

# *Using electromagnetic articulography for the purpose of studying speaking styles and speech disorders*

Katarzyna Klessa, Anita Lorenc & Łukasz Mik



ADAM MICKIEWICZ  
UNIVERSITY  
POZNAŃ



UNIVERSITY  
OF WARSAW



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SZKOŁA ZAWODOWA  
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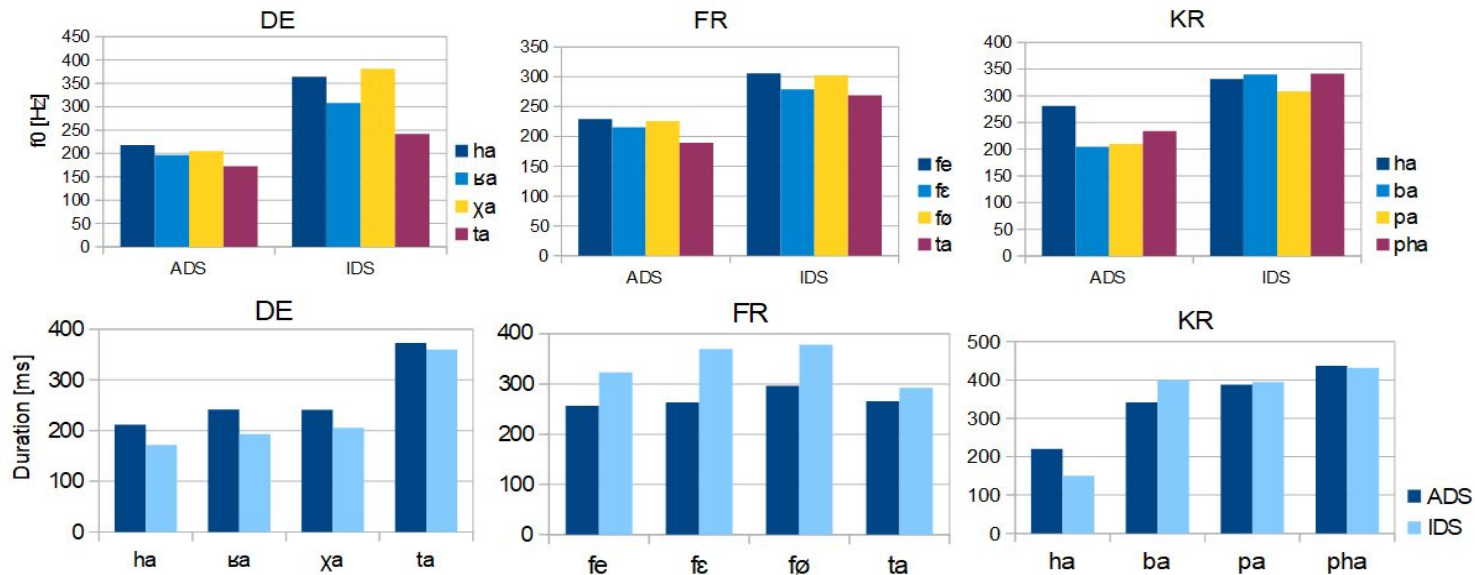
# Speaking style studies

We studied features of **ADS** (adult-directed speech) as compared to **IDS** (infant-directed speech)

Infant directed speech (IDS) is a speaking style involving certain facilitatory features that help infants to:

- segment speech;
- distinguish between speech sounds;
- learn new phonological categories in their native language;
- become **more successful in word / language learning**;

# Phonetic-acoustic features (previous projects)



1. **Fundamental frequency** is usually higher in IDS than in ADS for German, French, Korean
2. Speakers usually systematically differentiate **durations** of speech sounds
3. We confirmed these phonetic-acoustic tendencies in the present study

## The present work: articulatory differences?

- We used electromagnetic articulography (EMA) device: Carstens AG501 to collect speech production data (a new generation of the device, less invasive than the previous ones).
- **4 healthy speakers** were recruited who did not report any speech disorders based on subjective judgement



# Recording scenarios

Part 1: tongue resting position and swallowing

Part 2: semi-spontaneous narration

Part 3: elicited utterances in ADS

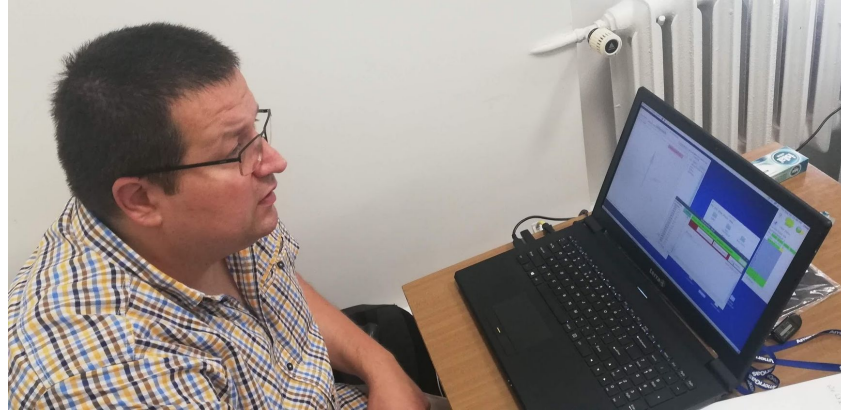
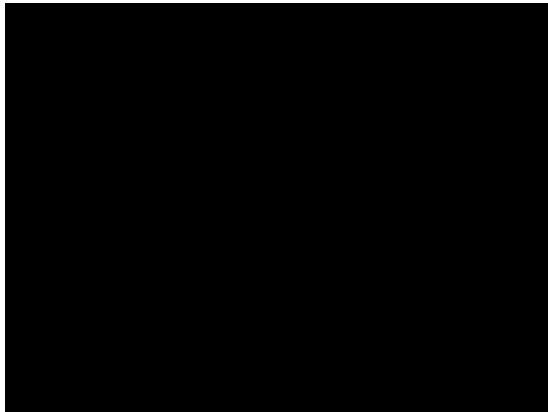
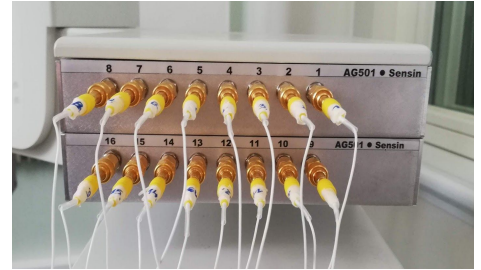
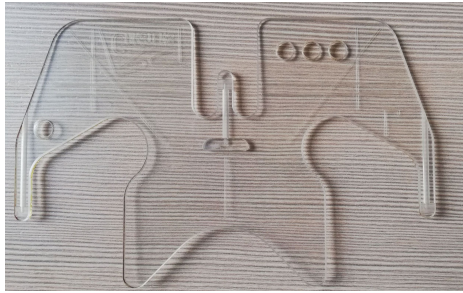
Part 4: elicited utterances in IDS

- ❖ *1\* participants get used to the sensors being attached to speech organs, watch movie, water administered in small quantities*
- ❖ *2\* participants talked about the movie*
- ❖ *3\* produced short phrases, syllables or (pseudo-)words one by one on the screen*
- ❖ *4\* - the procedure was the same as in 3\* but with pictures of infants displayed in between stimuli (instructed to speak as if to a baby)*



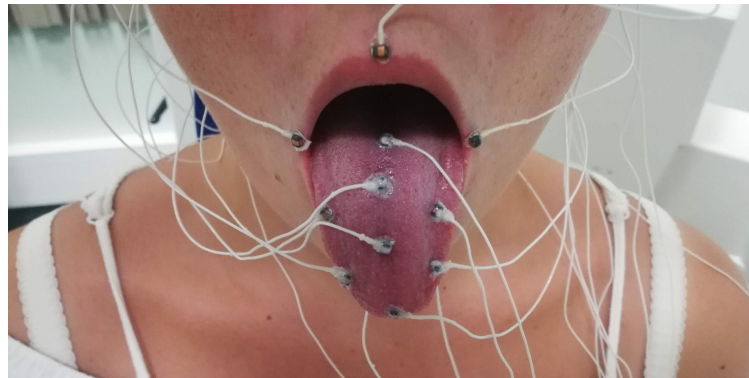
Photo by Kristina Paparo on Unsplash

# Data collection procedures: 2 types of reference sensors

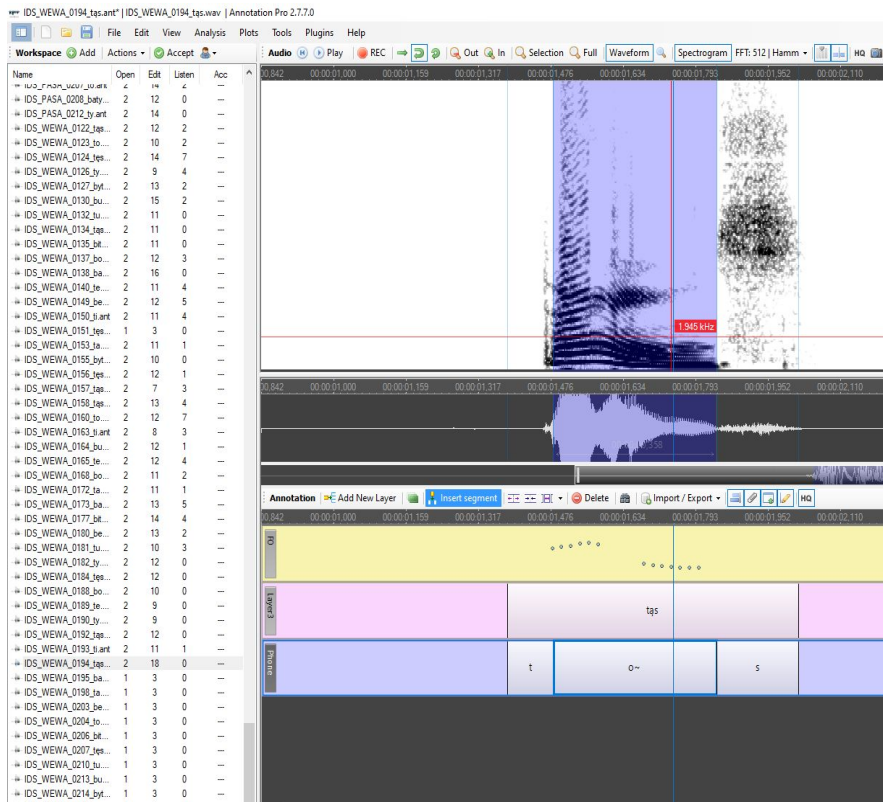


Archives of the project: *Infant-directed and adult-directed speech: preliminary investigation with Carstens AG501 Articulograph (Mowa kierowana do dzieci i dorosłych: badanie wstępne z użyciem artykulografu Carstens AG501)*. Miniatura-2 Project funded by the National Science Centre in Poland (ID: 2018/02/X/HS2/03593).

# Data collection procedures: Attaching sensors to articulatory organs



# Audio recordings



For each recorded file:

- $f_0$  extraction result
- the text of the utterance (orthographic transcription)
- segmentation on the phone level:
  - automatically (using AnnPro plugin: <http://mowa.clarin-pl.eu/tools/annotationpro>)
  - manual correction of the phone boundary positions

Thanks to the above, it becomes possible to perform basic phonetic-acoustic analyses of the data during which we confirmed the previous findings regarding the differences between ADS and IDS



# Articulographic data

horizontal dimension:

x - forward-backward movements

y - sideways movements

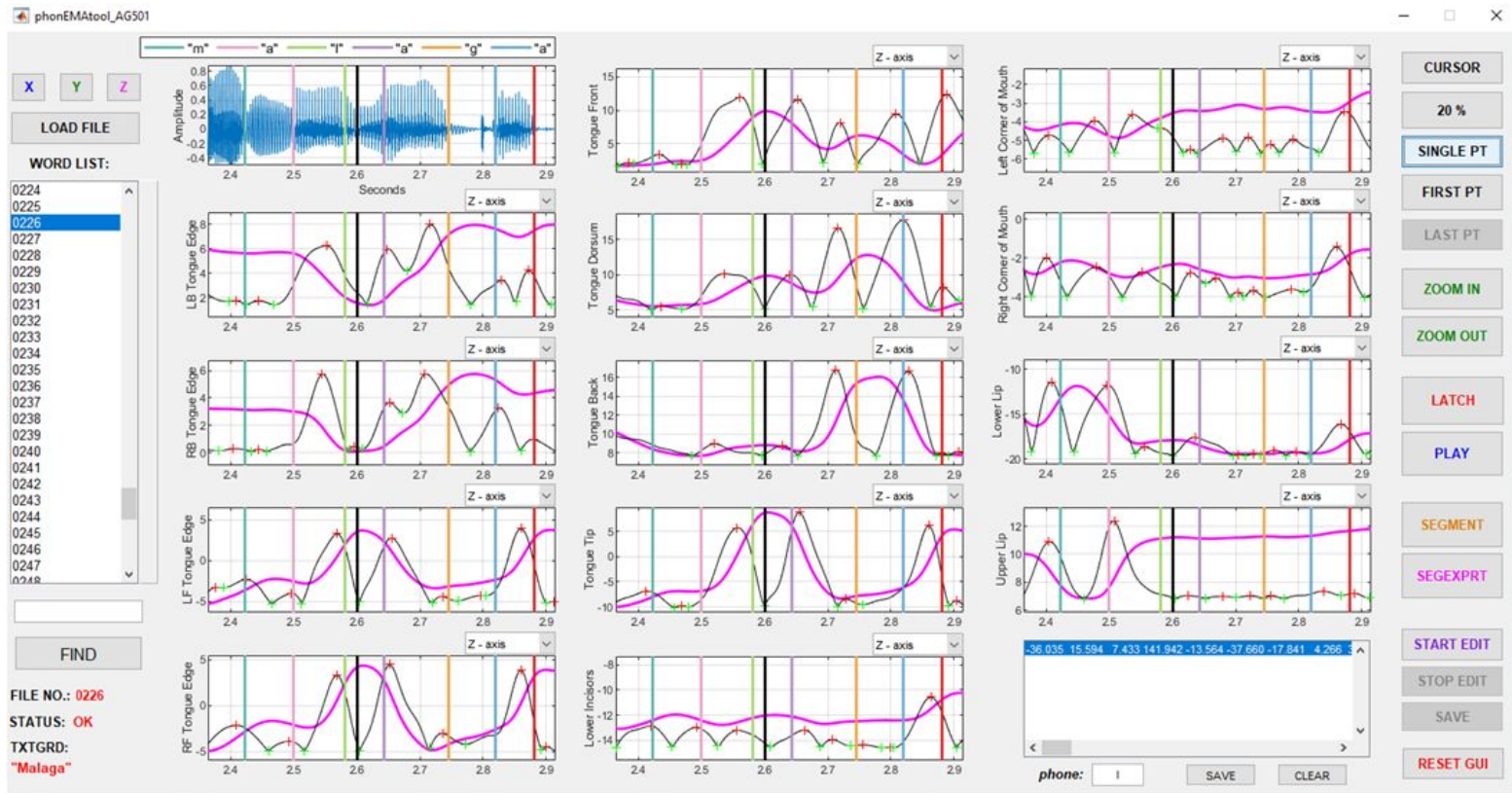
vertical dimension:

z - up-down movements

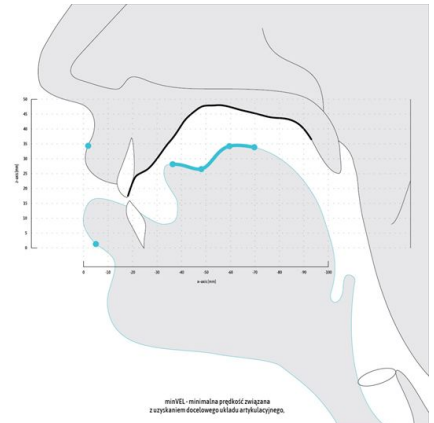
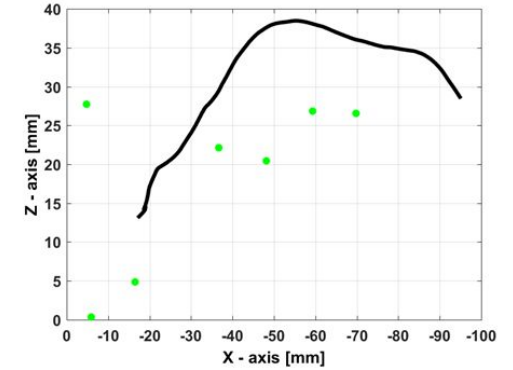
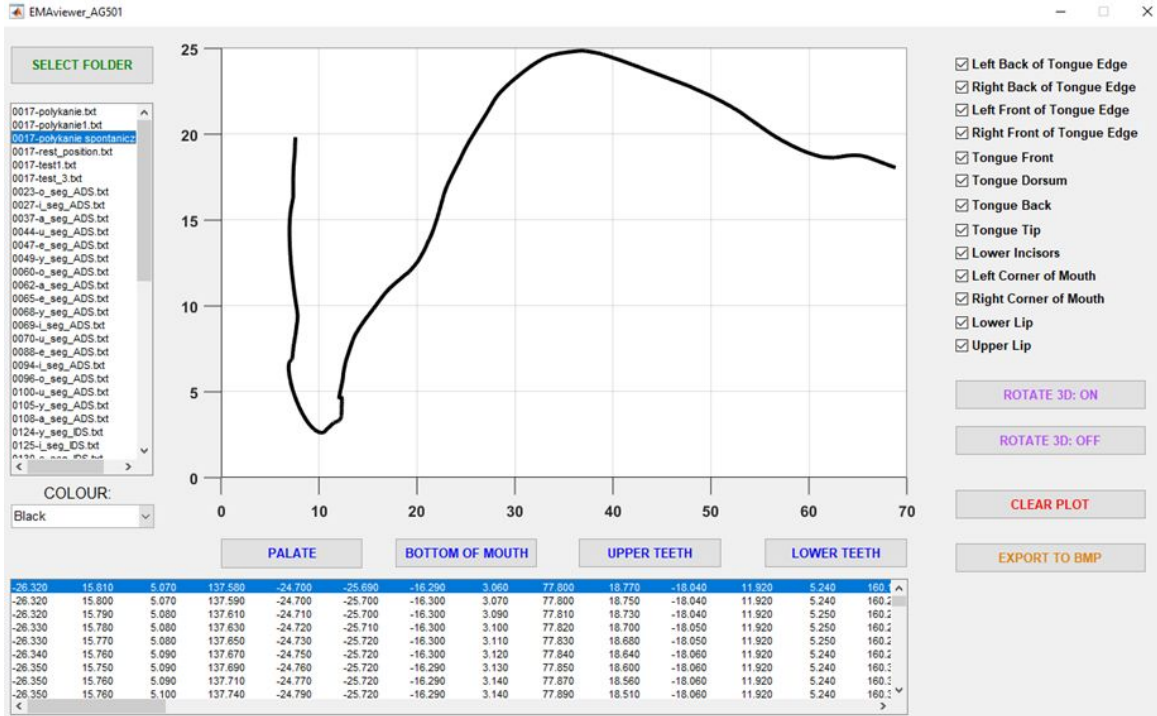
fi, th - angle coordinates (sensor rotation)

id	code	Sensor placement	Sensor position codes (x, y, z, fi, th)
1	LB	Left back of the tongue	LBE <sub>x</sub> ,LBE <sub>y</sub> ,LBE <sub>z</sub> ,LBE <sub>fi</sub> , LBE <sub>th</sub>
23	RB	Right back of the tongue	RBE <sub>x</sub> ,RBE <sub>y</sub> ,RBE <sub>z</sub> ,RBE <sub>fi</sub> ,RBE <sub>th</sub> ,
4	LF	Left front of the tongue	LFE <sub>x</sub> ,LFE <sub>y</sub> ,LFE <sub>z</sub> ,LFE <sub>fi</sub> ,LFE <sub>th</sub>
5	RF	Right front of the tongue	RFE <sub>x</sub> ,RFE <sub>y</sub> ,RFE <sub>z</sub> ,RFE <sub>fi</sub> ,RFE <sub>th</sub>
6	TF	Tongue front	TF <sub>x</sub> ,TF <sub>y</sub> ,TF <sub>z</sub> ,TF <sub>fi</sub> ,TF <sub>th</sub>
7	TD	Tongue dorsum	TD <sub>x</sub> ,TD <sub>y</sub> ,TD <sub>z</sub> ,TD <sub>fi</sub> ,TD <sub>th</sub>
8	TB	Tongue back	TB <sub>x</sub> ,TB <sub>y</sub> ,TB <sub>z</sub> ,TB <sub>fi</sub> ,TB <sub>th</sub>
9	TT	Tongue tip	TT <sub>x</sub> ,TT <sub>y</sub> ,TT <sub>z</sub> ,TT <sub>fi</sub> ,TT <sub>th</sub>
10	LI	Lower gum-teeth line	Ll <sub>x</sub> ,Ll <sub>y</sub> ,Ll <sub>z</sub> ,Ll <sub>fi</sub> ,Ll <sub>th</sub>
11	LC	Left corner of the mouth	LCM <sub>x</sub> ,LCM <sub>y</sub> ,LCM <sub>z</sub> ,LCM <sub>fi</sub> ,LCM <sub>th</sub>
12	RC	Right corner of the mouth	RCM <sub>x</sub> ,RCM <sub>y</sub> ,RCM <sub>z</sub> , RCM <sub>fi</sub> ,RCM <sub>th</sub> ,
13	LL	Lower lip (middle)	LL <sub>x</sub> ,LL <sub>y</sub> ,LL <sub>z</sub> ,LL <sub>fi</sub> ,LL <sub>th</sub>
14	UL	Upper lip (middle)	UL <sub>x</sub> ,UL <sub>y</sub> ,UL <sub>z</sub> ,UL <sub>fi</sub>

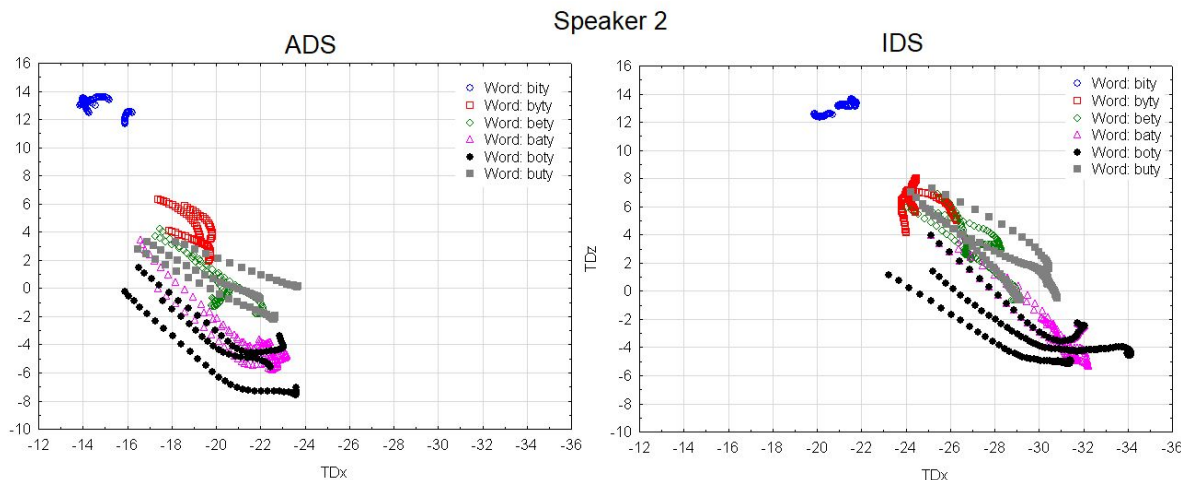
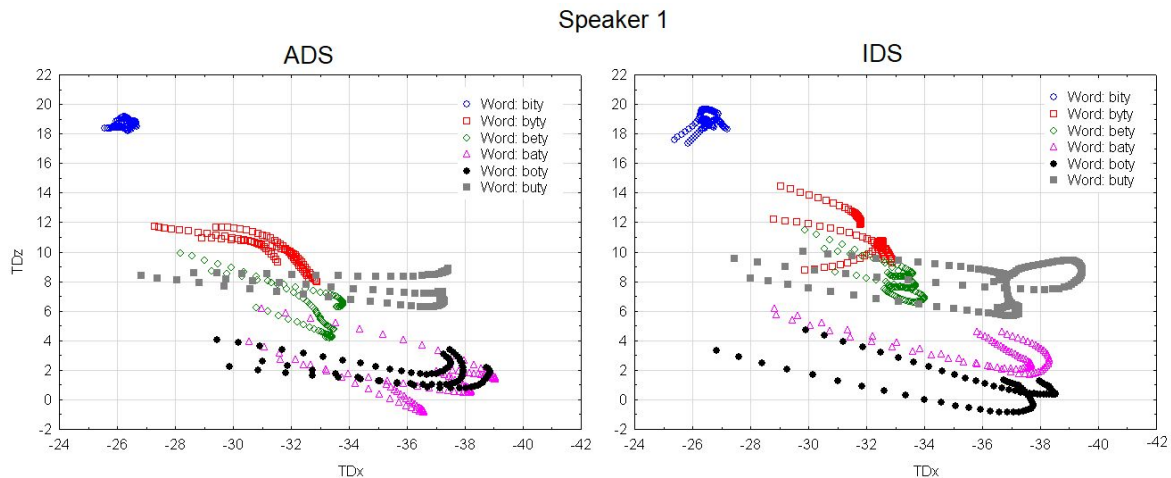
# Articulatory data analysis - phonEMAtool program [Mik, Lorenc 2015-2019]



# Passive articulator contours - EMViewer program [Mik, Lorenc 2015-2019]

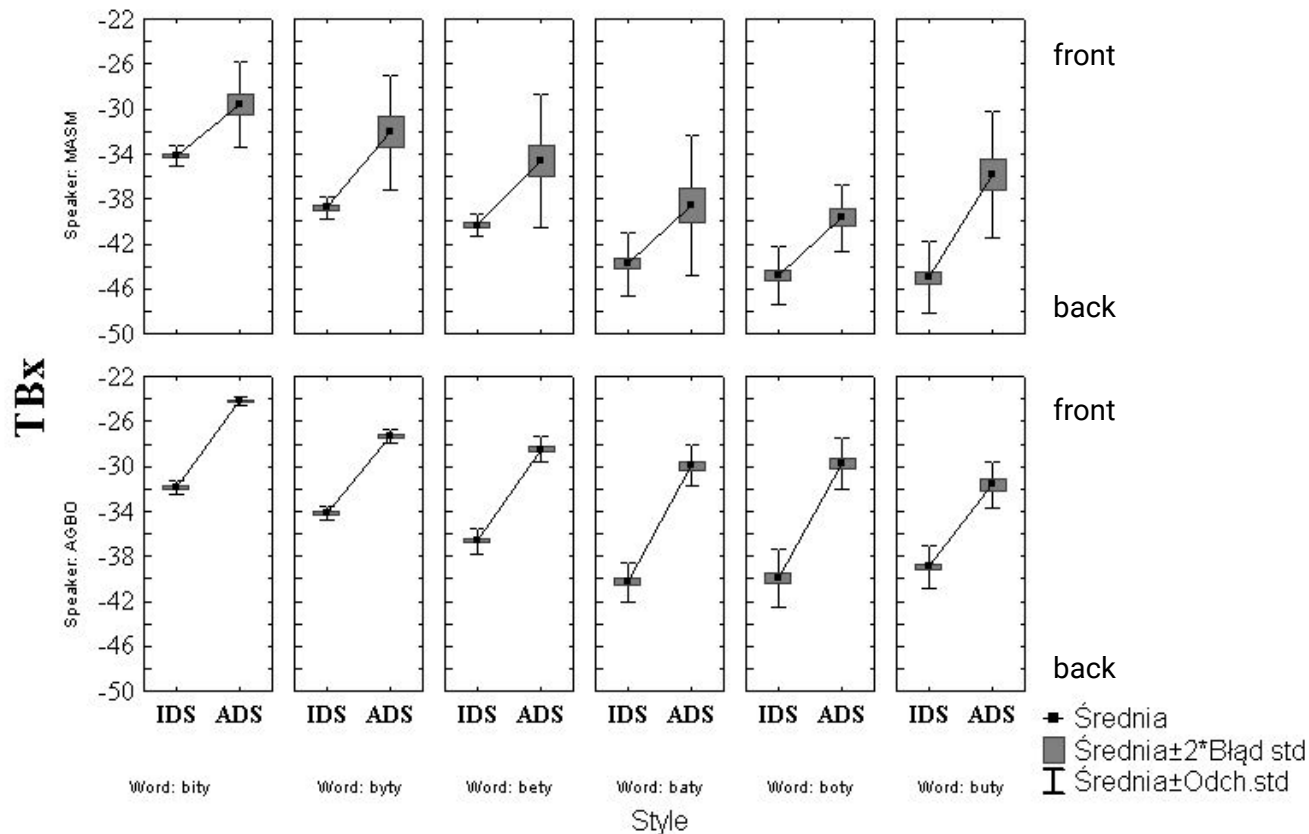


# Tongue dorsum sensor positions ( $TDx$ , $TDz$ ) in ADS & IDS



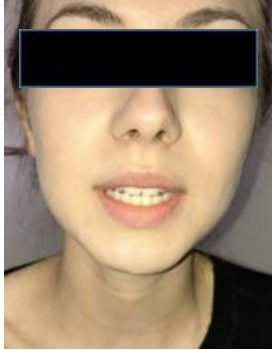
$TDx$  -  $TDz$  (tongue dorsum) sensor positions

# Tongue back sensor positions (*TBx*) in ADS & IDS



Tongue back  
 (horizontal  
 dimension)  
 in IDS vs. ADS  
 (mean values & std dev)

# Detailed speaker diagnosis: Speaker PaSa



asymmetry in the position of the head to the left + asymmetrical movement of the mandible to the left - causes occlusal conflict and damage to the teeth

Incorrect swallowing (tongue towards/between teeth)



difficulties in the vertical movement of the tongue

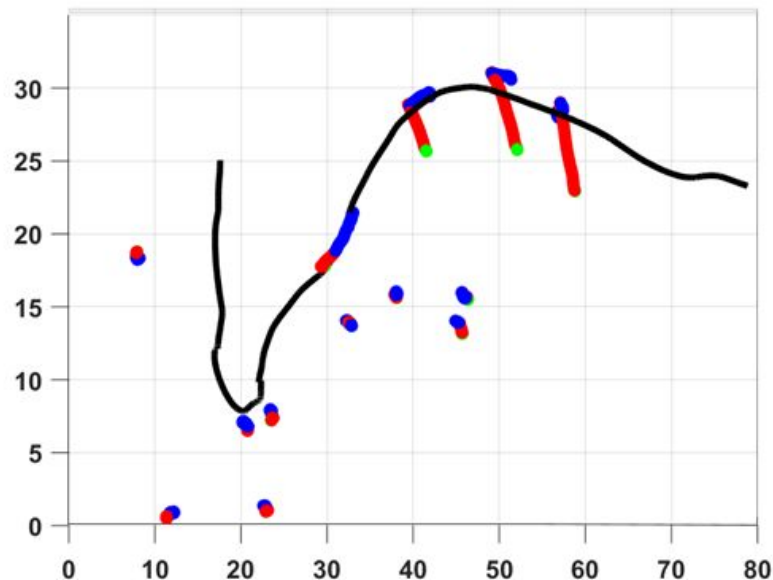


[r]

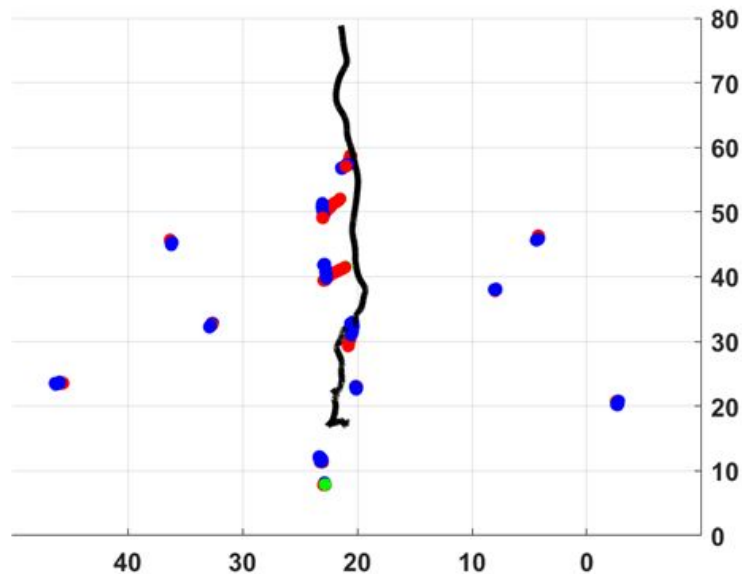


[n]


# Spontaneous swallowing - oral phase - gesture of receding the mass of the tongue



left side view



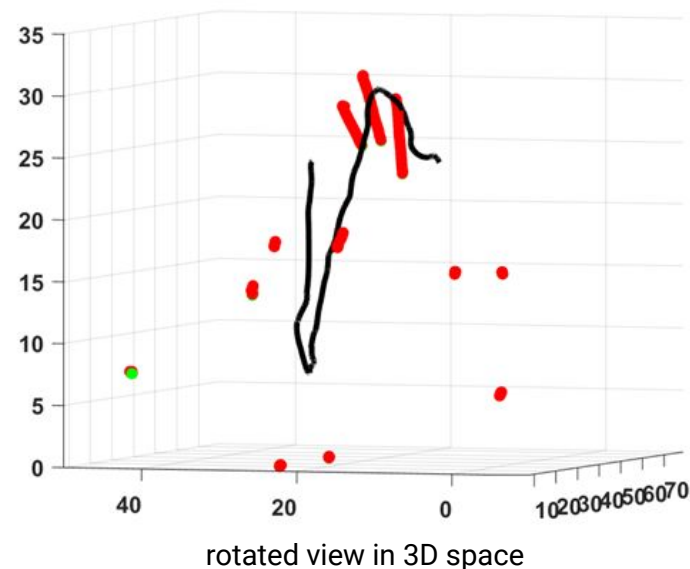
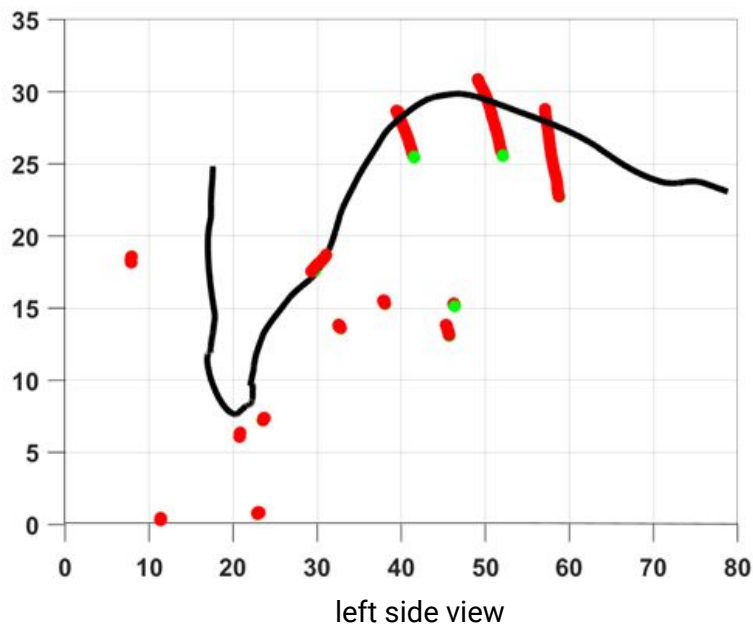
view from the top

 beginning  
of the gesture

 gesture rising

 gesture retracting

# Spontaneous swallowing - oral phase - gesture of rising the mass of the tongue (EMAviewer)

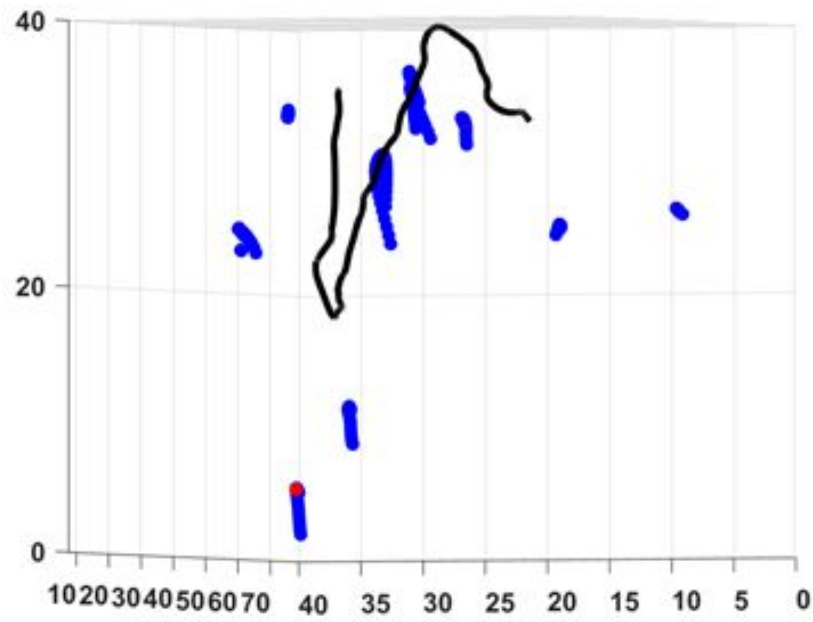
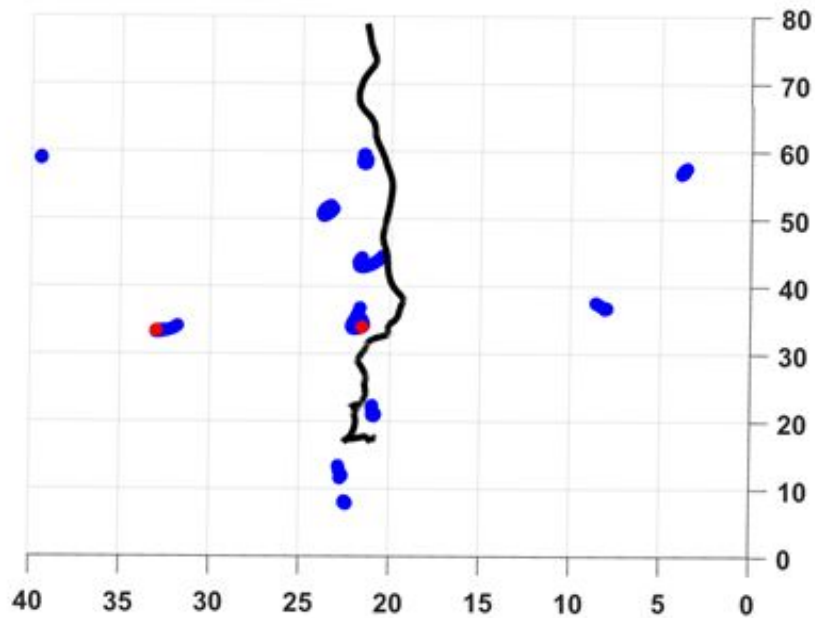


 beginning of the gesture

 gesture rising



[ɔ] in the word *zasiadać* [zaɔdatɔ] ‘sit down’



# A supplement data set: 51 year old patient after malignant tumor surgery

- A patient contacted our speech therapist
- The patient underwent **resection** of the tongue root, floor of the mouth and the oropharynx on the left side (life saving procedure);
- the defect was **reconstructed with an island flap from the greater pectoral muscle**;
- radical radiation therapy was performed as well as two courses of chemotherapy.
- Three months after the surgery, **speech therapy** (combined with physiotherapy) was started, which **after 12 months improved the speech to the communicative level**.



Lesions of the tongue, April 2018.



Reconstruction with an island flap from the greater pectoral muscle.

# Articulation - strategies of searching for new ways and places of articulation



[a]



[o]



[u]



[e]



[i]



[ɪ]



[t] [d]



[ʈ] [ɖ]



[s]

# Conclusions

- We collected the **first data set of ADS & IDS** for the Polish language. Differences between sensor positions in IDS and ADS were found to be statistically significant. The differences relate to e.g. the shape of the tongue mass.
- During the experiment, we observed a range of **subtle phenomena and strategies for both primary functions and articulatory movements**, including **disordered articulations**.
- The methods may **support traditional speech diagnosis and provide insights into strategies realized in primary functions** (tongue rest position, oral phase of swallowing) and articulation, which can be further used in implementing therapeutic procedures.

# Consent form (speaking styles data set)

Will soon be shared  
via [DELAD](https://delad.pl) website  
as well as at  
[katarzyna.klessa.pl](https://katarzyna.klessa.pl)

## **CONSENT 1 (obligatory)**

*I hereby give my consent to the registration of my voice recordings and articulographic data at ... [location of the laboratory, e.g. Applied Phonetics Studio Maria Przybysz-Piwko (University of Warsaw)] ... on ... [date of the recording session] ... for the purposes of scientific research, within the research project entitled 9e.g. "Infant-directed and adult-directed speech: preliminary investigation with Carstens AG501 Articulograph" carried out by [name, surname of the responsible experimenter, e.g. prof. AMU dr hab. Katarzyna Klessa].*

*I also consent to the archiving of these recordings and articulographic data.*

Date signature

## **CONSENT 2 (optional)**

*I consent to the publication of the above-mentioned recordings or their fragments, as well as articulographic data or their fragments, without publishing my name and surname, only in the context of presenting the results of scientific research (e.g. during a scientific conference).*

Date signature

## **CONSENT 3 (optional)**

*I agree to video recording and taking photos during the above-mentioned recording session at the Applied Phonetics Studio Maria Przybysz-Piwko (University of Warsaw). I also consent to the archiving of these videos and photos.*

Date signature

## **CONSENT 4 (optional)**

*I consent to the publication of the above-mentioned video recordings or excerpts thereof, as well as photos for the purpose presentation of research results or the popularization of knowledge.*

Date signature

# Thank You!

<sup>1</sup>klessa@amu.edu.pl

<sup>2</sup>anita.lorenc@uw.edu.pl, <sup>3</sup>magmikmen@wp.pl



ADAM MICKIEWICZ  
UNIVERSITY  
POZNAŃ



UNIVERSITY  
OF WARSAW



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NARODOWE CENTRUM NAUKI

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