

Artificial Intelligence Solutions in Parkinson Therapy

Kerstin Bilda, Fiona Dörr, Anika Thurmann

*Hochschule für Gesundheit Bochum, University of Applied Sciences,
Gesundheitscampus 6-8, 44801 Bochum, Germany*

ABSTRACT

Parkinson's disease (PD) is the second most common neurodegenerative disease in Europe [1]. PD requires a high-frequency therapy offer for a sustainable improvement of the communicative abilities. To improve speech therapy care in PD, technology-based therapies can be useful, essential in these digital health applications is that objective feedback is available for correct exercise performance. The "Speech" application from the ISi-Speech research project [1] provides technology-based training for the therapy of dysarthria in PD. The overall goal of the application is to improve speech functions and thus promote participation and quality of life for those affected. Methodologically, a strictly user-centered implementation approach is planned. Therapists* implement ISi-Speech into an existing evidenced based therapy format. Assumptions about the development of digital maturity levels among therapists*, best practice models for inpatient and outpatient therapy settings and implementation strategies will be identified through the feasibility study. The intervention is part of a public project of the Federal Ministry of Education and Research in Germany. The project humAine - human centered AI network focuses on different areas of business and healthcare. This specific use case is about the implementation of AI in speech

therapy with the aim to sustainably simplify the workflow, identify competency strategies and identify best-practice models.

Keywords: Parkinson's Disease, technology-based therapies, dysarthria, implementation strategies, artificial intelligence, best-practice-modell

INTRODUCTION

Parkinson's disease (PD) is the second most common neurodegenerative disease in Europe [1], the leading symptom being bradykinesia. Other symptoms manifest themselves in the form of rigor, resting tremor and often postural instability [2]. For speech therapy, 12% of cases are relevant, showing dysarthric symptoms in the form of reduced intelligibility when speaking. These speech motor and vocal dysfunctions are based on motor disturbances of the articulation and respiratory muscles as well as on an unfavorable posture during speech. In addition, the symptoms can be traced back to a pathological scaling ability [3]; when speaking, this results in a softening of volume, a low variance in prosody, and reduced articulation movements. Due to the dysarthria, the affected persons are significantly limited in their functions and thus in their social participation. Nevertheless, in 2018 only a small part of 400,000 affected persons received logopedic care for PD, via the AOK 4350 affected persons received logopedic care [4] [5]. Parkinson's disease requires a high-frequency therapy offer for a sustainable improvement of communicative abilities, due to professional structures of speech therapy the required therapy frequency (S3 guideline) is mostly not fulfilled. To improve speech therapy care in PD, technology-based therapies can be useful, essential in these digital health applications is that objective feedback is available for correct exercise performance. In addition, technology-enabled systems offer the possibility of independent exercise beyond individual therapy sessions. Studies in recent years have demonstrated efficacy for self-training in dysarthria [6]. The "Speech" application from the ISi-Speech research project (Individualized Speech Recognition in Rehabilitation for People with Impairments in Speech Intelligibility) provides technology-based training for the therapy of dysarthria in PD. The overall aim of the application is to improve speech function and thereby promote participation and quality of life for those affected. For a long time, quality of life in Morbus Parkinson received little attention, with purely motor symptoms being the main focus of consideration [7]. Numerous studies on quality of life point to indirect effects due to the consequences of motor impairment, such as impairments due to dysarthric symptoms and limitations in verbal and nonverbal communication [7]. The limitations in speech and voice quality, in addition to a reduced quality of life, lead to impairments in social interaction and may result in social withdrawal [7]. New software systems with integrated speech recognition represent promising and individualized therapy offers for people with multiple communication impairments across the lifespan [8]. This requires the development of a systematic approach that includes a definition and description of therapy standards [9]. Use cases such as the ISi-Speech feasibility study, which describe a digital therapy format, form a basis for this systematics. The UseCase aims to look at digitization not only from the technical development perspective and feasibility, but also to investigate usability and effectiveness for individual users for the sustainable use and acceptance of digital solutions [10]. But what digital competencies are required to enable speech and language therapists* to cope confidently with the new demands? Digitization

means a change in familiar and trusted work processes and, in particular, a new role and identity as a therapist. The prototype system developed in a preliminary project (ISi-Speech - Individualized Speech Recognition in Rehabilitation for People with Speech Intelligibility Impairments 2015-2018) focuses on speech disorders and the computer-aided analysis of the speech disorder. Advanced assistive technologies from the field of automatic speech recognition can be used for training purposes to support communication in people with speech intelligibility impairments. However, currently available speech recognition systems cannot be used for this purpose, as they only work sufficiently well for speech utterances of people without speech impairments. It is well known that disturbances in the ability to communicate lead to social withdrawal in the medium term. Therefore, it is highly relevant to increase speech intelligibility by means of a system adapted to the individual needs of the person with speech disorders and to stabilize the ability to communicate in such a way that social isolation can be prevented.

In this context, the current speech therapy exercise therapy financed by health insurance companies is an important component of patient care. A useful addition is technology, which, after therapeutic guidance, provides a platform for the exercise context and, in the longer term, for successful autonomous communication by patients*. For individuals with speech disorders, practicing pronunciation requires individualized therapeutic feedback. ISi-Speech has achieved a major technical breakthrough. For the first time, automatic speech recognition recognizes patients* disordered speech and can assess the quality of pronunciation. Based on this, the artificial system can provide individualized, qualitative feedback. Based on automatic speech recognition with an integrated feedback system, this training system improves the individual, self-regulated practice situation and strengthens the independence and self-management of affected patients*.

QUESTIONS

New technologies can be an important element in expanding and improving therapeutic services in Germany. The targeted use can be beneficial for the therapy system and for the patients* themselves. Based on the theoretical background and previous knowledge about speech assistance systems in speech therapy, the following main and secondary questions arise.

Key Questions

1. How can a digital speech assistant like ISi-Speech be systematically integrated into inpatient speech therapy rehabilitation?
2. What contribution can ISi-Speech make in outpatient logopedic care: with regard to improving the quality of speech; securing the learning effects after inpatient, intensive rehabilitation in communicative everyday life as well as for the health-related quality of life of the patients* and their relatives?

Further questions

3. What contents must training courses for therapists* imply in order to achieve a safe and confident handling of new technologies?

4. 4. Which strategies for implementing ISi-Speech prove to be effective? Which determinants for the transfer of a speech assistance system can be identified?

Description of the Implementation object and prototype ISi-Speech

The already developed prototype ISi-Speech, with the application "Speech", will be used for the study. The research project ISi-Speech (Individualized Speech Recognition in Rehabilitation for People with Speech Intelligibility Impairments) has developed a technology-based training for the therapy of dysarthria in PD from 2015-2018. The training is web-based and can thus be used on various devices via a browser. ISi-Speech aims to be an adaptive motivation and feedback system that can be individually adapted to the abilities and possibilities of the user, thus promoting motivation for long-term use and also for supplementary rehabilitation measures. The aim is to stabilize the user's own communication and to promote social participation. ISi-Speech combines evidence-based and best-clinical-practice exercises for the therapy of articulation, prosody, speech volume, speech rate, voice volume and respiration. The training program works with automatic speech recognition and can thus provide feedback on the intelligibility of speech, this enables an objective assessment of intelligibility, as patients* are usually unable to correctly assess their speech intelligibility due to impaired scaling ability [11].

- The therapy material consists of different requirements for:
- Articulation: repeating and reading tasks aloud, application of "Clear Speech" i.e. speaking loudly, slowly and overarticulation of words, phrases, sentences and texts.
- Prosody: training of prose
- Speech rate: virtual metronome, virtual pacing board
- Exercises to increase vocal vigilance

In order to provide sustained motivational support for patients*, ISi-Speech incorporates psychologically effective motivational elements in addition to logopedically based exercise formats, which have an impact on both short-term and long-term use.

Description of Parkinsons Complex Therapy (PCT)

The implementation of ISi-Speech takes place within the framework of the PCT. The specifications of the PCT [12] (service catalog for operational procedures - OPS classification 8-79d) are supplemented by the application "ISi-Speech- Speech".

Since 2008, PCT is billed according to §39 SGB V under the term "Multimodal complex treatment for Parkinson's disease and atypical Parkinson's syndrome". This complex treatment focuses on multimodality and the patient. In addition to medical-neurological and psychotherapeutic treatments, patients* also benefit from sports and exercise therapy, occupational therapy, speech therapy, psychotherapeutic procedures and socio-medical care. Of these, at least three non-medical therapies are provided at 7.5 therapy hours per week, five of which are individual therapy [13].

The use, efficacy, and acceptance of new technologies into speech therapy has been

demonstrated by numerous studies for various indications [14]. However, the standardized use in the clinical setting and the transfer to the outpatient therapy situation is not defined, gaps in care are often the result.

What knowledge gain can be expected from the study? Who will benefit from the results, how and to what extent?

The complementary use of ISi-Speech promotes the acceptance of digital tools within/outside of therapy for patients* and therapists*. Patient* compliance can be increased for a successful PCT therapy, the qualitative and quantitative sustainability of PCT can be positively affected. Implementation strategies and models can be developed and used for the transfer of other digital therapy assistance systems. Best-practice models for the use of ISi-Speech can be developed and thus statements on the socio-technical workflow can be made.

Patients* benefit from the findings on the use of digital speech/language assistance systems:

- They can train their speech performance independent of time and place.
- They receive objective feedback on their speech performance independently of therapists* and relatives.
- autonomous influence on therapy quality and quantity.
- Patients* be able to compensate for gaps in therapy through self-training.
- Patients* improve quality of life through constant practice and self-efficacy in the therapy process.
- Best practice model development in dealing with ISi-Speech for patients*.
- Determinants for increasing the acceptance of new technologies in speech therapy are identified.
- Therapists* benefit from the findings on the use of digital speech/language assistance systems:
- ISi-Speech offers concrete instructions for the training of patients* and for the guidance of relatives at home.
- The therapy quantity can be increased and therapy gaps can be compensated.
- Support of patients* for autonomous self-training.
- Element in therapy to promote self-efficacy of patients*.
- Necessary competencies for the use of ISi-Speech are determined.
- Determinants for increasing acceptance of new technologies in speech therapy will be identified .
- Best practice model development in the use of ISi-Speech for therapists*.

- Development of implementation strategies from the user's perspective.

METHOD

Through the targeted anamnesis and diagnostics within the clinical routine of the PCT, the test persons are classified with regard to their Parkinson's disease. The affected person receives a 14-day inpatient PCT in which speech therapy with the ISi-Speech product "Speech" is integrated. At the beginning data (baseline - T0) are collected, including surveys on the quality of life of the affected person, the symptom expression of the dysarthria as well as the acceptance level of new technologies. After the inpatient PCT, the patient's quality of life and acceptance of technology are assessed again and a follow-up diagnosis of the symptoms of Parkinson's disease is performed (T1). The patient* is then transferred to the outpatient setting and receives eight weeks of outpatient speech therapy using ISi-Speech. In addition to the logopedic presence therapy, video therapy and self-therapy of the patient* are also used. After the outpatient therapy phase, a final survey (T2) of the above-mentioned parameters takes place (Follow Up).

In the process of the study, the involved actors are essential for the implementation, integration and acceptance of new technologies in therapy. Therefore, data of the treating therapists* will be collected at the process periods (T 0; T 1; T2). With the help of a determinant analysis at the beginning (T0), items such as potentials and opportunities of digital health applications, strategies for higher-level and individual use, but also basic technical requirements will be collected. A targeted workshop will prepare PCT therapists* for working with ISi-Speech on patients*. Guided interviews before and after the two-week therapy phase (T1; T2) will determine parameters that are relevant for the development of competencies and the implementation of new technologies in PCT and speech therapy in general.

Sample

Persons with reduced speech intelligibility as a result of the neurological Parkinson's disease are selected as the target group. This target group has a significant relevance, according to the Gesundheitsberichterstattung des Bundes (2019) the number of affected persons was 48,762. 12% of patients* with Parkinson's disease show symptoms of dysarthria [retrieved on June 23, 2021 from www.gbe.bund.de]. Included are adult patients* with diagnosed Parkinson's disease from the Parkinson's complex treatment of the Parkinson's outpatient clinic of the St. Josef Hospital in the Ruhr (Germany) area. The intervention starts at the same time as the basic rehabilitation of the outpatient clinic. Self-reporting and the assessment of the treating therapists* and physicians ensure compliance with the inclusion and exclusion criteria.

Tab. 1 Inclusion and exclusion criteria of the study

	Patients*:	Therapists*/ Stakeholders:
Inclusion criteria	<ul style="list-style-type: none"> - Age from 18 years - Acquired neurological speech intelligibility impairment - German as first language or premorbid good knowledge of the German language 	Included are adult persons working in the context of PCT at St. Josef Hospital Bochum and involved in the treatment of the PCT patients* (inpatient as well as outpatient).
Exclusion criteria	<ul style="list-style-type: none"> - significant cognitive and mental impairments - insufficient technical knowledge and/or lack of WLAN connection in the home setting - significant comorbidities - taking medication that impairs the ability to speak 	

The sample of included persons results from the survey period, the mentioned inclusion criteria, measures of Corona pandemic and technical conditions of the study. Each year, an average of 110 patients* are treated at St. Josef Hospital Bochum within the framework of the PCT. Approximately 20 patients* show symptoms of dysarthria and receive speech therapy. Two interview groups are assumed for the planned interviews (IG 1; IG 2). Probably n=3 therapists* and n=20 patients* will be interviewed.

Data collection

For the classification of Parkinson's symptoms, the anamnesis and diagnostic instruments are used that are provided in the routine of the clinic. At the beginning of the PCT, the Frenchay [15], diagnostic criteria of the MDS Diagnostic Criteria [16], the staging of Parkinson's according to Hoehn & Yahr [17], the Voice Handicap Index [18], and survey instruments for effective communication [CETI-M], among others, are used for this purpose. Also used are sustainable parameters such as acceptance, compliance and application habitus are recorded. The aspect of user acceptance of ISi-Speech will be classified. The effect of ISi-Speech in the short and long term regarding the experienced communication success, the quality of life and the effects of the system on the PCT will be measured by the determined user preferences. The instruments used are guided interviews with experts, self-evaluations (Short Form-36 Health Survey (SF-36) [19]), questionnaires on the quality of life of the patients* (EQ-5D and PDQ-8) and questionnaires on the workflow/acceptance level of the treating therapists*.

Data evaluation

The data will be evaluated qualitatively by means of a content-structured analysis according to Kuckartz [20]. By means of a representation in a usability model, levels of use and

discontinuation will be worked out. Within the quantitative evaluation, different evaluation periods will be used (intention to treat ITT; per protocol; interim evaluation). In addition to descriptive statistics, conclusive statistics (e.g. ANOVA) will be used for data evaluation.

Outcome

The study follows superordinate outcome parameters such as guideline interviews and self-evaluations to determine the wishes and challenges of new therapy models with integrated AI-based assistance systems. In addition, the project represents an exemplary case study for testing the AI-based assistance system ISi-Speech in different care scenarios in order to be able to make generalized statements about strategies. The creation of guidelines for sustainable implementation in this application is very important, new technologies should thus permanently enter the standard care in the German health care system.

Tab. 2 Short-Term and Long-Term Outcome

Short-Term Outcome	Long-Term Outcome
<ul style="list-style-type: none"> - Promoting the motivation of patients* to practice autonomously - Making successes visible for patients* (objective feedback through ISi-Speech) - Increase the frequency of therapy - Simplify documentation of therapeutic aims and progress monitoring - Promotion of usability in the inpatient setting - Promoting the acceptance of ISi-Speech in the context of PCT (from the patient's and therapists* perspective) 	<ul style="list-style-type: none"> - Linking ISi-Speech with individualized applications in the training environment - Usability and impact of ISi-Speech on the user by evaluating user perception - Enhancement of the sustainability of PCT through ISi-Speech - Development of competence models for the use of ISi-Speech - Create transfer models for digital tools in therapy (inductive) - Develop and derive implementation strategies for new technologies

CONCLUSION

Complementing classical PCT with ISi-Speech can increase the sustainability of therapy outcomes for patients*. ISi-Speech as a pilot will provide implementation strategies and models of digital tools (apps, therapy software). In terms of human-centered use, training material for users will be derived and specifically created. A changed/increased therapy adherence can be the consequence of ISi-Speech use. The pilot project aims at the inclusion of ISi-Speech in the standard care and thus sees itself as a signpost for the transfer of other digital therapy assistance systems. The results of the study can be important indications for promoting the acceptance of digital aids and AI in therapy. The focus of the study is on the users; the design of new technologies in therapy thus arises from the grassroots.

REFERENCES

[1]Sütterlin, S., Hoßmann, I., Klingholz, R. (2011). Demenz-Report. Berlin-Institut für Bevölkerung und Entwicklung. <https://nbn-resolving.org/urn:nbn:de:0168-ssoar-321483>

- [2]Deutsche Gesellschaft für Neurologie (2016). Ideopathisches-Parkinson-Syndrom. S3 Leitlinie.https://www.awmf.org/uploads/tx_szleitlinien/030-010k_S3_Parkinson_Syndrome_Idiopathisch_2016.pdf
- [3]Skodda, S. (2015). Die Dysarthrie des Morbus Parkinson: Klinische Präsentation, pathophysiologische und diagnostische Aspekte. *Sprache - Stimme - Gehör* 2015, 39: 182-186 Verlag: Georg Thieme KG
- [4]Wissenschaftliches Institut der AOK (2019). Heilmittelbericht 2019. Berlin: Wissenschaftliches Institut der AOK.
- [5]Deutsche Gesellschaft für Parkinson und Bewegungsstörungen. Hintergrundinformationen Parkinson-Krankheit. Abgerufen am 22.06.2021 <https://www.parkinson-gesellschaft.de/die-dpg/morbus-parkinson.html>
- [6]Frieg, H., Mühlhaus, J., Ritterfeld, U., Bilda, K. (2017). Assistive Technologien in der Dysarthrietherapie. Entwicklung des Trainingssystems ISi-Speech als Anwendungsbeispiel. *Forum Logopädie* 2017, 21: 10-15.
- [7]Möller, B. & Reiff, J. (2017). 3 Auswirkungen des Morbus Parkinson auf die Lebensqualität von Patienten und Angehörigen. in: Nebel, A. et al. (2017). *Dysarthrie und Dysphagie bei Morbus Parkinson*. Forum Logopädie. Verlag: Georg Thieme KG
- [8]Bilda, K., Mühlhaus, J. & Ritterfeld, U. (2016). *Neue Technologien in der Sprachtherapie*. Stuttgart: Thieme.
- [9]Bilda, K., Dörr, F., Urban, K., & Tschuschke, B. (2020). Digitale logopädische Therapie – Ergebnisse einer Befragung zum aktuellen Ist-Stand aus Sicht von Logopäden. *Logos*, 28(3), 176–183.
- [10]Widmer Beierlein, S., Kuntner, K., Reymond, C., Blechschmidt, A. (2019). E-INCLUSION – eine Benenn- App für Menschen mit Aphasie. 2019, Muttenz, Schweiz.
- [11]Frieg, H. (2021) Technikgestützte Dysarthrietherapie bei Morbus Parkinson am Beispiel der App „Sprechen!“. *Sprache - Stimme - Gehör*. 2021, 45: 35-37. Verlag: Georg Thieme KG
- [12]Deutsches Institut für Medizinische Dokumentation und Information DMDI (2019) Operationen- und Prozedurenschlüssel Version 2019. operationelle Prozeduren - OPS-Klassifikation 8-79d. Internetquelle: <https://www.dimdi.de/static/de/klassifikationen/ops/kode-suche/opshtml2019/>. Abgerufen am: 12.07.2021
- [13]Knop, M., Sämann, P. & Keck, M. (2017). Parkinson-Komplextherapie am Max-Planck-Institut für Psychiatrie – Ein multimodales, flexibles stationäres Therapieprogramm für kritische Krankheitsphasen. *Schweizer Zeitschrift für Psychiatrie & Neurologie* 05/2017.
- [14]Cordes, L., Loukanova, S. & Forstner, J. (2020). Scoping Review über die Wirksamkeit einer Screen-to-Screen-Therapie im Vergleich zu einer Face-to-Face-Therapie bei Patienten mit Aphasie auf die Benennleistungen. *Zeitschrift für Evidenz, Fortbildung und Qualität im Gesundheitswesen*, 156/157, 1 – 8.
- [15]Enderby, P. M. (1991). *Frenchay-Dysarthrie-Untersuchung*. Stuttgart, Jena, New York: Gustav Fischer.
- [16]Postume, R., Poewe, W., Litvan, I. (2018). Validation of the MDS clinical diagnostic criteria for Parkinson's disease. doi: 10.1002/mds.27362. Epub.
- [17]Hoehn, M. M. & Yahr, M. D. (2017). Parkinsonism: onset, progression and mortality. *Neurology*. doi:10.1212/wnl.17.5.427. 17 (5); 427-42.
- [18]Voice Handicap Index: Development and validation. *American Journal of Speech-Lang Pathology*, 6, 66–70.
- [19]Morfeld, M., Stritter, W., Bullinger, M. (2012). 3 Der SF-36 Health Survey. In: Schöffski O., Graf von der Schulenburg JM. (eds) *Gesundheitsökonomische Evaluationen*. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-21700-5_14.
- [20]Kuckartz, U. (2018). *Qualitative Inhaltsanalyse. Methoden, Praxis, Computerunterstützung* (4. Aufl.). Weinheim: Beltz Juventa.