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ISi-Speech: A Digital Training System for Acquired Dysarthria

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Abstract. Speech impairment like dysarthria poses a major risk to participation in society due to reduced speech intelligibility. This paper focuses on the ongoing development of the technology-based pilot training system, ISi-Speech, for treatment of dysarthria incorporating automatic speech recognition, a psychological model of motivation and evidence-based exercises.

Keywords. Dysarthria, Technology-Assisted Therapy, Autonomous Speech Training, Automatic Speech Recognition, Motivational Feedback Elements

1. Introduction

Speaking is an important aspect of successful communication and participation in society. However, speech motor impairments based on neuromuscular control disturbance such as dysarthria due to stroke or Parkinson's Disease (PD) show a significant impact on everyday communication due to reduced speech intelligibility [1]. Frequently, speaking difficulties result in withdrawal from communication. Speech and Language Therapists (SLT) provide one way of preventing social isolation by helping to improve intelligibility.

In many countries, health insurance covers only a limited set of treatment units. In consequence, many patients receive only one appointment per week for speech therapy. However, sustainable effects for treatment of dysarthria have primarily been achieved using intensive treatment approaches like the Lee Silverman Voice Treatment with at least two to four 60 minutes sessions a week [2]. Unfortunately, the attempt to increase frequency often fails due to the cost for providing therapy. This is where technology comes into play.

Technology can be embedded in the interaction with the SLT or add to face-to-face therapy by increasing the frequency through autonomous training. Especially in autonomous training, feedback on the correct execution of any therapy exercise is of utmost importance. In technology assisted training, this feedback may be provided based on automatic speech recognition (ASR). Moreover, people suffering from neurologic dysarthria are frequently unaware of their reduced intelligibility. Therefore,

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ASR-based objective feedback might help to boost awareness of intelligibility limitations. However, ASR systems applicable to impaired speech are scarce [3-4].

The ISi-Speech project currently seeks to adapt a speech recognition device to be able to cope with dysarthric speech and to integrate it into a speech therapy application that incorporates the motivational potential contributing to frequent and autonomous usage. These challenges shall be met within an elaborate and continuous user driven design exemplifying psychological theory, namely self-determination theory [5].

2. ISi-Speech Training System

The ISi-Speech training system shall help restoring intelligibility in people with dysarthria. It is designed to be independent from the technology's operating system and can therefore be used with desktop or tablet computer, laptop or smartphone. The training system will be accessible as a web-based application on which log in from several devices will be possible. Thus, it will be ensured that even people without much experience or affinity to technology, but who still use any device, are able to access ISi-Speech on their own device instead of having to buy a new one and learn how to use it.

2.1. Evidence-Based Exercises

The ISi-Speech training system is being designed covering evidence-based and best clinical practice exercises for treatment of dysarthria including training of articulation, prosody and speech rate, vocal volume, and resonance as well as participation-oriented training of spontaneous speech.

ISi-Speech exercises targeting articulation encompass repetition and reading tasks as well as clear and exaggerated articulation [6]. Training of prosody is intended through metrically controlled sentences, utterances with specific empathic stress patterns, poems or rhythmic entrainment exercises [7]. As reduced speech rate is considered a core factor for increasing speech intelligibility [8], ISi-Speech users can practice with additive resources such as a virtual metronome or pacing board. Finally, frequent training of augmented vocal volume leads to considerable improvements in intelligibility and recalibration of the internal underscaling of articulation and volume patterns [9]. Increase in 'vocal vigilance' is especially useful for people with PD [10], but has been successful in dysarthria following stroke as well [11].

2.2. Automatic Speech Recognition & Feedback

ISi-Speech shall use ASR to obtain an objective rating of the user's intelligibility. The challenge, however, lies in building an ASR-device that can adjust to impaired speech. Since ASR is purely speech based and cannot take other information into account, e.g. embedding syntactic or semantic context information, gestures, or facial expression that are usually referred to by humans to facilitate understanding dysarthric speech, the system will provide a good estimate of the user's verbal communication abilities. Thus, the ASR-device might serve as a basic diagnostic tool and a way of providing feedback.

Immediate feedback is crucial for patient users, especially for people suffering from dysarthria, as they often are unaware of their reduced intelligibility. In consequence, they attribute problems in communication to others, e.g. to hearing

impairment in their communication partner, lack of attention etc. In this case, feedback that utilizes play back combined with evaluation of the recorded speech might guide them towards more adequate self-perception.

2.3. Motivation

In general, therapists can merely introduce and monitor some of the therapeutic exercises but usually, they cannot supervise all the frequent training that is needed for sustainable changes in patients' speech production. Thus, they need to give patients control over self-regulated training to ensure the necessary redundancy of several exercise units a day. Since such exercises are both, strenuous and boring, many patients lack the sustained motivation to keep up with their training. This is why game-based interventions might be an adequate tool to enhance motivation in therapy [e.g. 12-14].

To enable sustainable use of technology, theory-based design is necessary. Motivational theories, such as self-determination theory (SDT), demonstrated successfully how health behavior can be facilitated [15-16]. Incorporating the three principles of SDT - autonomy, competence and relatedness - gamification elements within a rehabilitation tool might be promising to support both, the acceptance and the effectiveness of a speech training, and in consequence the empowerment of patients with speech impairment.

2.4. Users

To allow for an effective training of the ASR-device, ISi-Speech is first focusing on patients suffering from PD. These patients show reasonably homogeneous symptoms of dysarthria, e.g. low voice and monotonous speech. Inclusion of other types of dysarthria (e.g. following stroke) in the future is intended.

In ISi-Speech, we base our work on a user-centered design and a model-based evaluation [17]. Throughout the whole process of development, potential patient users will be involved and a user driven approach is implemented [18]. We use an iterative exchange between users, developers and researchers. In doing so, seven principles of user participation are applied in the process of development: Partnership, user organization based, equal payment, accessibility, qualified staff, sound plan, and early involvement [18]. This is realised by working together with members of the German Parkinson Association, compensation for expanses, and inviting potential users, caregivers and SLTs as participants to workshops.

ISi-Speech workshops are undertaken with people suffering from PD who are recruited by the German Parkinson Association. The workshops aim at evaluating the technical and psychologic functionality of the application. Further aims are the early integration of potential users, getting feedback with respect to software issues as well as considering the needs of the target group while using the ISi-Speech application. In the workshops, the concept of patient partnership [19] is applied by getting in contact with the target group, informing about the project, asking for participation, supplying questionnaires, saving and backing up data, and finally, debriefing results with patients and caregivers.

At the first ISi-Speech workshop with three patients in May 2016, the project team got helpful feedback concerning potential users' technological experience as well as access, log in and use of the first components of the ISi-Speech application. Patients stated that they felt appreciated in their role and importance for the ISi-Speech project.

For the next workshop (October 2017), we will improve recruitment to enlarge participants' number and extend the quantity of tasks while using the ISi-Speech application. In the workshops, methods such as interviews and observations are applied to create a technology-based intervention tool that considers the patients' needs and experiences for technology-based speech therapy.

3. *Conclusion*

Technology-based interventions seem to become a promising tool for speech and language therapy assuming that principles such as user-driven and theory-based design are taken into account during the developing process. Finally, with a technology-based intervention tool such as ISi-Speech, empowerment of patients can be supported by enhancing the frequency of the speech training, giving highly specific feedback to the patient as well as being tailored to the patient's performance.

The ISi-Speech project ought to result in an operational demonstrator at its end in autumn 2018. Afterwards, a therapeutic evaluation shall follow.

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