Speech Rehabilitation in Parkinson’s Disease

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ABSTRACT
The purpose of this review was to evaluate the different speech therapy approaches for persons with Parkinson’s Disease (PD). Treatment methods reviewed include speech therapy (LSVT), pharmacological therapy and deep brain stimulation (DBS). Recent research data show that speech therapy has proven to be the most effective therapeutic strategy for improving voice and speech function. Pharmacotherapy or DBS methods not combined with speech therapy do not appear to significantly improve voice and speech function in PD across research studies. Possible explanation for this results is that LSVT is the major tool for speech rehabilitation in patients with PD. Research data comparing the efficacy of LSVT LOUD and LSVT ARTIC have confirmed the advantages of LSVT LOUD for the speech therapy in patients with PD

INTRODUCTION
Parkinson’s disease (PD) is a chronic progressive neurodegenerative disorder with an increasing incidence worldwide. PD is characterized by the idiopathic loss of dopaminergic neurons, primarily in the anterior part of the substantia nigra[1]. The main symptoms of PD result from significantly reduced activity of dopaminergic neurons in the pars compacta region of the substantia nigra[2]. There are several pathways in the brain connecting other brain areas with the basal ganglia: motor, oculomotor, associative, limbic and orbitofrontal pathways. All these tracts are affected in PD, and their dysfunction explains many of the symptoms of the disease since these pathways are involved in different functions including motor activities, attention and learning. The motor pathway has been examined more intensively than other tracts. The model of motor pathway alteration in PD has been studied extensively for the last three decades, although some aspects of the model and the hypothesis as a whole have been challenged which have led to various modifications. According to this model, the basal ganglia normally inhibits a number of motor systems, preventing them from becoming inappropriately active. When a motivation or decision is made to perform an action, inhibitory influence is reduced for the target motor system, facilitating the activation. Dopamine has a major role in such inhibition, so high levels of dopamine can promote motor activity, whereas low levels of dopamine require greater effort for any given movement. This mechanism- dopamine depletion is the cause of hypokinesia and reduced motor output. Pharmacotherapy of PD is aimed to induce excessive dopamine activity, prevent the activation of motor systems at inappropriate times and thereby prevent dyskinesias.

Almost two centuries ago, J. Parkinson first described the disease that bears his name. There are various etiological factors in PD. Age is the most evident risk factor and the genetic predisposition second. This explains the increase in prevalence of Parkinson’s disease with age. PD reduces the life expectancy and in few decades the neurodegenerative disorders will be the main cause of mortality in elderly, surpassing cancer.
Results of clinical trials showed that PD has higher incidence after the age of 50. Less than 10% of patients manifest symptoms before the age of 40[9]. On the other hand the prevalence of the disease decreases after 65 years of age and in persons over 80 is not more than 1%.

PD symptoms are classified as motor and not motor. The motor symptoms include: resting tremor, bradykinesia, muscular rigidity, and postural impairment. Non motor (non-dopaminergic) symptoms of PD are various: disorders of mood, behavior, cognition and a speech disorder characterized as hypokinetic dysarthria[10]. Sustained vowel phonation in PD is measured by the basic frequency or pitch of vocal vibration, extent of voice range variability (jitter), the extent of expiratory flow changes (shimmer), and the noise amplitude relative to normal speech tone. Voice onset time (VOT) is also used to evaluate speech in PD. VOT is the period from articulation of a stop consonant to the pronunciation the following vowel[11]. All these measures or parameters are changed in PD differently and have specific alteration pattern.

The jitter or extent of voice variation represents the variability of the speech basic frequency (characterized also as pitch period) from one cycle to the next[12]. It could be characterized also as short-term perturbations (from cycle-to-cycle) in the basic frequency of the voice[13]. The shimmer is the extent of expiratory flow variation typical for each vocal cycle. It is a cycle-to-cycle, short-term fluctuations in voice amplitude[14]. Resonance is defined the selective augmentation of certain frequencies using induced vibrations in the chest, pharynx, and head sinuses[15].

### SPEECH PARAMETERS

Articulation is one of the main parameters in speech. It is the pronunciation process of consonants and vowels, where lips, tongue, palate, and pharynx have a key role. The process is controlled by the laryngeal stops and initiation of phonation to pronounce voiced and unvoiced sounds[16]. The easiest method to analyze the articulation is the diadochokinetic (DDK) task. The DDK task analyzes the ability to repeat a combination of a consonant and a vowel (C-V combination) with both lips pronouned. The patients have to pronounce keeping the tongue against back of the upper teeth (alveolar), or pronounce keeping the tongue against the soft palate (velar) in a rhythmic manner. Subjects are required to repeat three-syllable item (usually ‘pa/-/ta/-/ka/) as fast and long as possible.

Prosody is another parameter studied in patients with PD. It is the variation in loudness, pitch, and timing of the speech. 13 Prosodic parameters are characterized as fundamental frequency, intensity (loudness), rate of articulation, characteristics of pause, and the rhythm of speech.

Asthenia is the measure of strength of voice. It is most often measured by the subjective GRBAS scale (Grade of Dysphonia, Roughness, Breathiness, Asthenia, Strain)[9].

### CHANGES OF SPEECH PARAMETERS IN PD

The vocal changes in PD are influenced by different factors. PD patients usually speak in a soft, monotone. This monotone speech is perceived as normal by the patients. The patients lack a feedback into account to identify motor speech processes, and to understand the influence of brain dysfunction not only on voice, but also on articulation[10].

A special voice therapy called Lee Silverman Voice Treatment

### COMPARATIVE EFFICACY OF PD TREATMENT BASED ON VOICE AND SPEECH IMPROVEMENT IN PATIENTS.

Acoustical voice analyses can provide useful information for the diagnosis of PD in different stages of the pathology, for continuous monitoring of patients, but first of all, for providing a sound feedback in voice treatment for therapists[10].

The significant impact of task on speech motor parameters was evaluated. The task used to analyze voice disturbance must be taken into account to identify motor speech processes, and to understand the influence of brain dysfunction not only on voice, but also on articulation[10].

A special voice therapy called Lee Silverman Voice Treatment...
(LSVT) has been studied in several trials and was shown to be an effective tool for the alleviation of hypokinetic dysthria. It affects the increased amplitude of motor output during speech production by applying increased vocal cord efforts and loudness, and in this way helps the patients to modulate their vocal output[12]. The trials have revealed statistically significant efficacy of this method on speech pathology in individuals with various stages of PD. The effects of LSVT usually last not less than 2-3 years. The obtained data showed that this methodology improves also swallowing, articulation, improves communicative gestures, neural functioning and facial expression[13]. Further efforts of researchers are aimed to develop a computer-based LSVT program which can increase the efficacy of treatment[14].

All mentioned trials had derived some common conclusions and recommendations for the application of LSVT in patients with PD. The first conclusion stated that LSVT can yield long lasting effects on the speech of patients. The second conclusion stresses that the method targets different systems that use the same muscles and nerves to produce speech and ensure the swallowing. In this the method can result in high efficacy for voice and swallowing recovery[13].

Deep brain stimulation of the subthalamic nucleus (DBS-STN) results in dramatical improvement of overall motor functions of the limbs. It effectively reduces tremor, but shows not stable results in speech rehabilitation. several studies that were focused on the efficacy of DBS in patients with PD have shown controversial results. Some of them have reported speech problems as side effects in patient receiving DBS after implantation. Others mentioned no changes in speech disturbances, and the third group has revealed an actual improvement. This diversity of results are most likely secondary, such as lesions induced by stimulating electrodes, difference in the stage of PD, different disease pattern in studied patient groups[13].

The studies have reported also high efficacy of DBS when changing the settings of stimulation and selecting zones away from motor control centers. A number of studies emphasize the differences within an individual in the effects of stimulation on the two speech subsystems. These findings should temper global statements about the effect of neurostimulatory implants on Parkinsonian patients. They also emphasize how important careful consideration of individual differences may have on the effect of deep brain stimulation on different subsystems of speech[16]. DBS affects the respiratory and laryngeal control not similarly. High-frequency stimulation results in respiratory overactivation which results in excessive closure of vocal folds. On the contrary low frequency stimulation has more beneficial influence. According to the statement of the authors the most important aspects in the rehabilitation of PD patients are not only the difference between high- versus low-frequency stimulation, but also between speech and limb function[17].

Electrical stimulation of the subthalamic nucleus aims to modulate the activity of the basal ganglia. The method is rather effective in the motor recovery, but in general does not affect the speech pattern. In the same way the pharmacological therapies (levodopa) are not as effective for speech as they are for motor functions.

These data underline differences in the relationship between speech and nonspeech motor control systems in PD and point out the complex input of these factors. DBS may have different effects on different components of motor speech processes in different and in some cases even in an opposite way. All these arguments make it rather difficult to compare effects of DBS on various elements of motor speech[18,19]. This difficulty is due to the complex pathogenesis of PD as the brain tissue alteration progresses on different brain structures based on their neurobiological characteristics rather than merely increasing degeneration in a restricted neuroanatomical zone. This fact points to a possibility that degeneration alters different transmitter systems.

Different drug groups have been developed to treat PD. Some of these drugs potentiate (DA agonists) or substitute (L-dopa) the DA in the brain of patients with PD. Treatment options for the Parkinson's disease include: anticholinergic agents, monoamine oxidase-B (MAO-B) inhibitors, and catechol-O-methyl transferase (COMT) inhibitors[20,21]. Pharmacotherapy of PD was initiated with anticholinergic agents which have been used for years. Blocking the action of acetylcholine (ACh), they reduce tremor which is caused by the deficiency of DA[22]. Little improvement in articulation was observed after the administration of anticholinergic agents[23]. MAO-B inhibitors such as Deprenyl stop the degradation of DA and may potentiate the L-dopa action. Deprenyl has been shown to improve speech in both subjective and objective measures of articulation and respiration[24]. Articulatory improvements were observed in oral motor diadochokineses and respiratory improvements were revealed in values of vital capacity and number of words pronounced per exhalation[24]. Though speech improvement was not found to be as significant as motor symptoms, the speech parameters were improved to a certain level by L-dopa therapy[25]. Patients were evaluated by an oral reading task, and speech rate, pauses, and rhythm were reported as the most improved[21].

Other studies have studied labial kinematics and muscle physiological responses induced by L-dopa. Labial movement study revealed a shorter period of time between the initiation of labial movement and speech, and increased speed and symmetry of labial activity[26]. This snowed that L-dopa normalizes the neuronal control of labial movements contributing to the speech improvements in patients with hypokinetic dysthria[27]. More recent studies have not shown significant difference in acoustic measures. Persons with PD had lower intensity and variability of baseline frequency and intensity, and highly expressed whisperiness and harshness in PD patients compared to healthy control subjects and these data did not change after pharmacotherapy[28].

Thus, presented strategies for the treatment of PD have different impact on speech recovery. Being a special method of speech therapy LSVT has maximum positive influence on speech recovery (Table 1). DBS-STN and pharmacotherapy result in partial recovery of speech and must be followed by such a specialized method of speech rehabilitation like LSVT (Figure 1). Various tasks have been applied evaluating the stimulability of speech in Parkinson's disease. These tasks include automatic speech tasks, maximum phonation time, maximum pitch range and loud calling. Interesting specific pattern of speech recovery has been reported by different authors. Partial recovery of speech in patients treated with DBS-STN, pharmacotherapy and LSVT are presented in the table 1.

<table>
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<th>Table 1</th>
<th>Efficacy of different methods on motor and speech recovery in patients with PD.</th>
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in patients with Parkinson’s disease, we have underlined the most
important aspect of that - the dysarthria is not purely dopaminergic,
and therefore traditional pharmacotherapy or DBS for motor defects
do not target the speech problems. Voice therapy can be very
helpful, especially for mild to moderate cases of PD. Other methods,
including electrical stimulation of the subthalamic nucleus or Deep
Brain stimulation have distributed controversial results. Application
of DBS or stimulation of the subthalamic nucleus requires individual
approach and detailed analysis of manifestations and various
radiologic examination data in patients with PD. LSVT LOUD
remains as a better option for the speech therapy in patients with PD.

**CONFLICT OF INTERESTS**

The authors have no conflicts of interest to declare.

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