Separating representational and noise components of speech prosody perception after stroke

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preprint https://www.medrxiv.org/content/10.1101/2023.10.17.23297140v2

Research questions

Problem: After a **right hemisphere stroke**, more than half of the patients are impaired in their capacity to **produce or comprehend speech prosody**. Despite its social-cognitive consequences for patients, aprosodia following stroke has received limited attention. How can we enhance the **accuracy and specificity** of aprosodia diagnosis compared to the current gold standard (MEC) scale (Côte et al. 2007) ?

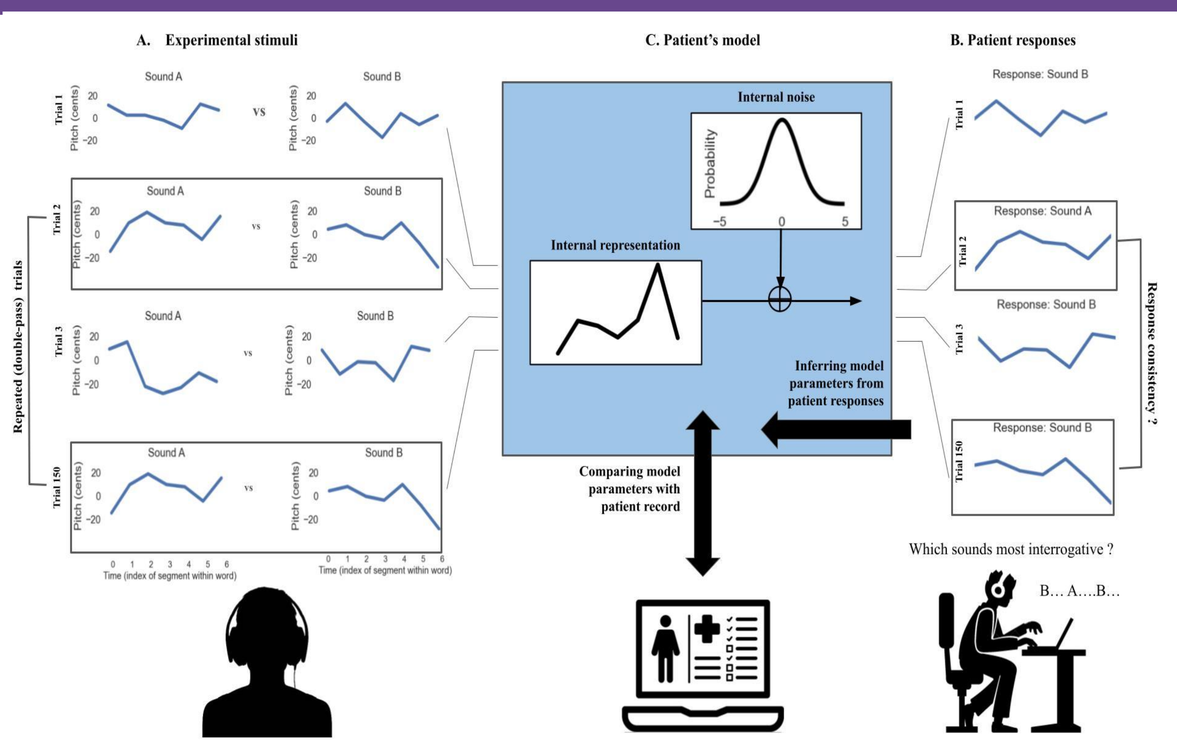
Idea: Use psychophysical reverse correlation to estimate (1) the internal representations underlying how an individual patient perceive speech prosody and (2) the level of internal noise represented as additive Gaussian noise, governing the consistency of applying these representations, and see if these two parameters are better biomarkers of aprosodia.

Methods

Study:

- ❏ Patients listen to multiple pairs of random prosodic variations for the word "really" and judge which pronunciation sounds more like a question.
- ❏ The experiment comprises 150 pairs of pronunciations, taking approximately 10 minutes to complete, with 50 pairs repeated (double-pass).
- ❏ Random pronunciations generated by the CLEESE toolbox (Burred et al. 2021), which uses phase-vocoder as a pitch transformation algorithm.
- ❏ A computational model is fitted to explain patient behavior, relying on two parameters→ **internal representation + internal noise**.

Study Participant characteristics			
		Controls	**Patients**
n		21	22
Sex, n (%)	f	8 (38.1%)	5 (22.7%)
	m	13 (61.9%)	17 (77.3%)
Month after stroke, median [Q1,Q3]			4.0 mo [1.0,5.0]
Stroke type, n (%)	HEM		3 (33.3%)
	ISCH		6 (66.7%)
NIH stroke scale (NIHSS), median [Q1,Q3]			10.0 [5.5,16.0]
MEC Total, median [Q1,Q3]			21.0 [18.2,22.8]



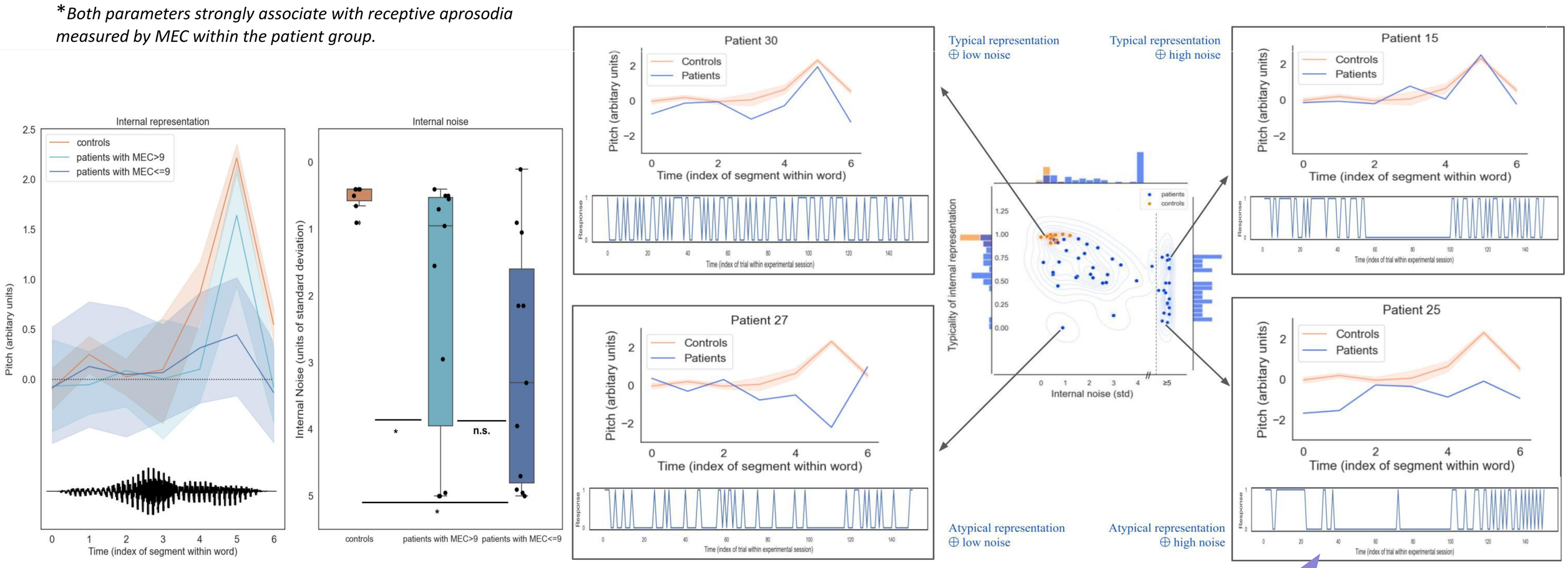
Results

- ❏ Control group responses consistently across trials exhibited typical final-rise prosodic contours with increased pitch at the end of the second syllable, characterized by low internal noise (M=0.51, SD=0.19).
- ❏ Patients' internal representations had both lower amplitude (indicating less discriminative power) and more variable shape across individuals, and were applied with higher levels of internal noise (M=2.57, SD=1.9).

**Both parameters strongly associate with receptive aprosodia measured by MEC within the patient group.*

- ❏ This model have better sensitivity than MEC for separating high-functioning patients from controls; and have good specificity with respect to non-prosody-related impairments of auditory attention and processing.

Measure	Predictor	R^2	β	t(DF)	p-value
Prosody Comprehension (MEC)	**Internal Noise**	0.19	-0.31	-2.22 (20)	0.03
Prosody Repetition (MEC)	**Internal Representation**	0.047	-0.98	-0.98 (20)	0.34
Controls vs. MEC-Negative	**Typicality of Representation**	N/A	N/A	23.0	0.005
Controls vs. MEC-Negative	**Internal Noise**	N/A	N/A	71	0.014
Tone Intensity & duration (AIRTAC 2)	**Internal Representation**	0.45	+0.04	2.97 (11)	0.013
Tone Intensity & duration (AIRTAC 2)	**Internal Noise**	0.35	-0.29	-2.43 (11)	0.033
Anxiety and Depression (HADS)	**Internal Noise**	0.24	+0.11	2.50 (20)	0.021



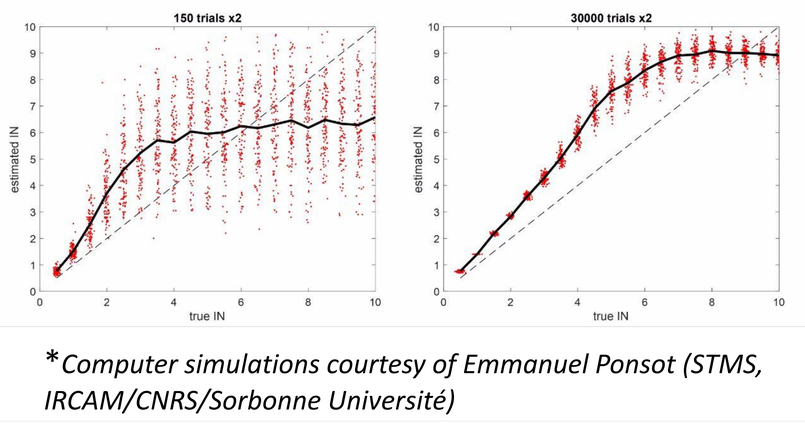
Future Work: Improving internal noise estimation

Issues with double-pass method:

- ❏ The double-pass method assumes that participant behaviour is stable in time, which is not the case with stroke patients who may perseverate in the repeated block.
- ❏ This method doesn't allow studying the evolution of internal noise within the experiment.
- ❏ Confidence intervals around Internal noise (IN) depends on how large the IN and the number of double-pass trials. Small double-pass blocks only allow estimating small IN values (Neri 2010); patients may have big IN and estimating it may require impractically large double-pass blocks.

Solution(s):

- ❏ Fit the data with more accurate and comprehensive statistical framework for calculating internal representations, such as Generalized Linear Model (GLM) (Knoblauch & Maloney 2008, Varnet et al. 2013), and estimate internal noise from within that model, using all non-repeated trials.



**Computer simulations courtesy of Emmanuel Ponsot (STMS, IRCAM/CNRS/Sorbonne Université)*