The process of initiating speech and The search for good analysis tools

Pertti Palo

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Land acknowledgement

I would like to respectfully acknowledge that we are located on Treaty 6 territory, a traditional gathering place for diverse Indigenous peoples including the Cree, Blackfoot, Métis, Nakota Sioux, Iroquois, Dene, Ojibway/ Saulteaux/Anishinaabe, Inuit, and many others. I am a very recent uninvited guest and I have only started learning about their histories, languages, and cultures and of their historical and continued contribution to our community.

Outline

- Introductions - Me and the topic
- Some naming experiments
- The principles
- The tool: Pixel Difference (PD)
- Conclusion

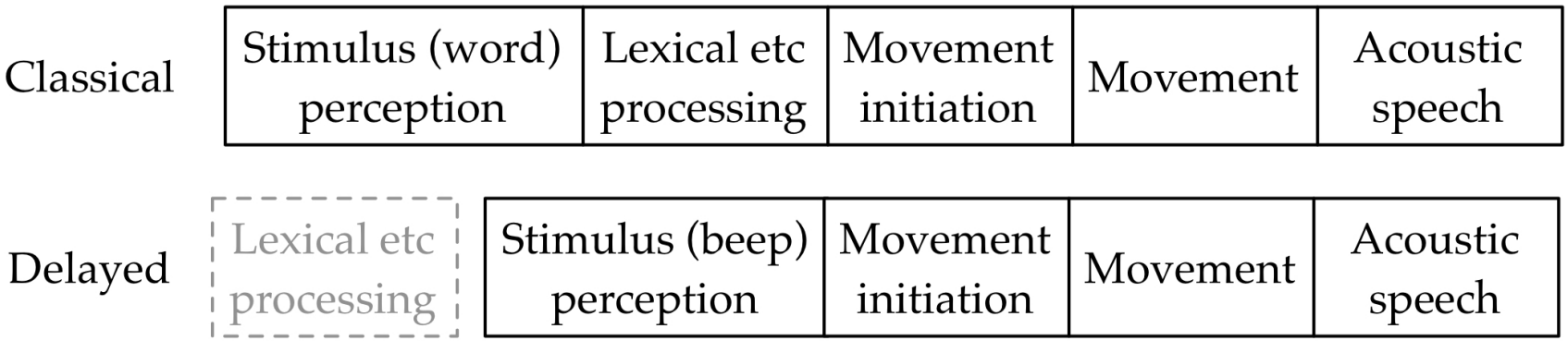
You can find these slides at:
`https://github.com/giuthas-talks/McEwan2025/`

Who's this Pertti Palo?

- I grew up in Finland, became me in Scotland and have since worked in Indiana and here in Edmonton.
- I have a couple of degrees in engineering and a PhD in Phonetics.
- I also have a life in folk music, folk dancing, oral storytelling, wandering (hiking and long distance skiing), role-playing games, crafts (knitting, terrain crafting, and other things).

Introduction

- In my thesis I concentrated on timing of utterance onset in both acoustics and articulation (Palo 2019).
- The data was high-speed tongue ultrasound from a delayed naming experiment – specifically one using the Rastle instructions (Rastle et al. 2005).



Some naming experiments

Demo of classical naming

- Let's try some versions of naming experiments.
- After the slide changes read out loud the word on the next slide as soon as you can.

red

Demo of classical naming

- Let's try that a second time.

green

Demo of delayed naming

- After the slide changes wait for me to snap my fingers.
- After you hear the finger snap, read the word out loud as soon as you can.

orange

Demo of delayed naming

- Rinse and repeat

purple

Demo of delayed naming with Rastle instructions

- After the slide changes wait **at rest** for me to snap my fingers.
- After you hear the finger snap, read the word out loud as soon as you can.

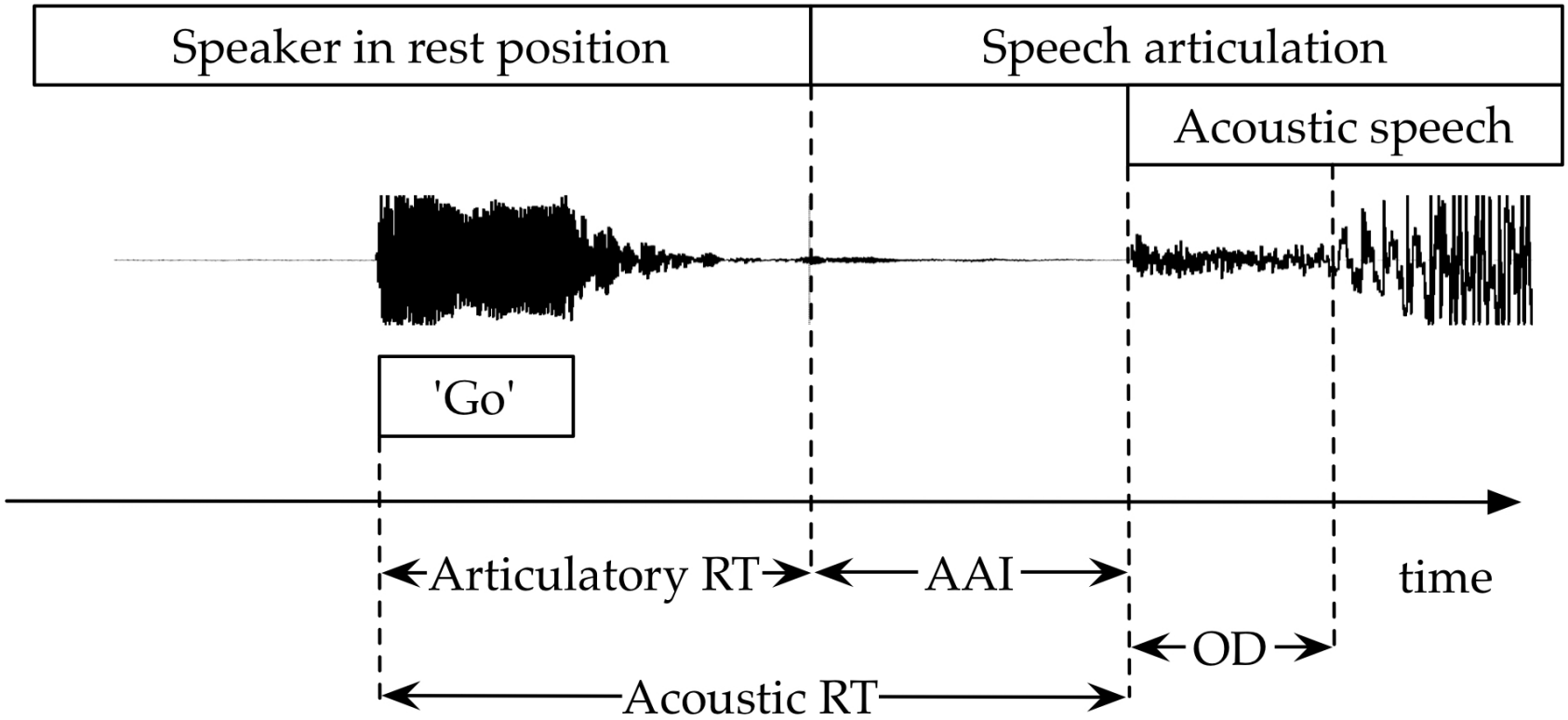
yellow

Demo of delayed naming with Rastle instructions

- Once more

blue

What happened in the last one?



- AAI = Articulatory onset to Acoustic onset Interval
- OD = Onset (or obstruent) Duration

Introduction

- Now imagine that final experiment was recorded with tongue ultrasound imaging.
- And your job was to find the articulatory onset in the resulting greyscale videos.
- Here, let's try it. [external slide set coming up]

Introduction

- When trying to identify movement onset in greyscale videos with a lot of speckle 'noise', it doesn't take long to grow a desire for an easier way.
- The speckle 'noise' maybe caused by a number of factors including bubbles in the acoustic gel between the chin and the probe, noise sources in the equipment, and more interestingly changes in internal structures of tissues – such as muscle fibres tensing and relaxing.

The principles

The principles I

- When we are holding a hammer, everything looks like a nail.
- Every tool is a hammer...
  - ...at least until the first time we use it as a hammer...
  - ...which may lead to the item no longer being a tool at all.

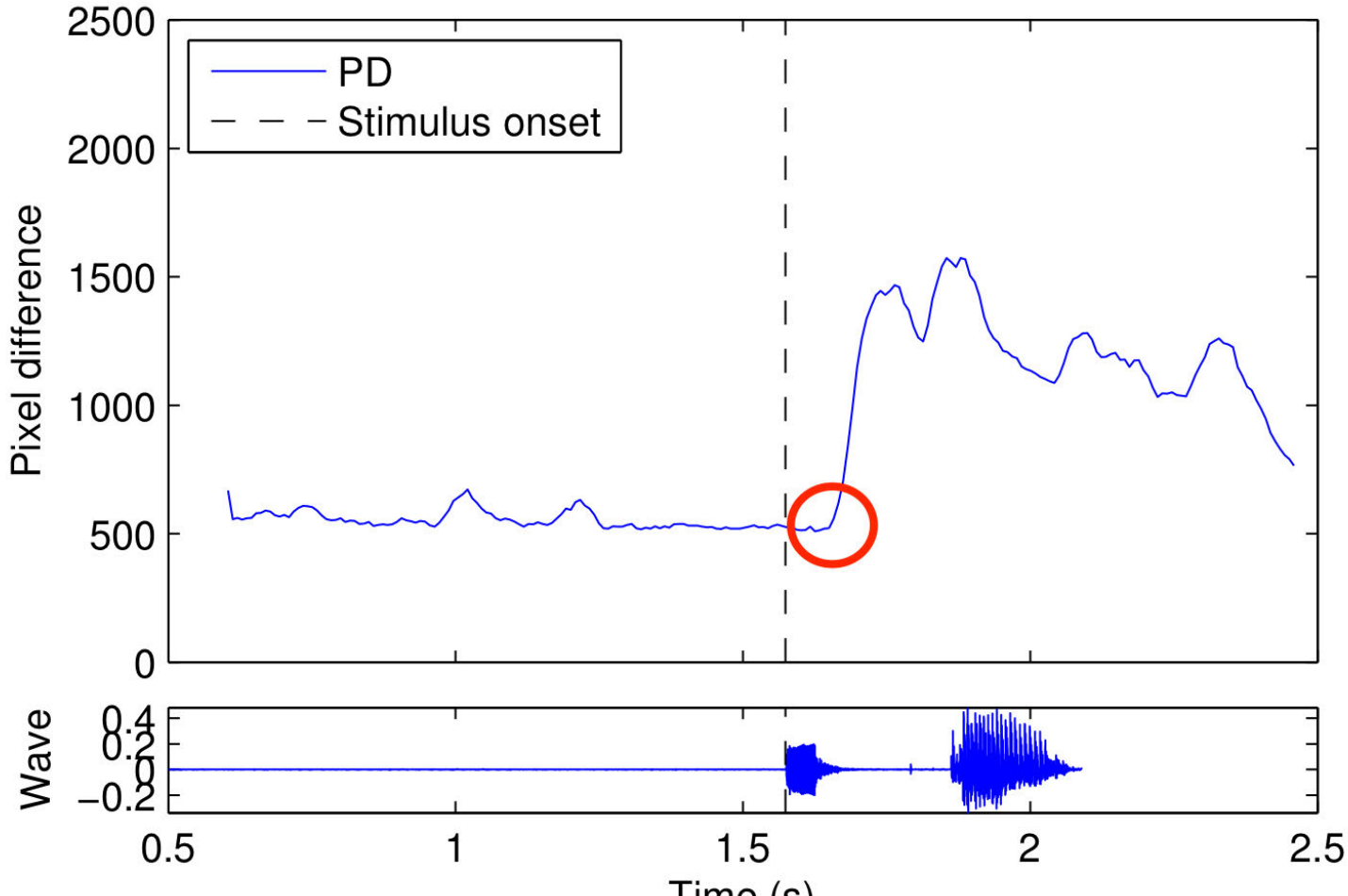
The principles II

- The first thing to do is to figure out if we have nails or something else.
- The second thing to do is to figure out if we are holding a hammer or something else.
- And then get the right tool for the job, if we aren't lucky to begin with.
- And to keep in mind that 'good' is often better than 'best'.

The tool: Pixel Difference (PD)

Pixel Difference (PD)

- The first tool out of the box was manual video segmentation.
- The second tool out of the box happened to work much better – and so for my thesis I used Euclidean distance or *l*2-norm to identify articulatory onsets.

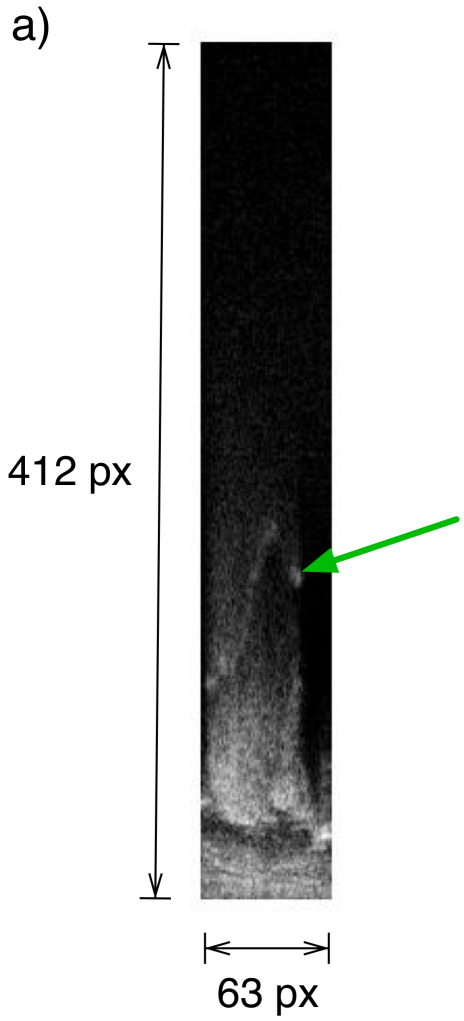


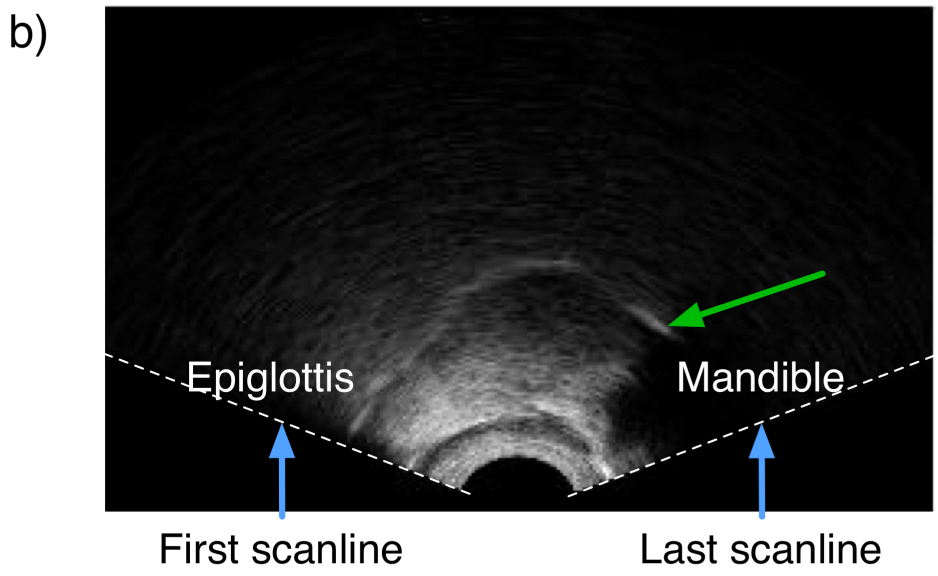
Pixel Difference (PD): Background

- The analysis methods presented here are similar to methods developed by
  - McMillan and Corley (2010) and Drake et al. (2013) who used Euclidean distance on ultrasound frames and
  - Raeesy et al. (2011) who used a similar method on MRI data.
- The way I have used it, it is actually just the Pythagorean theorem applied in a space with a lot more dimensions than 2.

Pixel Difference (PD): Raw vs. Interpolated

- PD is usually calculated on
  - (a) uninterpolated (probe-return) ultrasound data instead of
  - (b) interpolated (human-readable) data.



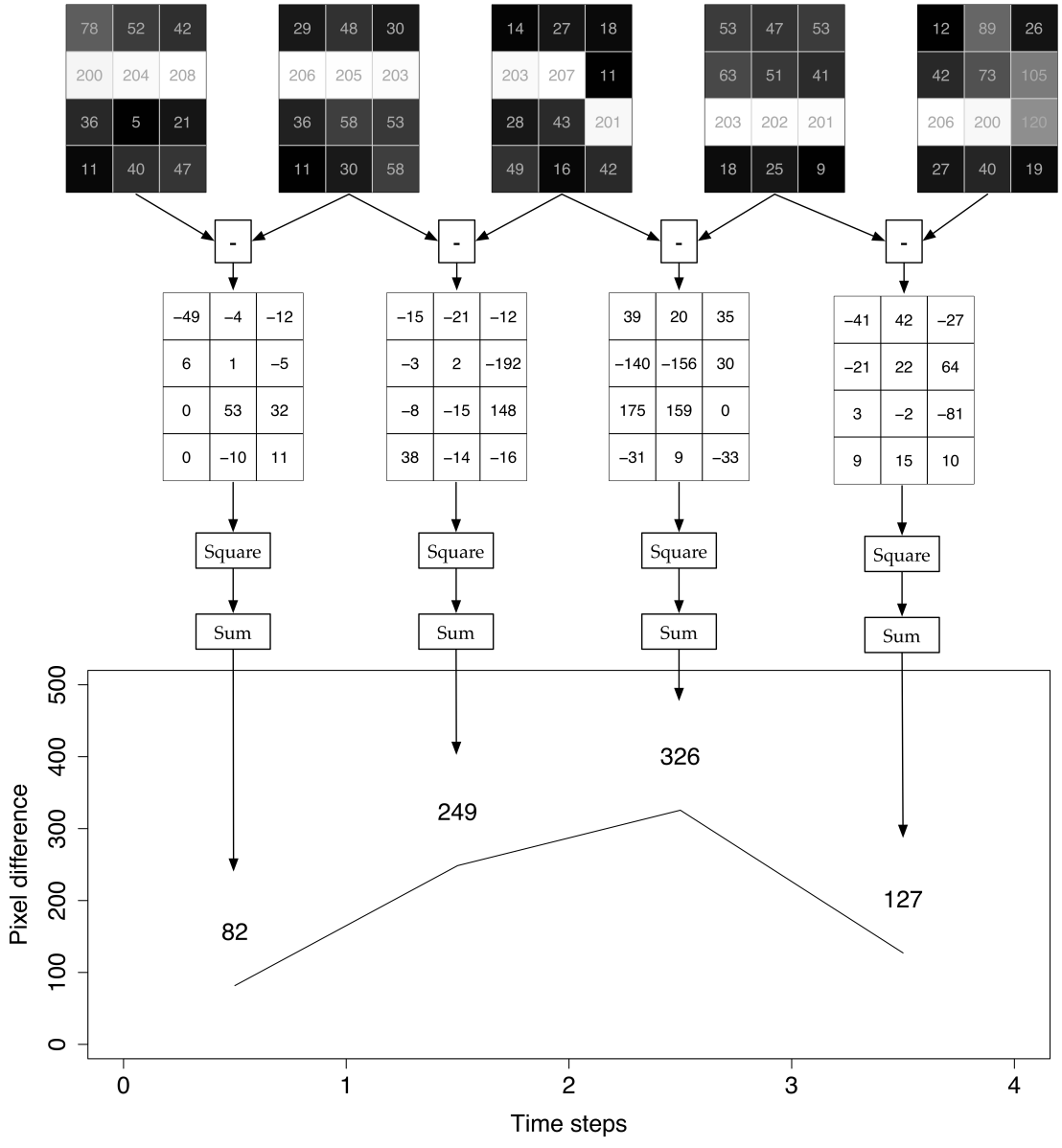


Pixel Difference (PD): The maths

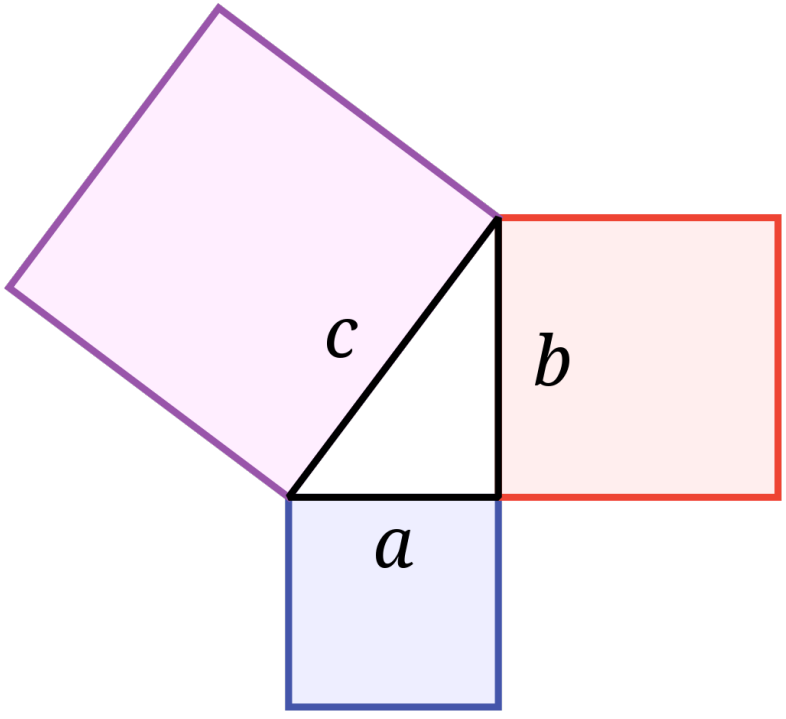
$$I2(t+0.5) = \sqrt{\sum_{i,j}(x(i,j,t+1) - x(i,j,t))^2}$$

- i and j are indices that span the width and height of the image, t is the time index.
- Like said, this is actually just the Pythagorean theorem applied in a space with a lot more dimensions than 2.

Pixel Difference (PD): The maths visually



Pixel Difference (PD): The maths even more simply



Pythagorean Theorem:

$$a^2 + b^2 = c^2$$

(Euclid 2006)

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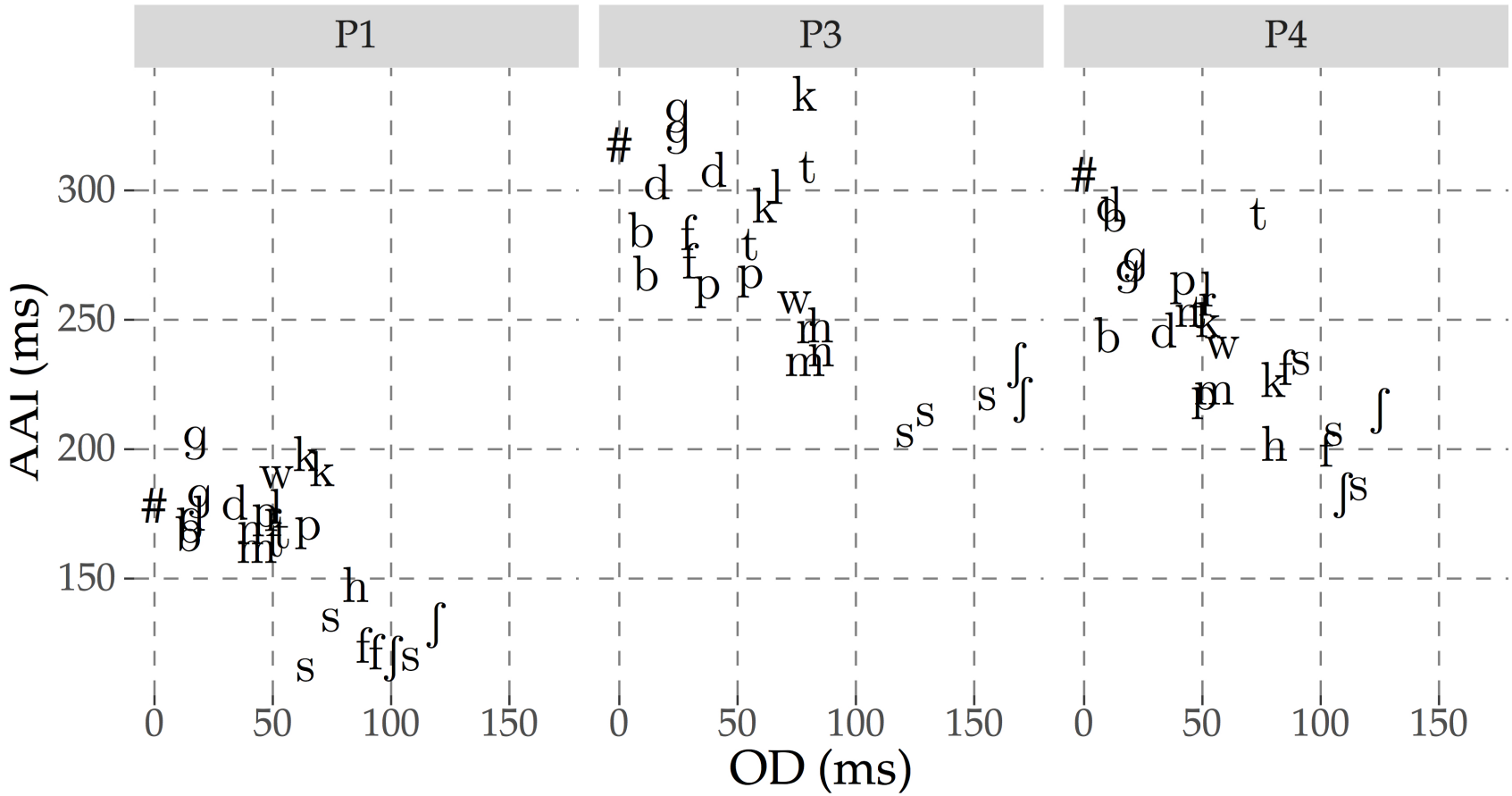
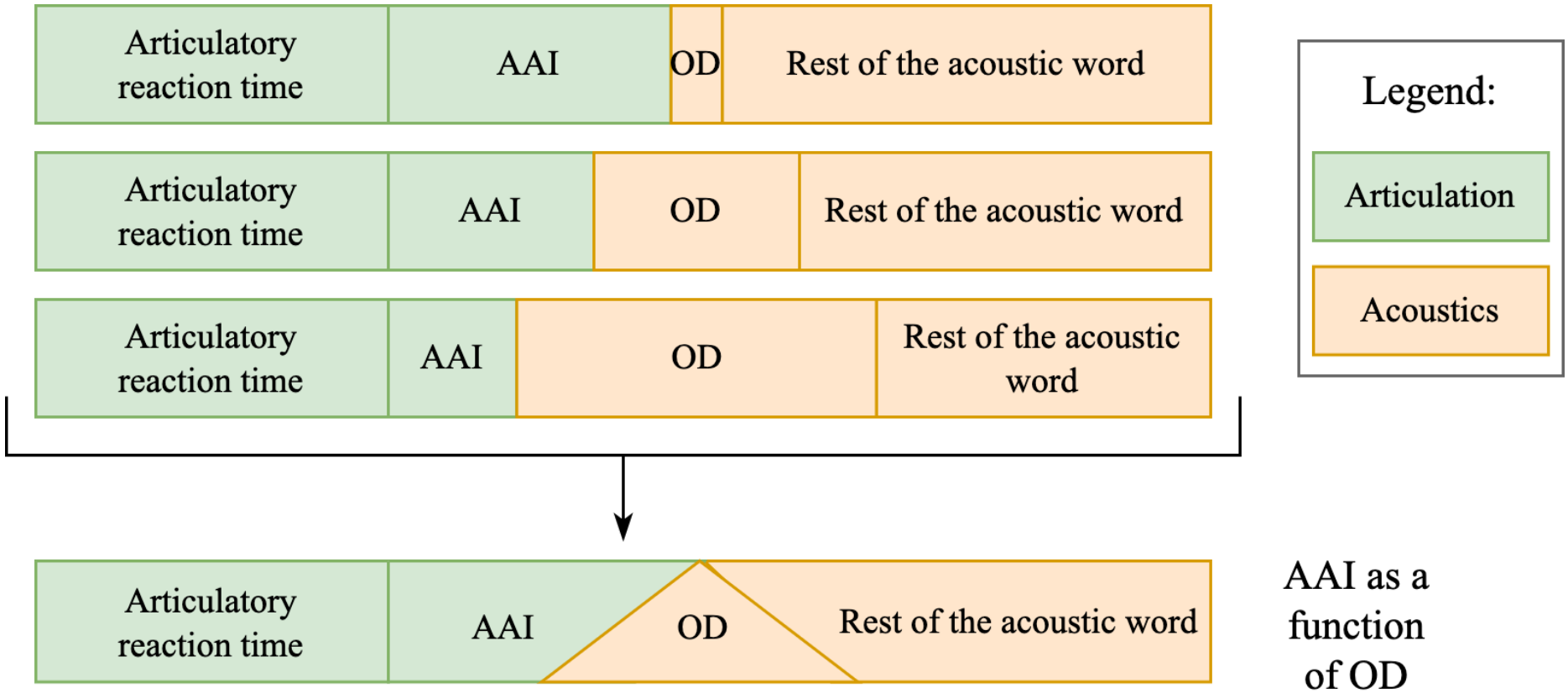
Developments with PD

Delayed naming results: Articulatory to Acoustic Interval

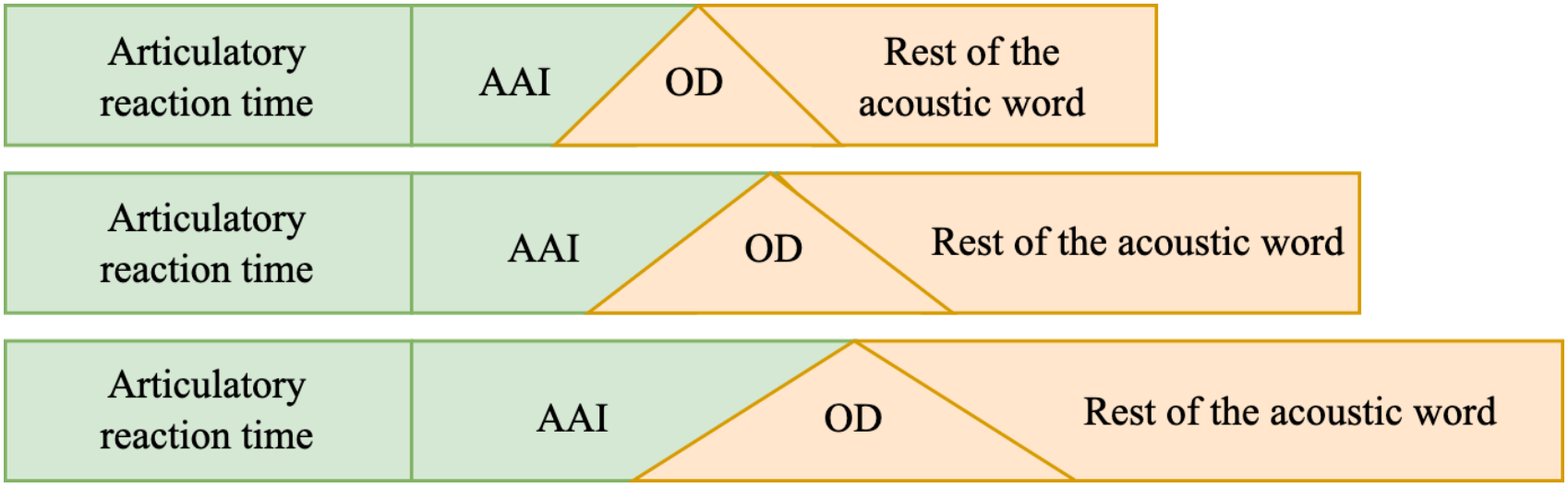


Medianised within participant, over several repetitions and over the vowels /a,i,ɔ/. Over all analysable n = 1386: 439 from P1, 672 from P3, and 275 from P4.

Theory: Effect of OD on AAI

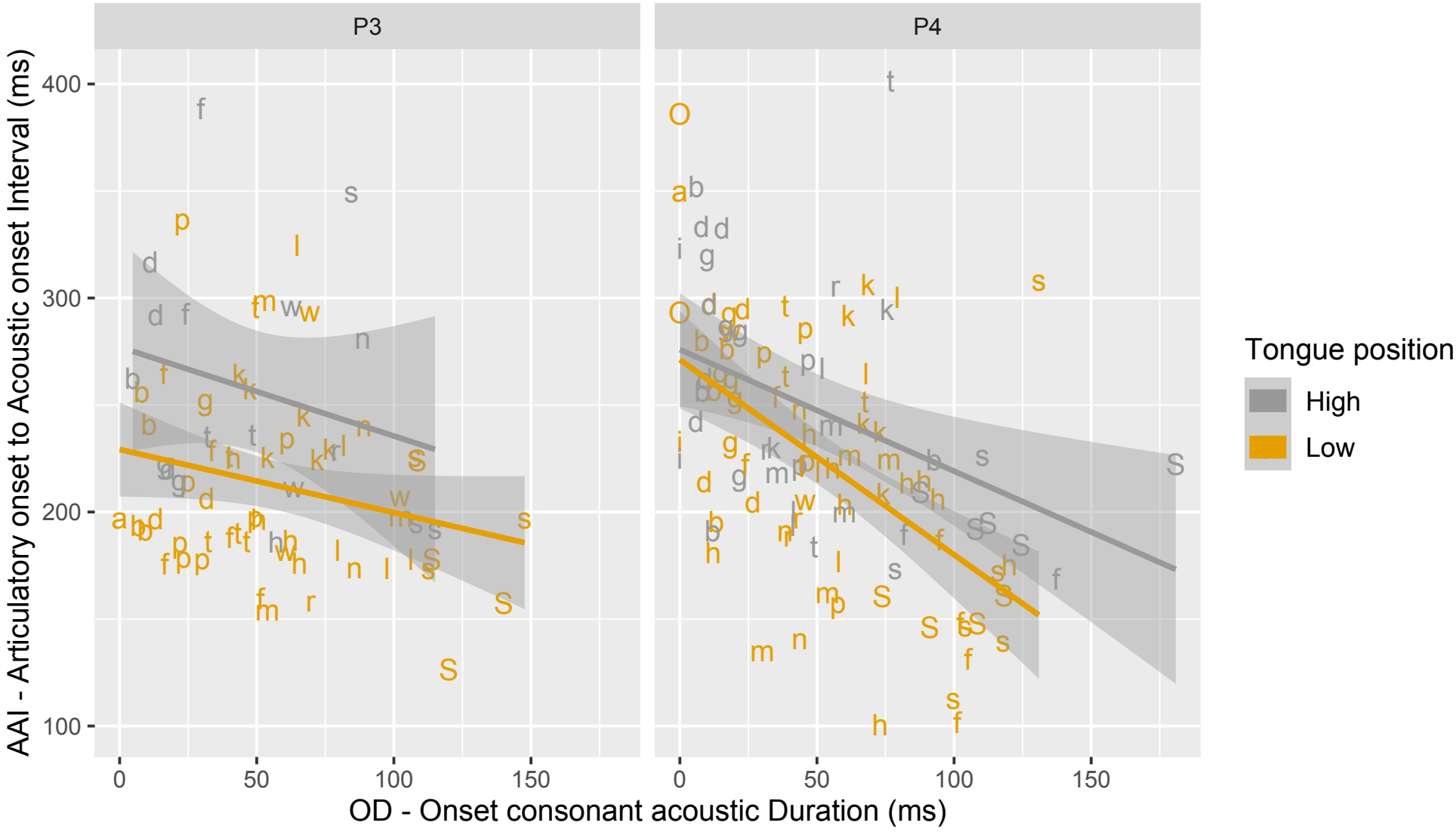


Theory: Effect of articulatory rate on AAI



Starting position

- 'Remain at rest' does not define what 'rest' means.



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Thank you! Questions?