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## Measurement of communication impairment after treatment for oral and oropharyngeal cancer by automatic analyses of spontaneous speech associated with biopsychosocial factors

Mathieu Balaguer, Julien Piquier, Jérôme Farinas, Virginie Woisard

IRIT, University of Toulouse Paul Sabatier, Hospitals of Toulouse



# BACKGROUND

- **Speech disorders after treatment of oral or oropharyngeal cancer** (*Borggreven et al., 2007*)
  - **Most common** symptom (*Plisson et al., 2017*)
  - Impact on **social dynamics** (*Reich, 2009*) or **quality of life** (*Mlynarek et al., 2008*)
- **Assessment of speech production**
  - Crucial step in **determining therapeutic strategies** (*Fontan, 2012*)
  - **Unsystematic assessment** of functional repercussion of the speech disorder (*Pommée et al., 2022*)
- Analysis of **spontaneous speech** in the prediction of communication abilities
  - **Most "ecological"** context (*Knuijt et al., 2017*)
  - **Lack** of studies (*Balaguer et al., 2020*)



# BACKGROUND

- Current clinical assessment: **mainly perceptual**  
(Middag et al., 2014)

- **Lack of standardization** altering the reproducibility of the measures (Pommée et al., 2021)

- Inter- and intra-rater **variability** (Kuo & Tjaden, 2016)

- Measure **not always representative** of the patients' own perception of their speech impairment and communication ability (Gray et al., 2012)



- Use of **acoustic and automatic tools**

# OBJECTIVE

**To measure the communication impairment  
in patients treated for oral/oropharyngeal cancer  
using**

Automatic analyses of spontaneous speech  
**ONLY**

Automatic analyses of spontaneous speech  
**AND**  
biopsychosocial questionnaires

- ANR “RUGBI” project (grant ANR-18-CE45-0008)
  - Reviewed and approved by the Committee for the Protection of Persons [CPP: Ouest IV, 19/02/2020, reference 11/20\_3]

# METHODS



## Inclusion criteria

- Patients coming for **consultation** or **hospitalization** in ENT department
- **At least 18 y.o.**
- Having been **treated for OC/OP cancer** for **at least 6 months**



## Non-inclusion criterion

- Patients with **other associated chronic disease**

# METHODS

## 1

### Speech recordings of spontaneous speech

- Semi-structured interview (*Prins & Bastiaanse, 2004*)
- Material
  - ZOOM H4N Pro digital recorder
  - Headset microphone (Thomann T Bone HC 444 TWS)
- Pre-treatment of the audiofiles
  - Isolation of patients' speech using a voice activity detector (Google WebRTC-VAD)\*



# METHODS

1

Speech recordings of spontaneous speech

2

Measurement of biopsychosocial factors (questionnaires)

Associated  
deficits

Cognitive  
status

Anxiety status

Social circles

Health  
perceptions  
relating to  
speech  
disorder

Quality of life

CHI  
(Balaguer et al., 2021)

MoCA  
(Rambeau et al.,  
2019)

HAD  
(Zigmond & Snalth,  
1983)

EDP  
(Nordmann-Dolbeault,  
2009)

ESCS  
(Balaguer et al., 2022)

PHI  
(Balaguer et al., 2020)

EORTC QLQ-C30  
(Aronson et al.,  
1993)  
  
QLQ-H&N35  
(Bjordal et al., 1999)

# METHODS

1

**Speech recordings of spontaneous speech**

2

**Measurement of biopsychosocial factors  
(questionnaires)**

3

**Extraction of acoustic / automatic parameters**

- Caron's psycholinguistic model (*François & Nespoulous, 2011*)

Level analyzed	Category of parameter	Software / System used
Speech signal	F0 and intensity	Praat
	Spectral parameters	
	Cepstral parameter	
Articulatory level	Duration	Voice activity detector (WebRTC-VAD)
	Speech rate	Praat
	Vocalic and non-vocalic segments and pauses	SpeechTools
Articulatory level	Phonemic inventory	Automatic speech recognition system (TDNNf-HMM)
	Confidence scores	
Morphosyntactic level	Lexical inventory	"Lexical" TDNNf-HMM + "Lexique 3.83" database
	Confidence scores	"Lexical" TDNNf-HMM
	Lexical diversity and density	
	Grammatical aspects	
	Grammatical forms	Iramuteq
Pragma-semantic and discursive level	Themes	Microsoft Azure
	Sentiment / feeling	



# METHODS

1

**Speech recordings of spontaneous speech**

2

**Measurement of biopsychosocial factors (questionnaires)**

3

**Extraction of acoustic / automatic parameters**

4

**Selection of parameters (reduction of dimensionality)**

- Relevant parameters: effect present in the sample, limited risk of bias, accessible interpretation (consensus of 3 experts)
- Non-redundant parameters (threshold:  $r_S = .90$ )

# METHODS

1

**Speech recordings of spontaneous speech**

2

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4

**Selection of parameters (reduction of dimensionality)**

5

**Prediction of the communication impairment**

- Outcome = HoCoS (*Balaguer et al., 2022*)
- (1) Using acoustic / automatic parameters only: LASSO regression (*Tibshirani, 1996*)
- (2) Using biopsychosocial parameters
  - (2a) LASSO regression only on biopsychosocial data
  - (2b) Full modelling: linear regression (acoustic / automatic + biopsychosocial)

# RESULTS

1

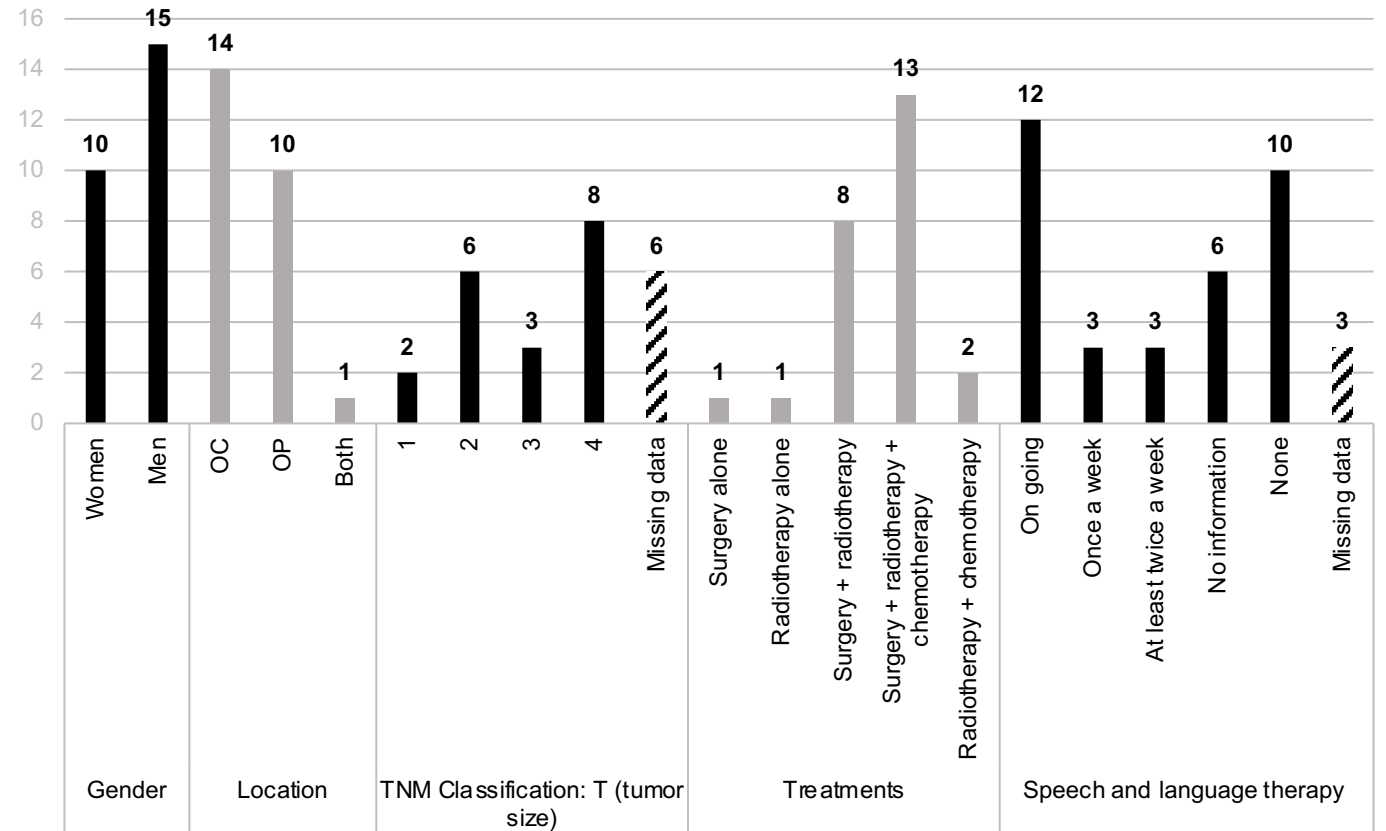
Speech recordings of spontaneous speech

2

Measurement of biopsychosocial factors (questionnaires)

## Characteristics of the participants (n = 25)

- Median age: 67 y.o., IQR: 12
- Average time since treatment: 87.2 months



# RESULTS

All parameters extracted  
149 parameters

3

Extraction of acoustic / automatic parameters

149

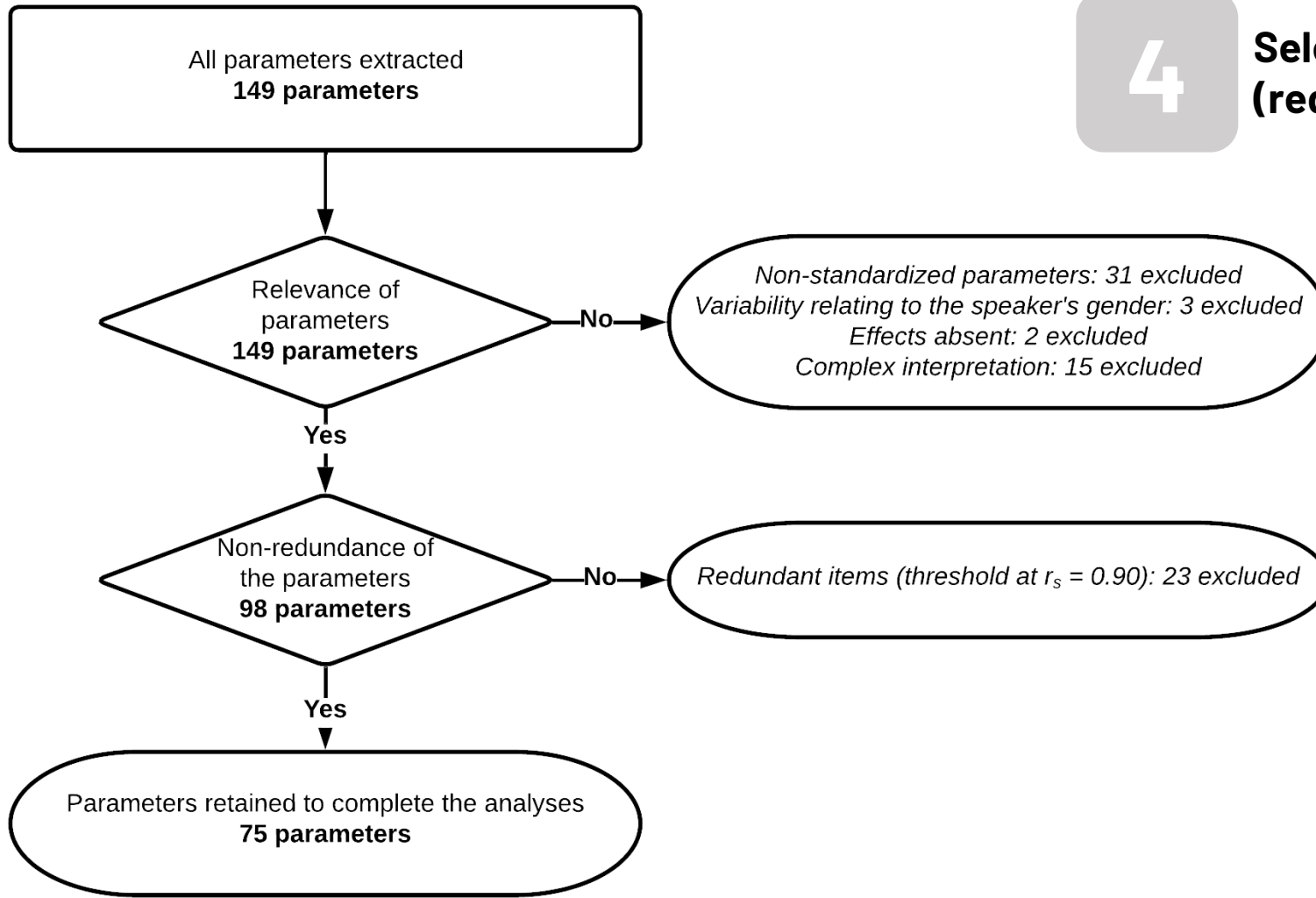
Level analyzed	Number of parameters	Parameters	
Speech signal	10	F0 and intensity	7
		Spectral parameters	2
		Cepstral parameter	1
Articulatory level	43	Duration	8
		Speech rate	9
		Vocalic and non-vocalic segments and pauses	26
Articulatory level	30	Phonemic inventory	24
		Confidence scores	6
Morphosyntactic level	64	Lexical inventory	16
		Confidence scores	7
		Lexical diversity and density	2
		Grammatical aspects	34
Pragma-semantic and discursive level	2	Grammatical forms	5
		Themes	1
		Sentiment / feeling	1

# RESULTS

4

## Selection of parameters (reduction of dimensionality)

149



75

# RESULTS

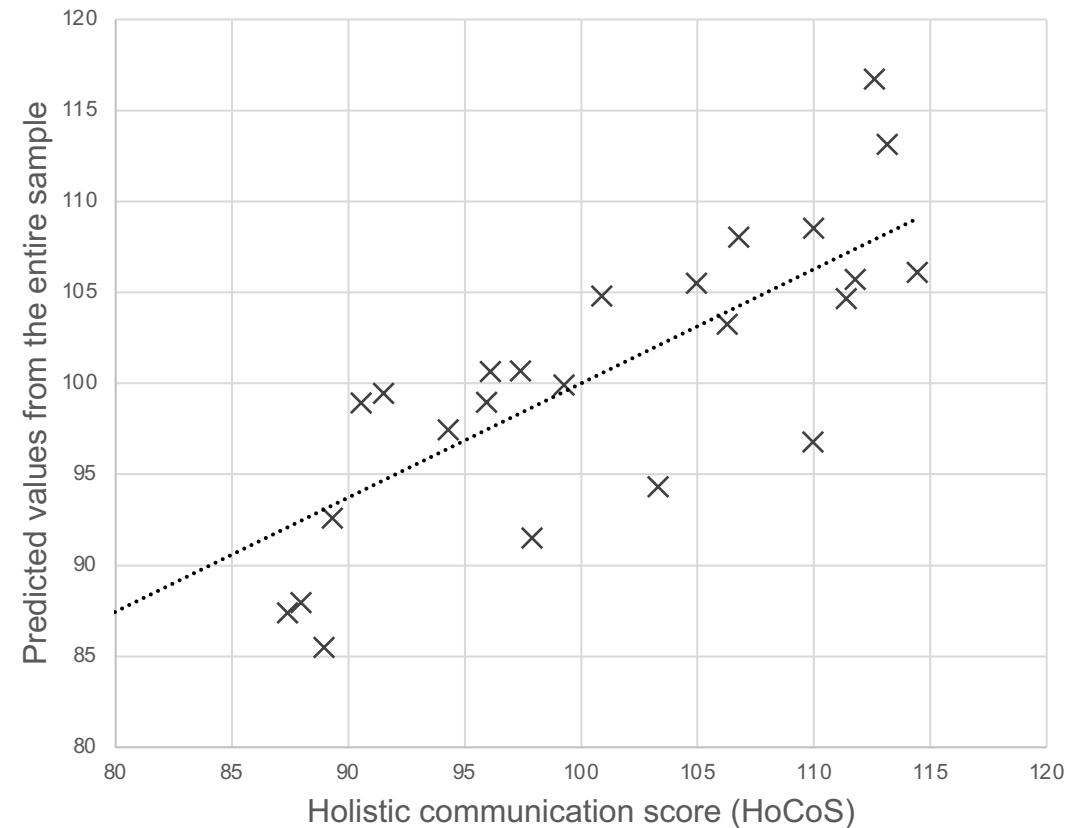
## 5

### Prediction of the communication impairment

- Automatic / acoustic parameters only

- $R^2 = 0.627$
- RMSE = 6.38
- Performances
  - $r_s = .83$  (HoCoS: predicted values)
  - 5-fold cross-validation:  $r_s = .82$
- HoCoS: Holistic Communication Score*
- occs: number of occlusives per second*
- sonants: number of sonants per second*

$$HoCoS = 83.672 + (10.139 \times occs) + (10.891 \times sonants)$$



# RESULTS

## 5

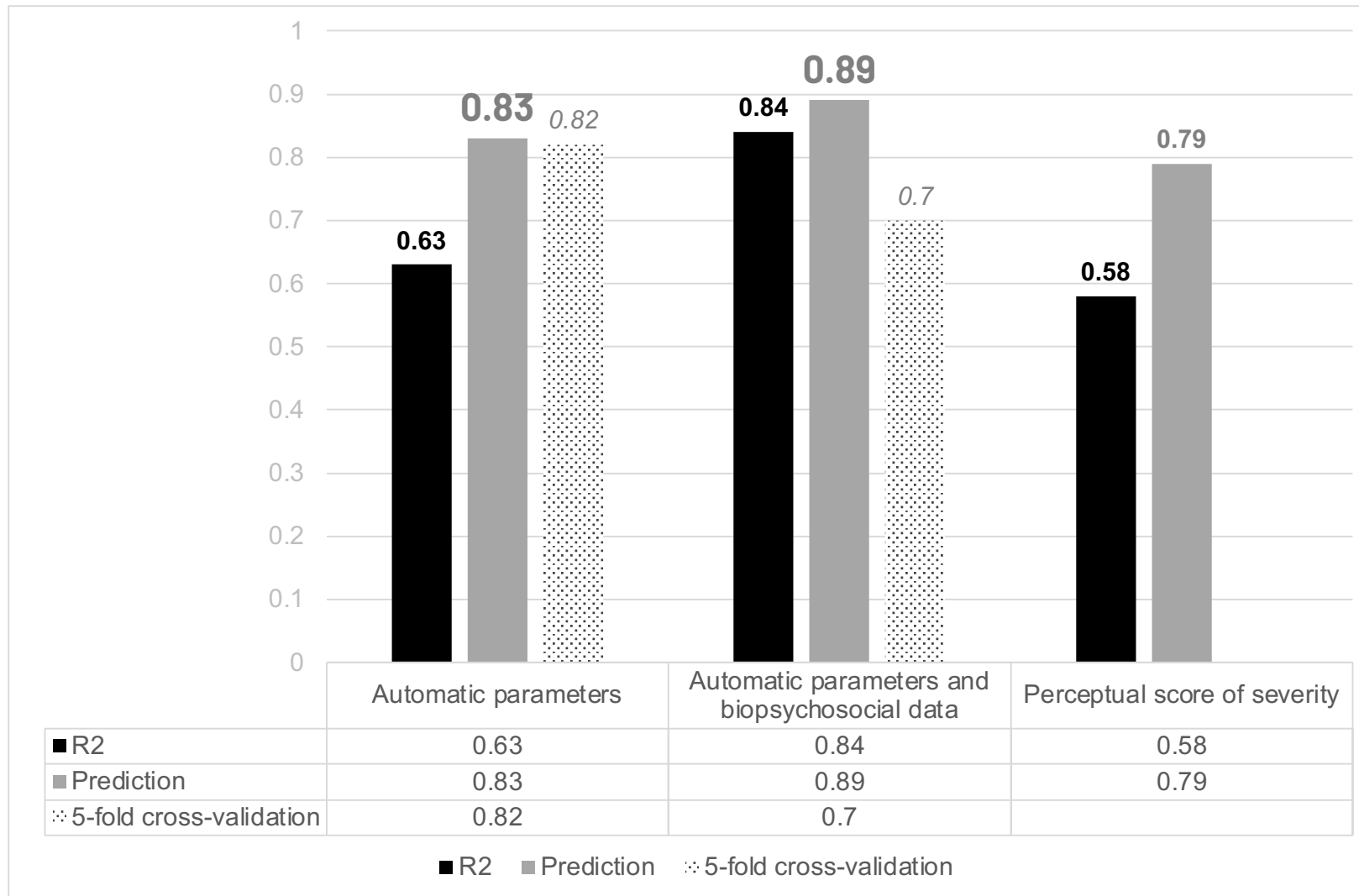
### Prediction of the communication impairment

- Including biopsychosocial data

- $R^2 = 0.836$
- $RMSE = 5.30$
- Performances
  - $r_S = .89$  (HoCoS: predicted values)
  - 5-fold cross-validation:  $r_S = .70$

	Item / Parameter	Coef.
<b>Constant</b>		<b>73.74</b>
<b>Automatic parameters</b>	Number of occlusives recognized per second	<b>9.10</b>
	Number of sonants recognized per second	<b>4.07</b>
<b>Social circles</b>	Average satisfaction with the frequency of contact with the members of the individual's personal circle	<b>1.32</b>
	Average satisfaction with the quality of the conversations with the members of the personal circle	<b>0.05</b>
	Satisfaction with the relationships with the members of extra-familial circle	<b>3.58</b>
	Satisfaction with the way in which financial and administrative aspects of the individual's life are managed	<b>1.56</b>
<b>Anxiety status</b>	"I enjoy the same things as I did before"	<b>-5.22</b>
	Overall anxiety score	<b>3.39</b>
<b>Associated deficits</b>	"Are you afraid of having an accident due to issues with your sense of smell?"	<b>-3.99</b>
<b>Health perceptions relating to speech disorder</b>	Daily handicap experienced due to the speech problem	<b>-0.12</b>

# RESULTS





# CONCLUSION

## 1

### Main elements

- **Reliable prediction of the communication impairment**
  - Using **automatic / acoustic analyses**
  - Holistic approach of communication **using biopsychosocial data**

## 2

### Perspectives

- Increasing the **sample size**
- Improving the **new instrumental measures** of speech disorders in oncology, namely the use of ASR systems
- Considering **functional needs** expressed by patients during follow-up

# THANKS FOR YOUR ATTENTION



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