differ between the groups ($p > 0.9$ for both).

Since we assumed that the Beatalk technique was an effective intervention tool, we wished to provide it to all participants, avoiding a deferral of therapy from the control group participants. Therefore, at the end of the study, participants in the control group also received the Beatalk intervention.

Procedures and experimental design

Treatment team

The Beatalk technique is novel and was implemented for the first time in the current study. Given the uncertainty about how best to implement the intervention (e.g., sounds to be focused on, appropriate rhythms), and

Table 1. Participants' data and speech–language pathologist (SLP) evaluations

Group	Age (years)	Gender	Severity of the intellectual disability	Cause of the intellectual disability and other problems	Expressive language level
Beatalk	48	Male	Mild	Down syndrome, hypothyroidism, instability, lung infections	Short sentences, can read; speech disfluencies
	25	Female	Mild to moderate	Anxiety disorder, prematurity	Short (simple and compound) sentences
	27	Female	Moderate	Developmental coordination disorder, impaired vision	Short and repetitive utterances
	25	Male	Moderate	Psychomotor unrest, attention-deficit hyperactivity disorder (ADHD)	Complex sentences, avoids eye contact
	32	Female	Moderate	Epilepsy, gastritis, impaired vision	Two-word utterances, very soft voice
	33	Female	Moderate to severe	Anxiety disorder, ADHD, impaired vision	Short (simple and compound) sentences
Control	26	Female	Mild to moderate	Epilepsy, hypotonia, obesity	Complex sentences
	37	Male	Moderate	Anxiety disorder with compulsive characteristics, tantrums, behaviour problems, short attention span	Single and two-word utterances, echolalia
	31	Male	Moderate	Cleft palate, spastic tetraplegia, epilepsy, eye-focusing problems (taking drugs for epilepsy and psychiatric drugs)	Complex sentences
	25	Female	Moderate	Hand tremor, behavioural problems, ADHD	Short sentences, dyspraxia
	27	Female	Moderate	ADHD, poor cooperation in some activities, reflux	Compound and complex sentences
	24	Male	Moderate to severe	Whole-body dysmorphism, left hypotonia, Failure to thrive (FTT), scoliosis, microcephaly, ptosis correction, hearing impairment, itching	Very few words, dysphonia

Table 2. Description of the intervention target sounds

Target sound effect	Beatalk program (standard beatbox notation description)	Control (International Phonetic Alphabet—IPA) description)
The *kick drum*	[p]	[p’]
The *hi-hat open*	[ts]	[tsː]
The *snare drum*	[k]	[kxː]
The *snare meshed*	[ksh]	[kʃː]

in order to adapt spontaneously certain elements of the technique to the immediate needs and specific abilities of the participants, it was important that it be delivered by a team of experienced experts. This professional treatment team included an experienced SLP (the author) and Isato Beatbox, a beatbox artist.

Treatment procedures

One week before the beginning of the intervention, a preliminary introductory meeting was arranged in order to familiarize the participants with the treatment team, the recorder and the setting. The following week, the Beatalk intervention programme began. For reasons of logistics and time management, the control group began only after the Beatalk group ended.

All participants received treatment for a period of 6 weeks. Each weekly individual session lasted 40 min. All sessions were conducted at the daycare centre, in a quiet, comfortable room with which the participants were familiar.

Beatalk sessions. These were delivered by the treatment team. The team members were accompanied by the SLP of the daycare centre (who knew the participants and their speech abilities), a research assistant (RA; an SLP student who assisted in voice recordings and later data analysis), and two to three volunteers (caregivers from the daycare centre staff, who ensured the cooperation of the participants). The treatment involved the acquisition of basic beatbox sounds (see table 2 for a description), and practice (production of target sounds in different rhythms, from simple to complex). Each session consisted of 5 min for baseline recordings (as will be detailed below), 15 min of repetition of the sounds and rhythms of the previous sessions (each participant separately, and then all together in a ‘band’), 15 min of learning and practising new sounds and rhythms (separately and together), and 5 min of practising (as a ‘band’) using a familiar song. Figure 1 illustrates the activities in a typical Beatalk session (individual and group practice with Isato).

Figure 1. Visual illustration of the individual and group practice with Isato in a typical Beatalk session. [Colour figure can be viewed at wileyonlinelibrary.com]

Control sessions. The same team members (SLPs and accompanying staff), without the beatbox artist, delivered these sessions. The treatment involved specific articulation training (the target phonemes matched the Beatalk sounds) (table 2) in isolation, and in word-initial, word-medial and word-final positions in mono- and di-syllabic words. The structure of the sessions was similar to that described above: 5 min for baseline recordings, 15 min of repetition of the sounds and words of the previous sessions (using card games, domino, etc.), 15 min of practising new sounds and words and 5 min of recapitulation.

Practice sessions

Following each therapy session, two weekly practice sessions were performed (on days 4 and 6), in which each participant practised the learning material for 3–5 min individually, with the daycare centre SLP. For the Beatalk group, practice was performed using a short video clip (about 30 s). The participants watched it using an iPad (several times), and then repeated the rhythms. For the control group, practice was performed using printed pages with the coloured pictures of the target words used in the most recent therapy session. Since all participants needed 24/7 supervision, they were always accompanied by a staff member (a therapist or volunteer), who prevented exposure of the control group participants to the Beatbox exercises.

Dependent measures and analysis

The pre- to post-treatment changes were assessed in terms of articulation accuracy and voice measures.

Articulation accuracy

Transcriptions of the verbal output of each participant on each practice session were performed according to broad phonetic transcription procedures (by the daycare centre SLP). Two independent RAs (SLP students, blinded for both study goal and participants' group assignment) coded and scored the transcriptions, according to the accuracy of repetition of the target utterance, on a four-point scale (the judgment criteria were defined in a detailed manner, to avoid subjectivity: 0 = unable to repeat the target utterance, 1 = repeats a single sound or a syllable, 2 = repeats two successive sounds or syllables, and 3 = a full and accurate repetition of the target utterance). A comparable four-point scale was suggested by Lousada *et al.* (2014) in a recent study to measure intelligibility of children (see also McLeod *et al.* 2012). The mean score for each participant in each practice session, and the mean group scores were calculated.

Voice measures

At the beginning of each of the treatment sessions, voice recordings of spontaneous speech, responses to simple questions and a prolonged [a] vowel were conducted. Recordings were made using a high-quality digital recorder (Olympus Europa SE & Co. KG; VN-8500PC). It was held about 5 cm from the speaker's mouth and slightly tilted toward the speaker (following Icht and Ben-David 2018).

The recordings were analyzed using Praat software (Boersma and Weenink 2017) for the following parameters: (1) vocal loudness of speech and of sustained phonation (sound pressure level, dB); (2) vocal

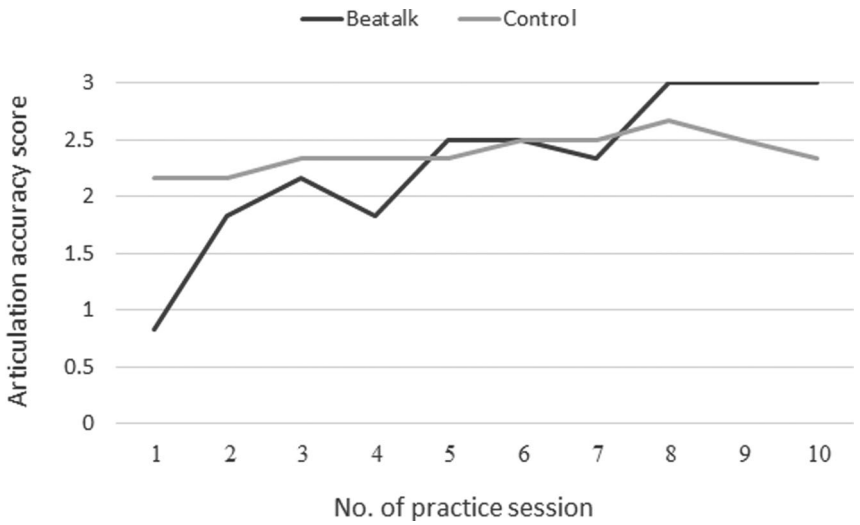

Figure 2. Articulation accuracy scores across the practice sessions for both groups.

shimmer, i.e., the cycle-to-cycle variability of the period amplitude of vocal cord vibration of the sustained phonation (%); and (3) harmonic-noise ratio (HNR, the ratio of the acoustic energy of the harmonic components to that of the noise) of the sustained phonation (dB). Mean group values for each measure were calculated.

For the voice measures, we also calculated a simple version of improvement rates (IRs), from baseline to intervention. This non-parametric measure is suitable for evaluating the size of intervention effects in the current design (for a detailed description, see Soto and Clarke 2017). Typically, the IR is calculated by dividing the number of 'improved data points' in a phase (either baseline or intervention) by the total number of data points in that phase. In our analysis, during the intervention phase (sessions 2–6), data points were considered improved if they exceeded the baseline data points (gauged in the first intervention session). Tentative benchmarks have been suggested to interpret effect sizes provided by the IRs (questionable $< .5$, effective .5–.7, very effective $> .7$). The IRs were obtained for each participant in each group for all vocal measures.

All the above analyses were conducted by two independent RAs, blinded for the study goal and participants' group assignment. Owing to a technical problem with the digital recorder, the voice recordings of the third intervention session were of poor quality and were removed from final analyses.

Evaluating the degree of functional improvement

As the articulation accuracy was rated on a scale of 0–3, taking the mean of ordinal data makes the interpretation of the results specific to this scaling. To assess and compare the efficiency of the intervention programmes in a more general manner, we used the articulation accuracy rating scale as a continuous measure to calculate the actual degree of functional improvement over time. Such an approach also enabled us to overcome possible biases related to pre- and post-treatment individual differences that characterized our sample.

We calculated a logarithmic trend line for each participant (the logarithmic trend line was best suited to the individual findings, $R^2 = 0.91$ for the Beatalk group), according to the following formula:

$$y = k * \ln(x) + b$$

We used the values of the coefficient k (averaged across participants in each group, for each of the tested variables) as a measure of the degree of improvement over time.

Results

Articulation accuracy

Transcriptions of the practice sessions were used to gauge articulation accuracy scores (0–3) along the practice sessions. Figure 2 shows the results of the articulation accuracy scores across the practice sessions for both groups. It reveals that the Beatalk group improved from a mean score of 0.83 to a mean score of 3.00 (the maximum score), $k = 0.88$ (this coefficient represents the slope or the degree of improvement over time). The control group showed a lesser improvement, from 2.16 to 2.33, and a smaller $k = 0.16$. A t-test confirmed the difference between the k-values of both groups, $t(5) = 7.96$, $p = .0002$.

To account for the high variance within and between groups, we averaged the articulation accuracy scores

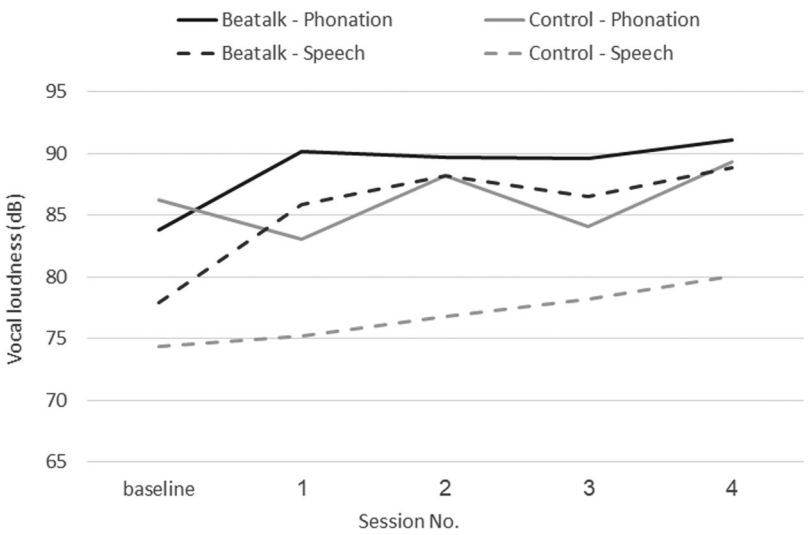

Figure 3. Vocal loudness (dB) for speech and for sustained phonation (the vowel /a/) for both groups across the therapy sessions.

for each participant across pairs of successive practice sessions (numbers 1 + 2, 3 + 4, 5 + 6, etc.). Next, we conducted a mixed-model repeated-measures analysis of variance (ANOVA) Generalized Linear Model (GLM) with mean articulation accuracy scores (averaged across two sessions) as the dependent variable, and group assignment (Beatalk or control) as a between-participant variable. Analysis showed a significant linear trend across groups, indicating an improvement in performance along the sessions, $F(1,10) = 22.5$, $p = .001$, $\eta_p^2 = .69$, which interacted with group, $F(1,10) = 10.9$, $p = .008$, $\eta_p^2 = .52$, with no main effect for group, $F(1,10) = .56$, $p = .7$. To clarify this interaction, separate tests were conducted for each group. The analysis indicated that the linear trend for session was significant for the Beatalk group, $F(1,5) = 23.4$, $p = .005$, $\eta_p^2 = .82$, but not for the control group, $F(1,5) = 1.7$, $p = .25$.

In sum, whereas the average scores in the first two sessions did not differ between the two groups, $t(10) = 1.92$, $p = .08$, in the final two sessions, performance of the Beatalk group was superior to that of the control group, $t(10) = 2.9$, $p = .01$.

Voice measures

Vocal loudness

Figure 3 shows the vocal loudness values (dB) for speech and for sustained phonation for both groups. It reveals that the Beatalk group mean loudness level improved from 77.9 to 88.8 dB for speech production ($k = 4.96$, IR = .91), and from 83.8 to 91.08 dB for phonation ($k = 3.07$, IR = .91). These IRs are indicative of *very effective* intervention.

The control group showed a smaller increase in vocal loudness along the therapy sessions, from 74.4 to 80.06 dB for speech production ($k = 2.43$, IR = .53), and from 86.25 to 89.28 dB for phonation ($k = 1.33$, IR = .6). The differences between the *k*-values of both groups were not significant (*p*s > .05).

Vocal shimmer

Figure 4 shows the percentage of vocal shimmer (the cycle-to-cycle variations of waveform amplitude for sustained phonation) for both groups. Lower shimmer values represent more stable voice quality. Figure 4 reveals that the Beatalk group improved from 6.59% to 2.8% ($k = –0.021$, IR = .83), while the control group showed a smaller and unstable decrease in vocal shimmer along the therapy sessions, from 5.85% to 4.4% ($k = –0.012$, IR = .5; the difference between the *k*-values of both groups was not significant, $p > .05$).

HNR

Figure 5 shows the HNR values (the ratio of the energy of the harmonic part to the energy of the remaining part of the signal, dB) for sustained phonation for both groups. For example, an HNR = 0 dB means that there is equal energy in the harmonics and in the noise. As HNR values are higher, the voice quality is perceptually better. Figure 5 shows that the Beatalk group improved from 14 to 17 dB ($k = 4.19$, IR = .55), while the control group showed a smaller and less consistent pattern along the therapy sessions, from 13.63 to 14.41 dB ($k = 0.65$, IR = .5; the difference between the *k*-values of both groups was not significant, $p = .09$).

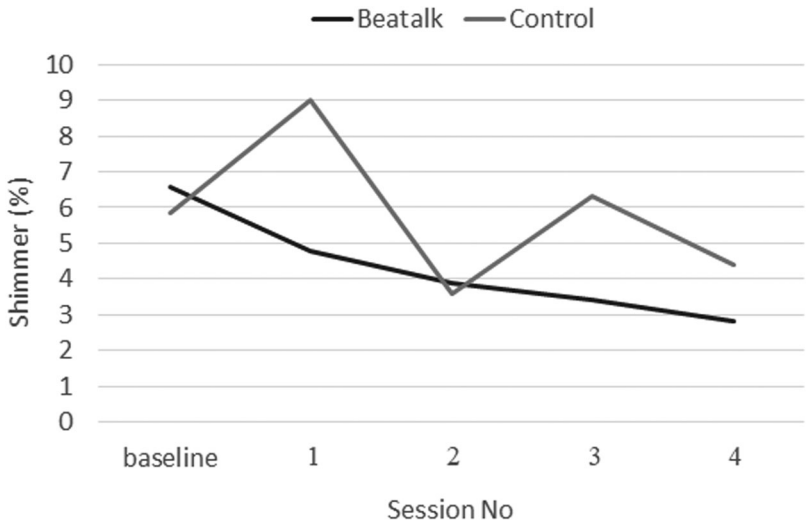

Figure 4. Percentage of vocal shimmer (in sustained phonation) for both groups across the therapy sessions.

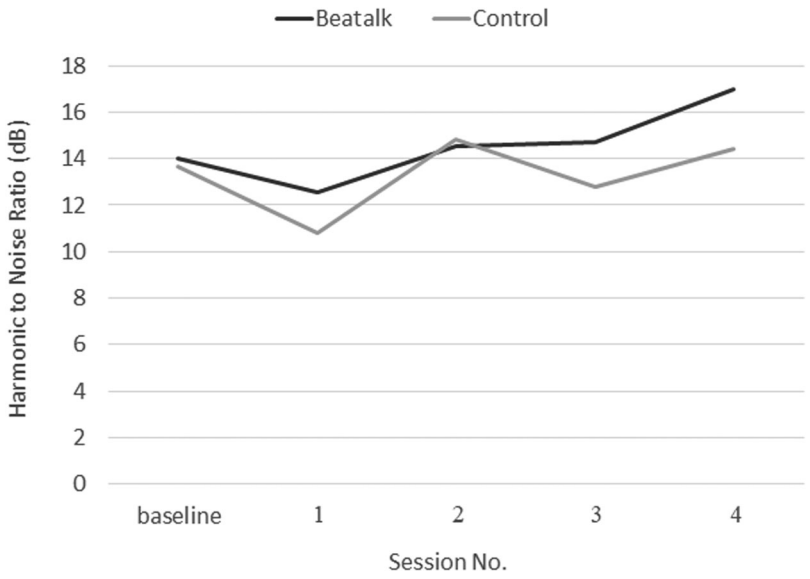

Figure 5. Harmonic-noise ratios (HNR—for sustained phonation, dB) for both groups across the therapy sessions.

Examining the efficiency of the Beatalk technique using a binomial model

Exploring available data, and in order to gain an estimate of the Beatalk technique effect, we employed a binomial model, assuming that the outcome measures could be reduced to a simple dichotomy (e.g., above or below a particular value). Following this rationale, the scores of the five measures (articulation accuracy, voice loudness for sustained phonation and speech, shimmer and HNR) could be described as binomial variables, where each measure had two possible outcomes: success or failure (Thornton and Raffin 1978).

The binomial test evaluates the probability of receiving positive results (success scores) from all five measures. The resulting score of a binomial test is $p = .03$. In other words, the probability of a success in *all* measures differs from the probability that these results are purely due to chance (0.5), demonstrating the efficiency of the Beatalk technique.

Next, we assigned each participant a score of 0 or 1 in each of these five variables, where 0 represents a failure (no improvement) and 1 represents a success, according to the criteria listed in table 3.

The data revealed that all participants in the Beatalk group improved in at least one of the measures, with four out of the six participants improving in more than half the measures. In contrast, in the control group, five out of six participants either did not improve or improved

Table 3. Definitions of 'successes' in each of the tested verbal communication measures

Verbal communication measure	Success
Articulation accuracy in the practice sessions	>1 point between the first and the last two sessions
Loudness of voice – sustained phonation	>4 dB (a noticeable difference) between first and last sessions
Loudness of voice – speech	
Vocal shimmer	>3.7 dB at the first session, <3.7 at the last session
Harmonic-noise ratio	<15 dB at the first session, >15 dB at the last session

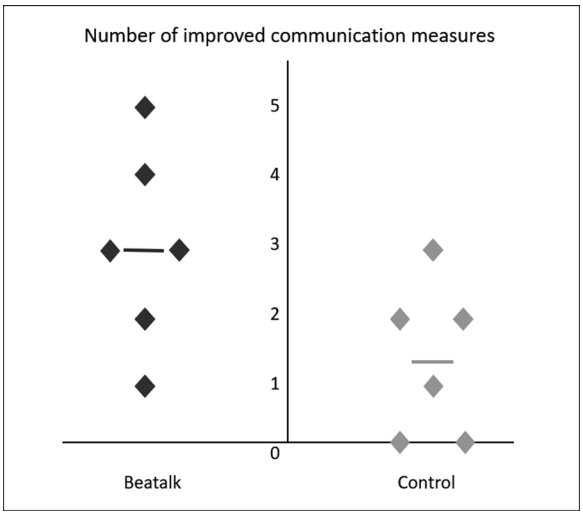

Figure 6. Total number of improved measures for the Beatalk and control participants (diamonds represent individual participants; horizontal lines represent group means).

in less than half the measures. Visual depiction of this individual level analysis is presented in figure 6.

Discussion

Adults with ID often have problems with verbal communication and speech. Their speech intelligibility is low, and multiple errors at the phonemic and syllabic level occur (Coppens-Hofman *et al.* 2016). Currently, there is a lack of validated treatment methods to improve speech production and intelligibility of adults with ID (Terband *et al.* 2018). The development of interventions for improving the speech output in this population is essential, as by improving their speech, one can improve communication abilities in general, and overall quality of life (Bott *et al.* 1997). In light of this need, in the current study we introduced a novel speech therapy intervention technique, Beatalk, based on vocally producing and practising beatbox sounds and rhythms.

We used this technique in a group-therapy setting, designing a beatbox choir. Choir rehearsals provide the opportunity for members to form an additional social support group and an additional social identity. According to social identity theory (Tajfel and Turner 1986), forming a new and valued group identity (as a choir member) is associated with emotional and health benefits for the participants (Clift *et al.* 2010). Articulation practice within the beatbox choir can be seen as a more enjoyable version of traditional intervention methods, as the same target sounds are produced as part of a musical theme rather than as mere repetition. The implementation of music-based intervention elements into speech therapy may help make the therapy sessions more entertaining, and thus increase participants' motivation to practise the therapy exercises, resulting in more effective therapy.

We tested the effectiveness of the Beatalk technique in improving the verbal communication skills of a group of adults with moderate ID, compared to a 'traditional' speech-therapy intervention delivered to a matched control group. Treatment was delivered for 6 weeks, 40-min weekly group therapy sessions, each followed by biweekly practice sessions.

Results indicate improvements on speech variables in both treatment groups. Yet, on several variables, one can observe a marked increased improvement for the Beatalk over the traditional intervention. First, articulation accuracy increased to a larger extent in the Beatalk group, as the participants produced the target items (beatbox sound and rhythms in the practice sessions) in a more accurate and full manner, relative to controls (who produced the same sound in the context of single words). For example, at the beginning of the programme, some of the participants did not close their lips while producing the phoneme [p] but rather produced it in a labio-dental manner. Along the Beatalk therapy and practice sessions, which required a strong lip seal to produce the kick-drum sound, it appeared that the function of the lips improved, and the participants successfully produced this sound in a bi-labial accurate manner. An improvement in the articulation of this sound was also noted for the control participants, yet to a lesser extent.

Second, in all the tested voice measures (vocal loudness, shimmer and HNR, in spontaneous speech and in sustained phonation), the Beatalk intervention led to a larger increase in scores than did the traditional treatment. The Beatalk participants showed increased vocal loudness along the sessions, with high *k*-values and very high IRs (indicative of a *very effective* intervention). In contrast, the control participants showed lesser improvement, with medium-sized IR scores (which are indicative of an *effective* intervention), and low *k*-values, denoting only a moderate gradient over time. Vocal shimmer also

improved to a larger extent in the Beatalk group relative to the control group. Importantly, the mean final value for the Beatalk group (2.8%) is considered within normal range for healthy speakers (<3.69%; Maryn *et al.* 2009).

Taken together, the overall supportive nature of the current findings suggests that the Beatalk technique can be an effective tool in improving speech abilities for adults with ID. These results are in accord with recent evidence by Terband *et al.* (2018), who concluded that speech therapy for people with ID can be effective at an adult age. Coppens-Hofman *et al.* (2016) also posited that continued attention to speech could help augment verbal communication skills in adults with ID.

Evaluating the Beatalk technique, another important issue is that of motivation and engagement. Throughout the sessions, the treatment team and staff members' impressions were that most participants were very interested in the beatbox sound and rhythms. They were well motivated throughout the intervention, eager to start the weekly session, and to participate in the biweekly practice sessions. If a session was postponed (e.g., due to a holiday), the participants expressed their disappointment. In fact, the daycare staff members had to 'hide' the practice beatbox video-clips from the participants of the control group, who expressed their desire to watch them with the Beatalk participants. The Beatalk participants initiated 'informal' opportunities for practice in many everyday contexts. Such practising on multiple everyday contexts, the time available for teaching and the opportunities for learning could be dispersed throughout the day, within frequently occurring activities and events. In addition, multiple communication partners (besides the SLP) were involved in practising in various settings. We assume that the high levels of interest and motivation contributed to the success of the treatment.

Obviously, not all participants showed similar enthusiasm. One of the participants in the Beatalk group did not fully cooperate during the weekly sessions. Although he had relatively good language abilities, he refused to repeat the target sounds, producing various other types of vocalizations (mainly humming and vowels) in their stead. Nevertheless, he often practised the target sounds and rhythms on his own, activated the iPad with the practice video clips and practised independently or with one of the daycare volunteers. Hence, it seems that limited cooperation in the group meetings does not require exclusion from the group. Of course, the extent to which members are suited to the therapy group should be considered according to their personal preferences and interests and their ability to function in a group setting (e.g., given the presence of emotional and behavioural problems).

Limitations and future directions

As this study was the first of its kind, the generalizability of its results may be limited by several factors. First, the study involves a relatively small sample of participants. As a result, it is limited in its ability to draw general conclusions, and the preliminary findings must clearly be corroborated by further studies of much larger groups. Second, due to the small sample size, there were many factors that were not controlled, for example, aetiology of ID, comorbidity, hearing level, etc. Third, due to logistics, no follow-up session was conducted. Further research to assess directly long-term effects with measures of speech and communication is warranted. Another limitation concerns the practice sessions transcriptions. These were performed by the SLP of the daycare centre, who was not blinded (i.e., she knew the allocation of participants, and actively participated in the study sessions, Beatalk as well as control). She was the only SLP who worked in the daycare centre, and thus the practice sessions took place during her working days. No other staff members had sufficient knowledge in phonetics to perform the transcriptions in a full and accurate manner (note: those who coded and scored the transcriptions were blinded). To avoid bias due to knowledge of allocation and expected benefits of the Beatalk technique, future studies should blind those responsible for transcriptions. Finally, the treatment schedule implemented in this study was relatively shorter than the treatment typically provided in clinical practice. A longer intervention period is called for in future studies.

An important aspect of therapy lies in the degree of its ability to enhance skills in other domains, or *skill transfer*. Skill transfer can be classified into two types: (1) 'near transfer' effects, when there is a close resemblance between training and transfer domains; and (2) 'far transfer' effects, when the relationship between the training and transfer domains is less clear (Hallam 2010). The aforementioned short-term improvements in articulation accuracy and voice parameters along the Beatalk sessions can be taken as near transfer effects. Yet, our measure of articulation accuracy focused on the practice sessions (within the context of single words or beatbox sounds and rhythms). Future studies should assess changes at higher levels of the phonological and verbal hierarchy and far transfer effects (e.g., gains in single word intelligibility, picture naming, and spontaneous speech).

In evaluating the efficacy of an intervention, far transfer effects are also relevant, as these demonstrate gains in other abilities, not identical to the intervention or practice tasks (Henry *et al.* 2014). Some preliminary evidence that the Beatalk technique may produce far-transfer effects may be found in within- and post-study personal impressions of the staff members of the

daycare centre. During the course of the intervention, the staff members (teachers, volunteers) reported noticeable improvements in the everyday communication abilities of the participants of both groups (although enhancing communication was not the goal of the intervention). This may warrant systematic evaluation in future studies.

Upon completion of the study, we can assume that a decisive component in increasing the Beatalk technique's effectiveness may be the participants' high engagement and motivation levels, due to its enjoyable nature. As expected, during the Beatalk sessions a 'learning community' was formed, with obvious social benefits. The participants encouraged each other, and tended to turn to each other for support, feedback and connection. Although the practice sessions were conducted separately with each individual (in order for the SLP to document accurately the vocal productions of each participant), the participants initiated other opportunities for group practice and enjoyed practising together, as a 'band'. Future research may directly address this point, assessing engagement levels and motivation (e.g., the client's active involvement, expression of interest and seeking of information).

From the cognitive perspective, the active engagement with music in a group involves many skills associated with executive functioning, such as sustained attention for long periods of time, goal-directed behaviour, and cognitive flexibility to keep musical passages in working memory or encode them into long-term memory (Hallam 2010). In light of these advantages, assessing possible effects of the Beatalk technique on working memory is also called for in future studies. Some researchers have suggested that the speech difficulties of individuals with ID may stem from a phonological delay, or from functional limitations in the phonological loop of the working memory system (Schuchardt *et al.* 2011, Van der Molen *et al.* 2007). Possibly, repeating the sequences of beatbox sounds, from simple to more complex, may serve as a working memory training strategy. During the therapy sessions as well as the practice sessions, we noted considerable individual differences in the ability to accurately repeat a given sound sequence (regardless of the ability to correctly produce a single sound). For example, some of the participants produced a sequence in reversed order. Working memory training can be used as a remediating intervention for individuals for whom low working memory capacity is a limiting factor for academic performance or in everyday life, that is, individuals with ID (Klingberg 2010).

The positive results of the current pioneering study, and the benefits of the Beatalk technique, may guide future studies with other populations (e.g., teenagers and adults with mild ID; individuals with speech disorders due to craniofacial defects, such as cleft palate or Cerebral Palsy). In addition, it is important to verify that less experienced professionals can successfully deliver the Beatalk technique with similar benefits, establishing the validity of the technique and the ability to easily adopt its principles in typical clinical settings.

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