

# Construction of the automatic Carcinologic Speech Severity Index (C2SI) score



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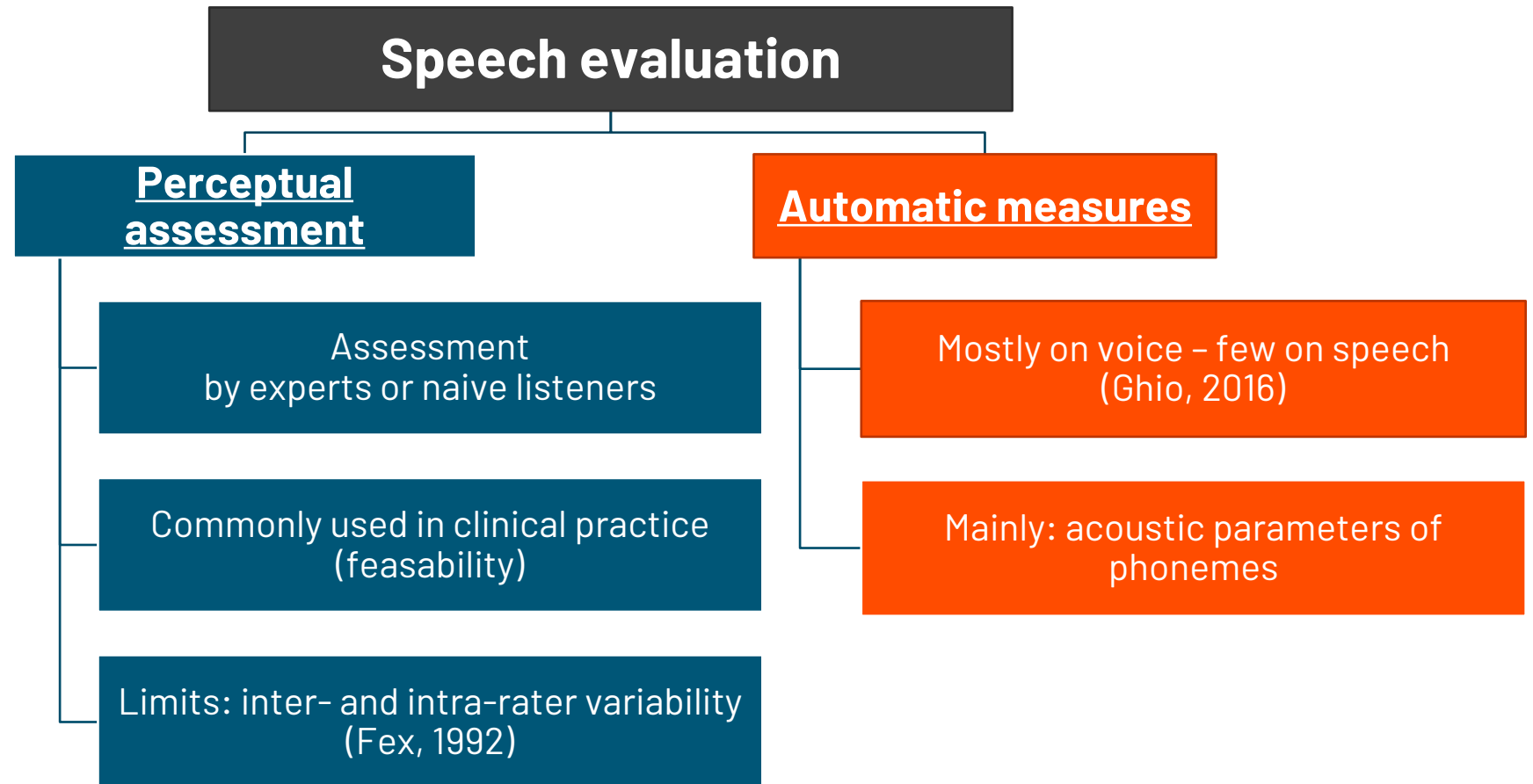


# Context

Upper aerodigestive tract cancer:

14,700 new cases every year in France

massive impact on communication and on the quality of life



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Middag, C. (2013). Automatische analyse van pathologische spraak Automatic Analysis of Pathological Speech.

Borggreven, P. A., Verdonck-De Leeuw, I. M., Muller, M. J., Heiligers, M. L. C. H., De Bree, R., Aaronson, N. K., & Leemans, C. R. (2007). Quality of life and functional status in patients with cancer of the oral cavity and oropharynx: Pretreatment values of a prospective study. *European Archives of Oto-Rhino-Laryngology*, 264(6), 651-657. <https://doi.org/10.1007/s00405-007-0249-5>

# Objectives

Evaluate the validity  
of different automatic speech disorder severity measures  
in patients treated for upper aerodigestive tract cancer,  
in order to build an automated global score

# Materials and Methods

## Database from the C2SI project (Carcinologic Speech Severity Index)

*Grant 2014-135 from the Institut National pour le Cancer in 2014, "Sciences Humaines et Sociales, épidémiologie et santé publique" call, led by Pr Virginie Woisard at the University of Toulouse*



# Materials and Methods

## Study sample

Patients:



Controls:



### Inclusion criteria

- Oral and/or oropharyngeal cancer (TNM: T2 to T4)
- Treatment: surgery and/or radiotherapy and/or chemotherapy
- At least 6 months since the end of treatment

### Non-inclusion criteria

- Additional potential causes of speech disorders (e.g. stuttering)
- Cognitive or visual impairment that might affect the tasks

- Paired by age and gender with patient group

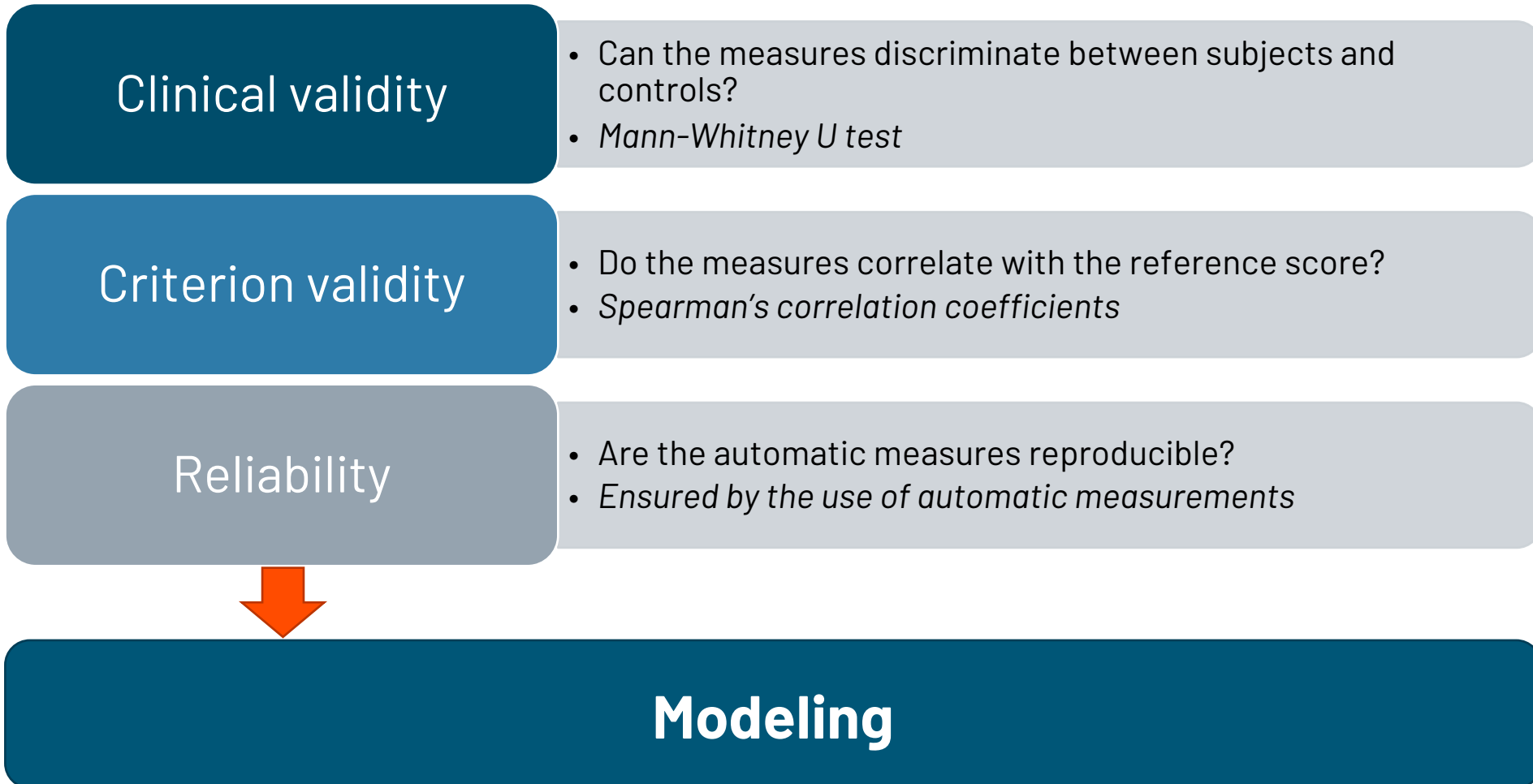
# Materials and Methods

## Tasks

Perceptual assessment			Automatic measures
Visual analog scales (VAS)	Recognition rate		
<b>Intelligibility</b>	Reading ( <b>RED</b> )	Acoustic-Phonetic Decoding ( <b>APD</b> )  <i>Prosodic tasks:</i> Modality ( <b>MOD</b> ) Focus ( <b>FOC</b> ) Syntax ( <b>SYN</b> )	Sustained [a] <b>AAA</b> <b>APD</b> <b>RED</b>
	Picture description ( <b>DES</b> )		
<b>Comprehensibility / Severity</b>	Reading ( <b>RED</b> ) Picture description ( <b>DES</b> )	Comprehensibility ( <b>SVT</b> )	

# Materials and Methods

## Validity and reliability of the automatic measures



# Results

## Study sample characteristics



87 patients

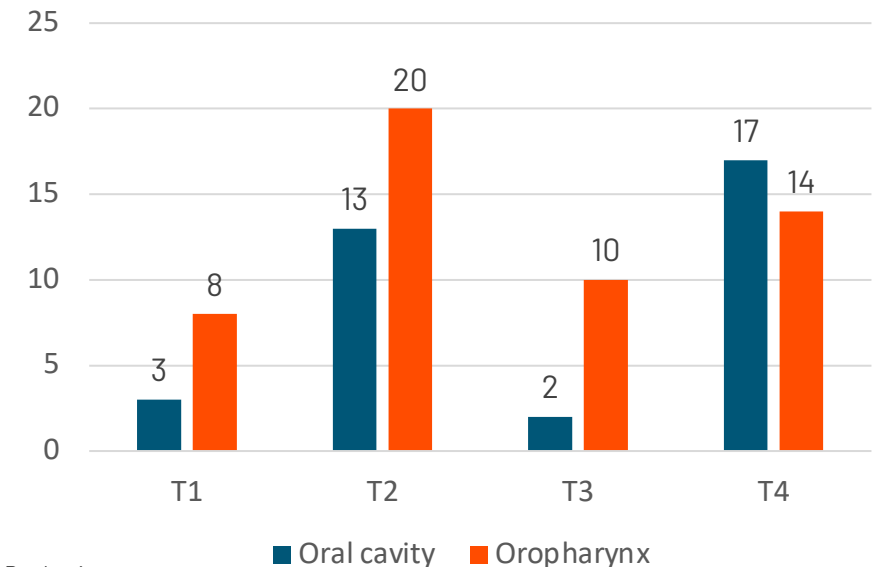
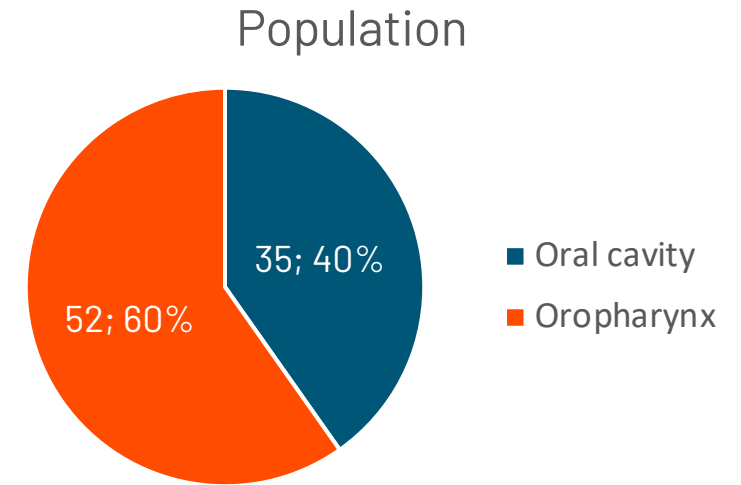
*Median age: 65.8 years old*

*With surgery: 73%*



42 controls

*Median age: 62 years old*

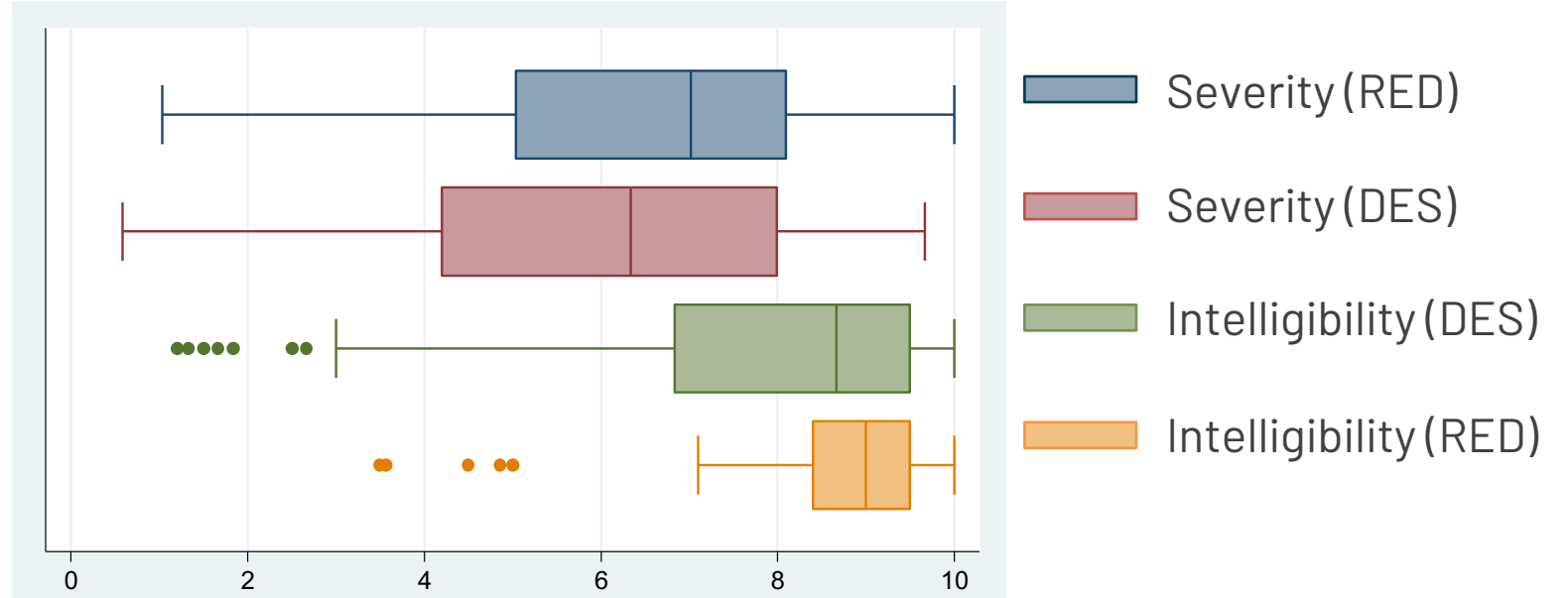




# Results

## Perceptual assessment:

Which reference ?



<i>Patients</i>	<b>Mean</b>	<b>Median</b>	<b>Min</b>	<b>Max</b>	<b>Interquartile range</b>	<b>ICC</b>	<b>95% confidence interval</b>
<b>Severity (RED) / 10</b>	6.51	7.02	1.03	10	5.03 – 8.1	0.69	0.61 – 0.77
<b>Severity (DES) / 10</b>	6.06	6.33	0.58	9.67	4.2 – 8	0.69	0.62 – 0.77
<b>Intelligibility (DES) / 10</b>	7.61	8.67	1.2	10	6.83 – 9.5	0.77	0.70 – 0.83
<b>Intelligibility (RED) / 10</b>	8.69	9	3.5	10	8.4 – 9.5	0.43	0.32 – 0.55

# Results

## Automatic measures: Clinical and Criterion Validity

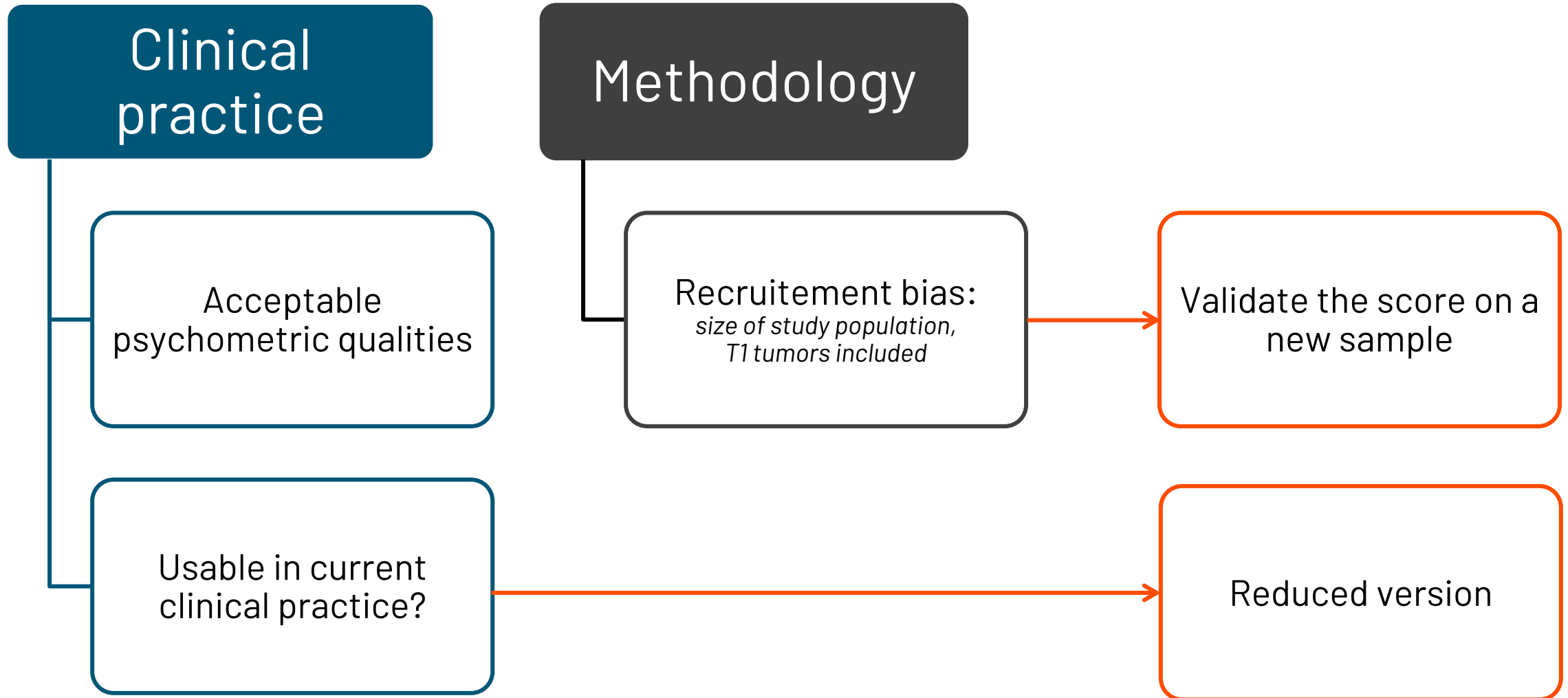
	Task	Clinical validity (U-test)	Criterion validity (Spearman – Severity DES)
<b>Voice dimension</b>			
Fundamental frequency – interquartile range	AAA	p = 0.028	<b>-0.29</b>
Harmonic poorness		p = 0.009	0.05
Quality of glottal attack		p = 0.005	0.01
Jitter – median		p = 0.001	-0.14
Jitter – interquartile range		p = 0.001	-0.11
Pitch instability		p = 0.001	<b>-0.25</b>
Amplitude instability		<b>p = 0.072</b>	0.01
log-HNR – median		<b>p = 0.432</b>	0.23
Harmonics-to-noise ratio		p = 0.005	-0.06
<b>Speech dimension</b>			
Mean number of automatically computed deviation features per phoneme	APD	p < 0.001	<b>-0.62</b>
Distance stimulus – most probable identified logatome (Cumulative rank)		p < 0.001	<b>-0.81</b>
Anomaly rate		p < 0.001	<b>-0.64</b>
Automatic likelihood score		p < 0.001	<b>0.68</b>
Automatic likelihood score	RED	p < 0.001	<b>0.85</b>

# Results

## C2SI score modeling:

Task	Perceptual severity	Bivariate analysis		C2SI		
		Coef.	p-value	Coef.	95% CI	p-value
	Constant			<b>11,26482</b>	9,57 ; 12,96	<0,001*
<b>AAA</b>	Fundamental frequency - interquartile range	-0,29	0,01*	<b>-0,0049184</b>	-0,02 ; 0,01	0,45
	Pitch instability	-0,25	0,04*	<b>-0,0946604</b>	-0,29 ; 0,10	0,34
<b>RED</b>	Automatic likelihood score	0,85	< 0,001*	<b>1,391981</b>	0,84 ; 1,94	<0,001*
<b>APD</b>	Automatic likelihood score	0,68	< 0,001*	<b>-0,147016</b>	-0,77 ; 0,48	0,64
	Cumulative rank	-0,81	< 0,001*	<b>-2,09e-06</b>	-3,86e-06 ; -3,07e-07	0,02*
	Anomaly rate	-0,64	< 0,001*	<b>-0,0111486</b>	-0,05 ; 0,02	0,52
				<b>R<sup>2</sup> = 0,7565</b> <b>Adjusted R<sup>2</sup> = 0,7285</b>		

# Discussion



# Discussion

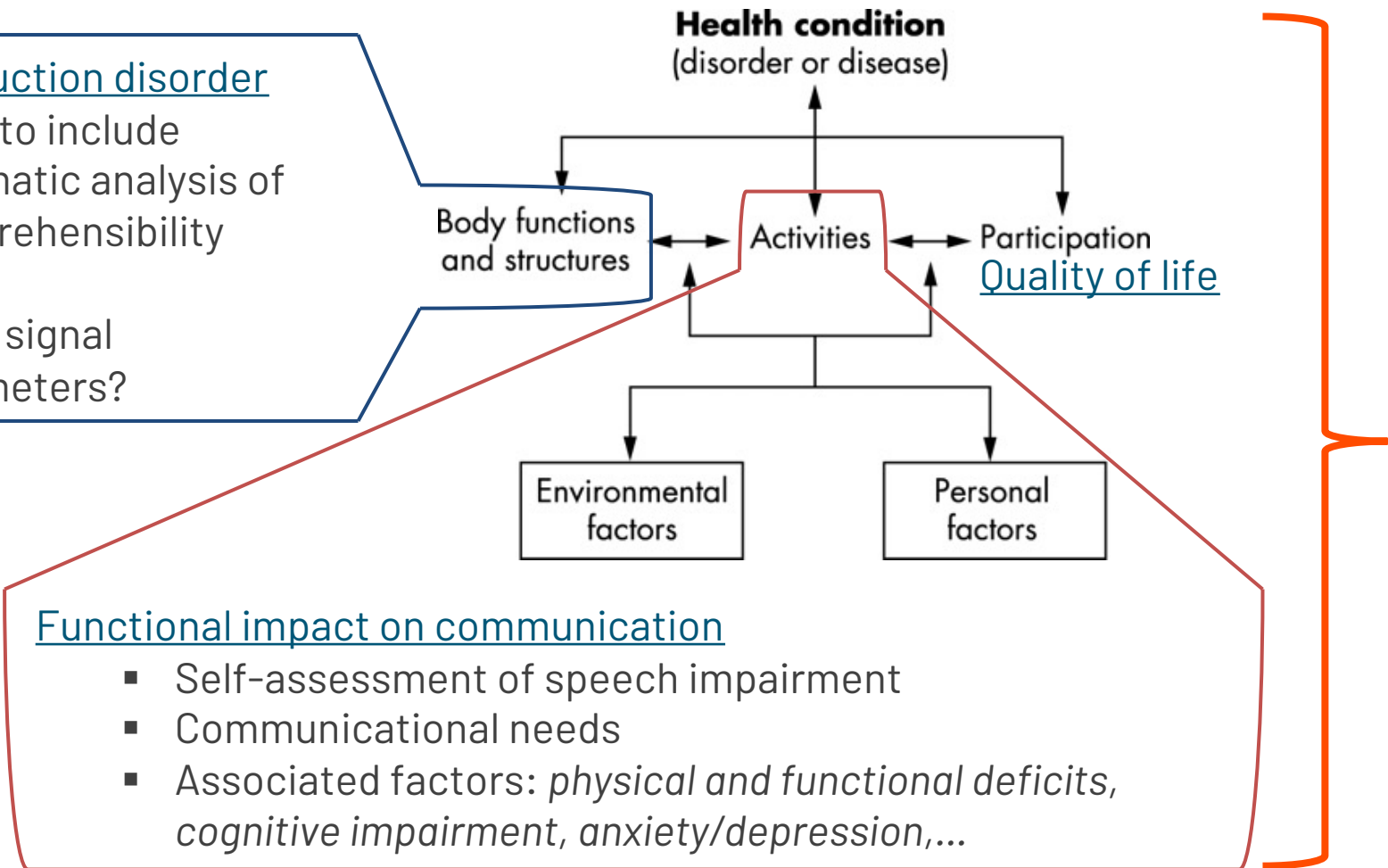
## C2SI score modeling:

Tasks	Perceptual severity	Bivariate analysis		C2SI FULL VERSION			C2SI REDUCED VERSION		
		Coef.	p-value	Multivariate analysis			Multivariate analysis		
		Coef.	p-value	Coef.	95% CI	p-value	Coef.	95% CI	p-value
	Constant			<b>11.26482</b>	9.57 ; 12.96	<0.001*	<b>11.48726</b>	10.50 ; 12.47	<0.001*
<b>AAA</b>	Fundamental frequency - interquartile range	-0.29	0.01*	<b>-0.0049184</b>	-0.02 ; 0.01	0.45			
	Pitch instability	-0.25	0.04*	<b>-0.0946604</b>	-0.29 ; 0.10	0.34			
<b>RED</b>	Automatic likelihood score	0.85	< 0.001*	<b>1.391981</b>	0.84 ; 1.94	<0.001*	<b>1.52926</b>	1.16 ; 1.90	<0.001*
<b>APD</b>	Automatic likelihood score	0.68	< 0.001*	<b>-0.147016</b>	-0.77 ; 0.48	0.64			
	Cumulative rank	-0.81	< 0.001*	<b>-2.09e-06</b>	-3.86e-06 ; -3.07e-07	0.02*	<b>-1.94e-06</b>	-3.36e-06 ; -5.12e-07	0.008*
	Anomaly rate	-0.64	< 0.001*	<b>-0.0111486</b>	-0.05 ; 0.02	0.52			
				<b>R<sup>2</sup> = 0.7565</b>			<b>R<sup>2</sup> = 0.7618</b>		
				<b>Adjusted R<sup>2</sup> = 0.7285</b>			<b>Adjusted R<sup>2</sup> = 0.7550</b>		
				<b>Correlation with reference: 0.87</b>			<b>Correlation with reference: 0.87</b>		

# Discussion

A measure to assess the functional impact of the speech disorder?

- Speech production disorder
- Need to include automatic analysis of comprehensibility tasks
  - Other signal parameters?



- Functional impact on communication
- Self-assessment of speech impairment
  - Communicational needs
  - Associated factors: *physical and functional deficits, cognitive impairment, anxiety/depression,...*

Care adaptation based on the automatic score:

Speech deficit improvement

+

Functional improvement

Thank you for your attention

