CoBeN

Novel Network-Based Approaches for Studying Cognitive Dysfunction in Behavioural Neurology

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MARIE CURIE ACTIONS

D2.2 Standardized protocol for language and acoustic assessment and analysis

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1 Introduction

In the frame of this deliverable we aimed to design a short but as comprehensive as possible speech tasks protocol that could be used in 3 languages (English, Czech, Hungarian) and that could assess both hypokinetic dysarthria (HD) and apraxia of speech (AOS). Specific acoustic analysis of speech data will be performed in all 3 languages. The battery should not exceed 15 min of data acquisition. We tested this in older healthy subjects.

2 Methods

Based on a comprehensive literature review we firstly identified all possible speech/voice disorders that could be present in HD or AOS. In the consequent step, we identified acoustic features (measures) that could quantify these disorders. Finally, based on this review we proposed a completely new speech tasks protocol that enables complex quantitative analysis of HD/AOS in all three languages, while its performance is not demanding in terms of acquisition time.

3 Results

Based on the literature review we identified 22 possible speech/voice disorders that could be present in HD or AOS. These disorders can be split into 4 speech dimensions: phonation, articulation, prosody, and lexical stress. The considered disorders as well as acoustic features that quantify them are listed in Table 1. Finally, the newly designed speech/voice examination protocol is reported in Table 2.

Table 1: HD/AOS dimensions and specific disorders

HD/AOS dimension and specific disorder	**Speech tasks** (see Table 2)	**Acoustic feature**	**Feature definition**
Phonation			
Airflow insufficiency	Sustained phonation (TSK6)	MPT	Maximum phonation time, aerodynamic efficiency of the vocal tract measured as the maximum duration of the prolonged vowel.
Irregular pitch fluctuations	Sustained phonation (TSK3–6)	relF0SD	Standard deviation of fundamental frequency relative to its mean, variation in frequency of vocal fold vibration.
Microperturbations in frequency	Sustained phonation (TSK3–6)	Jitter (PPQ)	Frequency perturbation, extent of variation of the voice range. Jitter is defined as the variability of the F0 of speech from one cycle to the next.
Microperturbations in amplitude	Sustained phonation (TSK3–6)	Shimmer (APQ)	Amplitude perturbation, representing rough speech. Shimmer is defined as the sequence of maximum extent of the signal amplitude within each vocal cycle.
Increased noise	Sustained phonation (TSK3–6)	HNR	Harmonics-to-noise ratio, the amount of noise in the speech signal, mainly due to incomplete vocal fold closure. HNR is defined as the amplitude of noise relative to tonal components in speech.
Aperiodicity	Sustained phonation (TSK3–6)	DUV	Degree of unvoiced segments, the fraction of pitch frames marked as unvoiced.
Tremor of jaw	Sustained phonation	relF1SD, relF2SD	Standard deviation of first (F1) and second (F2) formant relative to its mean. Formants are related to

	(TSK3–6)		resonances of the oro-naso-pharyngeal tract and are modified by position of tongue and jaw.
Articulation			
Decreased tongue movement (imprecise vowels)	Monologue, reading (TSK1–5)	VAI	Vowel articulation index, based on formant centralization, defined as VAI = (F1a + F2i)/(F1i + F1u + F2a + F2u).
Rigidity of tongue and jaw	Monologue, reading (TSK1–2)	relF1SD, relF2SD	Standard deviation of first (F1) and second (F2) formant relative to its mean.
Imprecise consonants	Diadochokinetic task (TSK7–8)	VOT	Voice onset time, defined as the length of the entire consonant from initial burst to vowel onset.
Slow alternating motion rate	Diadochokinetic task (TSK7)	DDK rate	Diadochokinetic rate, representing the number of syllable vocalizations per second.
Irregular alternating motion rate	Diadochokinetic task (TSK7)	DDK reg	Diadochokinetic regularity, defined as the standard deviation of distances between following syllables nuclei.
Prosody			
Reduced loudness	Monologue, reading (TSK1–2)	Mean SEO	Mean speech loudness, representing the average squared amplitude within a predefined time–energy segment.
Monoloudness	Monologue, reading (TSK1–2)	relSEOSD	Speech loudness variation, defined as a standard deviation of intensity contour relative to its mean after removing silences exceeding 50 ms.
Monopitch	Monologue, reading (TSK1–2)	relF0SD	Pitch variation, defined as a standard deviation of F0 contour relative to its mean.
Inappropriate silences	Reading (TSK2)	SPIR	Number of pauses relative to total speech time after removing periods of silence lasting less than 50 ms.
Higher proportion of silence time	Reading (TSK2)	PPR	Percentual pause ratio, defined as total duration of silences (longer than 50 ms)/total duration of speech.
Longer duration of silences	Reading (TSK2)	DurMED	Median duration of silences longer than 50 ms.
Higher variability of silence duration	Reading (TSK2)	DurMAD	Median absolute deviation of silence duration (silences longer than 50 ms).
Unnatural speech rate	Reading (TSK2)	AR	Number of speech sounds produced per second after pauses longer than 50 ms were removed.
Lexical stress			
Abnormal intensity stress pattern	Polysyllable word repetition (TSK8)	PVIint	Pairwise variability indices based on the first two syllables' intensity.
Abnormal duration stress pattern	Polysyllable word repetition (TSK8)	PVIdur	Pairwise variability indices based on the first two syllables' duration.

Table 2: Speech acquisition protocol

Label	Speech task	Description
TSK1	Monologue	Monolog, at least 90 s long without interruption of a clinician. The participants will be instructed to speak about their hobbies, family, job, actual date activity, etc.
TSK2	Reading	Reading a short text. The patient can read the text for her-/himself in advance.

TSK3	Sustained phonation	Approximately 3-s (not longer than 5 s) sustained vowel of /a/ at a comfortable pitch and loudness. Performed on one breath.
TSK4	Sustained phonation	Approximately 3-s (not longer than 5 s) sustained vowel of /i/ at a comfortable pitch and loudness. Performed on one breath.
TSK5	Sustained phonation	Approximately 3-s (not longer than 5 s) sustained vowel of /u/ at a comfortable pitch and loudness. Performed on one breath.
TSK6	Sustained phonation	Sustained phonation of /a/ at a comfortable pitch and loudness **as constant and long as possible**, at least 5 s. Performed on one breath.
TSK7	Diadochokinetic task	Rapid steady /pa/-/ta/-/ka/ syllables repetition as constant and long as possible, repeated at least 5 times. Performed on one breath.
TSK8–17	Polysyllable word repetition	Repeat 10 polysyllable words according to the clinician. 6 of the words should have at least 3 syllables and CVCV (C – consonant, V – vowel) structure for the first two of them.

Since the protocol is multilingual, TSK2 and TSK8–17 must have been adjusted for a specific language. In the case of TSK2 we integrated texts that contain all possible phonemes that occur in the specific language. These texts can be found in Supplementary File 1. Analogically, we used different polysyllable words for each language, nevertheless, we were satisfying the requirement of CVCV structure in all languages. These words can be found in Supplementary File 2.

Finally, we measured the time that is needed to complete the whole protocol. For this purpose, we recorded English, Czech and Hungarian speaking healthy controls (HC). The maximum measured time is: 8.52 minutes (3 English speaking HC), 8.87 (20 Czech speaking HC), 8.51 (2 Hungarian speaking HC).

4 Conclusion

In the frame of this deliverable, we introduced a completely new speech tasks acquisition protocol that enables a comprehensive acoustic analysis of 22 speech/voice disorders that could be present in HD or AOS. The protocol is monitoring these disorders in the field of phonation, articulation, prosody and lexical stress. Moreover, it provides multilingual assessment and its performance does not take longer than 9 minutes.

Supplementary File 1

English Version

Do you like amusement parks? Well, I sure do. To amuse myself, I went twice last spring. My most MEMORABLE moment was riding on the Caterpillar, which is a gigantic rollercoaster high above the ground. When I saw how high the Caterpillar rose into the bright blue sky I knew it was for me. After waiting in line for thirty minutes, I made it to the front where the man measured my height to see if I was tall enough. I gave the man my coins, asked for change, and jumped on the cart. Tick, tick, tick, the Caterpillar climbed slowly up the tracks. It went SO high I could see the parking lot. Boy was I SCARED! I thought to myself, "There's no turning back now." People were so scared they screamed as we swiftly zoomed fast, fast, and faster along the tracks. As quickly as it started, the Caterpillar came to a stop. Unfortunately, it was time to pack the car and drive home. That night I dreamt of the wild ride on the Caterpillar. Taking a trip to the amusement park and riding on the Caterpillar was my MOST memorable moment ever!

Source: PATEL, Rupal, et al. "The Caterpillar": A novel reading passage for assessment of motor speech disorders. American Journal of Speech-Language Pathology, 2013, 22.1: 1–9.

Czech Version

Maminka se zeptala Milana:
„Milánku, už máš hotový úkol? Kdy ho budeš psát?"
Milan chvilku přemýšlel, a pak odpověděl:
„Já musím napsat pár souvětí na Říhovou, kde budou nějaké gramatické fígle. Například vztažné věty, čárky před ‚a' a podobně. Vlastně jsem tě chtěl poprosit, jestli mi s tím nepomůžeš."
„Můžeme se na to mrknout klidně hned," řekla maminka. „Jen bych dala vařit vodu na čaj a podívám se, jestli máme citróny. Jak dlouho nám ten úkol zabere? Bude to těžké?"
„No, mají tam být i různé příklady na zastaralou a knižní slovní zásobu. Skoro půlku jsem už ve škole udělal, ale moc dobře mi to nešlo. Chtěl bych začít co nejdřív. Až budu hotov, došel bych ti do lékárny pro ten *PNEUMOCYT*.
A potom půjdu hrát fotbal. Včera jsem dal čtyři góly. Nebýt Láďových faulů, mohlo jich být víc. Jen míč budu muset přifouknout. Neboj se, dám pozor na auta."

Source: doc. Mgr. Radek Skarnitzl, Ph.D., Institute of Phonetics, Faculty of Arts, Charles University in Prague, Czech Republic

Hungarian Version

Két hétig terveztük, hogy majd veszünk. Mindennap megálltunk a kirakatok előtt, sóváran néztük. Végül is a születésem napján, április 5-én déli tizenkét órakor megkérdeztük, mibe kerül. - 275 frankba - mondta a gyümölcsárus. - Elsőrendű, teljesen friss, zamatos ananász.

A feleségem drágállotta, én nem. A görögdinnyéhez képest persze sok, de az ananászhoz képest bizonyára nem. Megvettük, hazavittük. Beállítottuk egy hamutartóba, néztük. Körbejártuk, barátkoztunk vele, dicsértük, milyen szép és egzotikus. A tetején külön növény hajtott ki belőle, valami pálmaféle; ha locsolnánk, vagy vízbe tennénk, talán hamarosan nagyra nőne és kivirágzana.

A szállóban rögtön híre futott, hogy a kilencesben vettek egy ananászt. A takarítónő bejött, és bemutatkozott - eddig a percig ugyanis színét se láttuk -, és azt javasolta, hogy hámozzuk meg, és fölszeletelve, kristálycukorral meghintve hagyjuk állni egy vagy két napig.

"Ostobaság - mondta egy angol diáklány a lépcsőfordulóban. - Rummal egyék, úgy a legfinomabb."

Egy honfitárs, akivel eddig csak köszönő viszonyt tartottunk, cédulát csúsztatott az ajtóhasadékba. "Ne hallgassanak senkire - írta. - Jó vastagon le kell hámozni, mert a héja élvezhetetlen, de a húsát úgy kell fogyasztani, ahogy van."

Este meghámoztuk és megettük. Semmi íze sem volt. Alig valamivel volt rosszabb, mint a tök. Nyersen is, cukorral is, rummal is. Nagy nehezen legyűrtük, ittunk rá egy pohár vizet.

Source: Örkény István – Válogatott Egyperces Novellák

Supplementary File 2

English Version

TSK8: dinosaur

TSK9: potato

TSK10: barbeque

TSK11: banana

TSK12: bicycle

TSK13: computer

TSK14: butterfly

TSK15: tomato

TSK16: stethoscope

TSK17: detergent

Czech Version

TSK8: batika

TSK9: potápka

TSK10: dikobraz

TSK11: terasa

TSK12: kytara

TSK13: Gabriel

TSK14: tramvaje

TSK15: Rožmberk

TSK16: bankéřův

TSK17: přetvářka

Hungarian Version

TSK8: babona

TSK9: pacsirta

TSK10: denevér

TSK11: taliga

TSK12: bizalom

TSK13: gavallér

TSK14: trombita

TSK15: rozmaring

TSK16: boritek

TSK17: kerites