

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

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10 Mar 2025

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).

Classical	Stimulus (word) perception	Lexical etc processing	Movement initiation	Movement	Acoustic speech
Delayed	Lexical etc processing	Stimulus (beep) perception	Movement initiation	Movement	Acoustic speech

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.

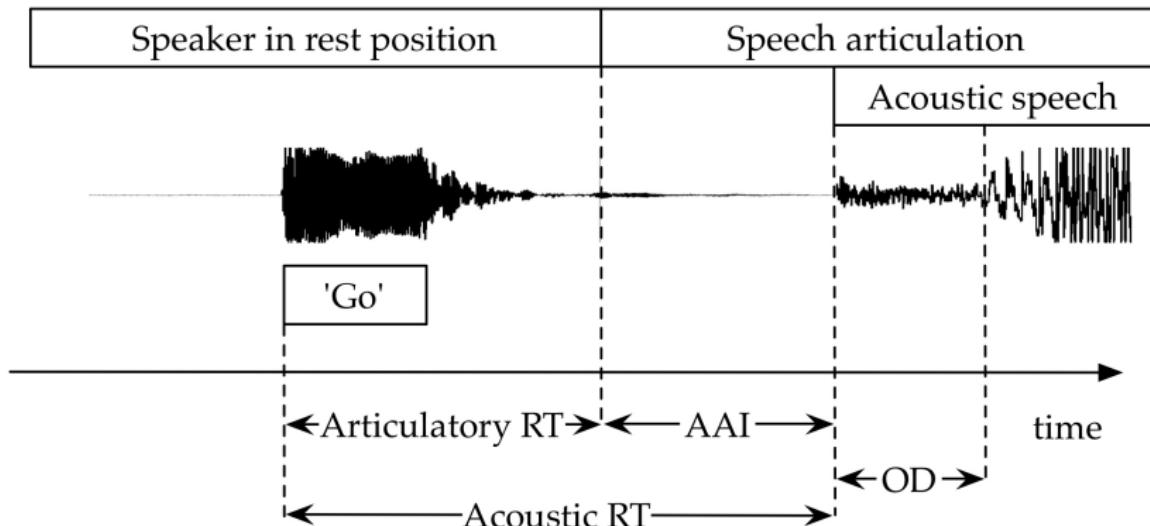
yellow

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.

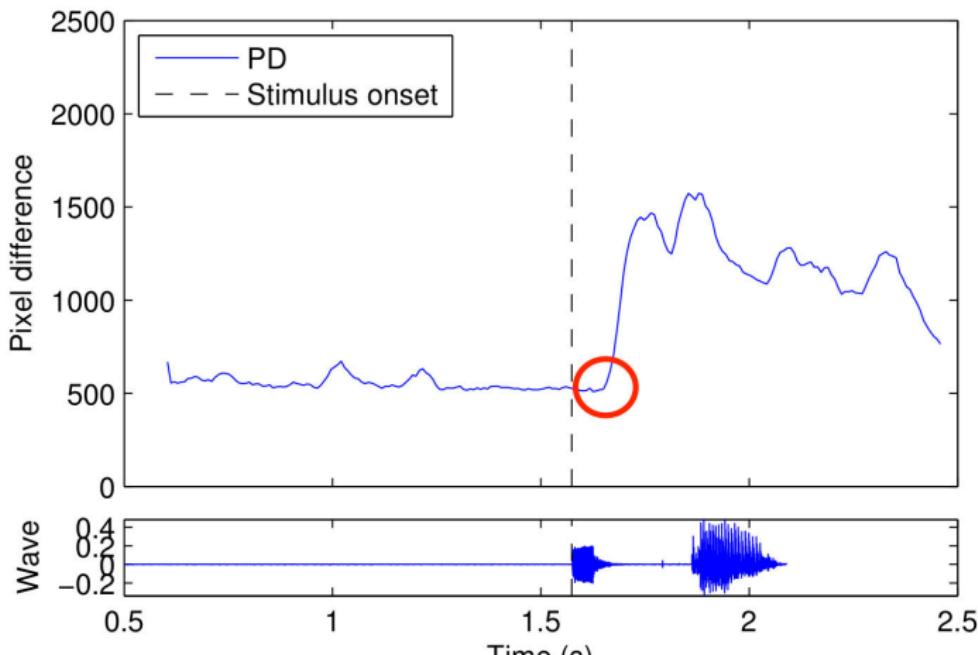
The principles II

- ▶ 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.

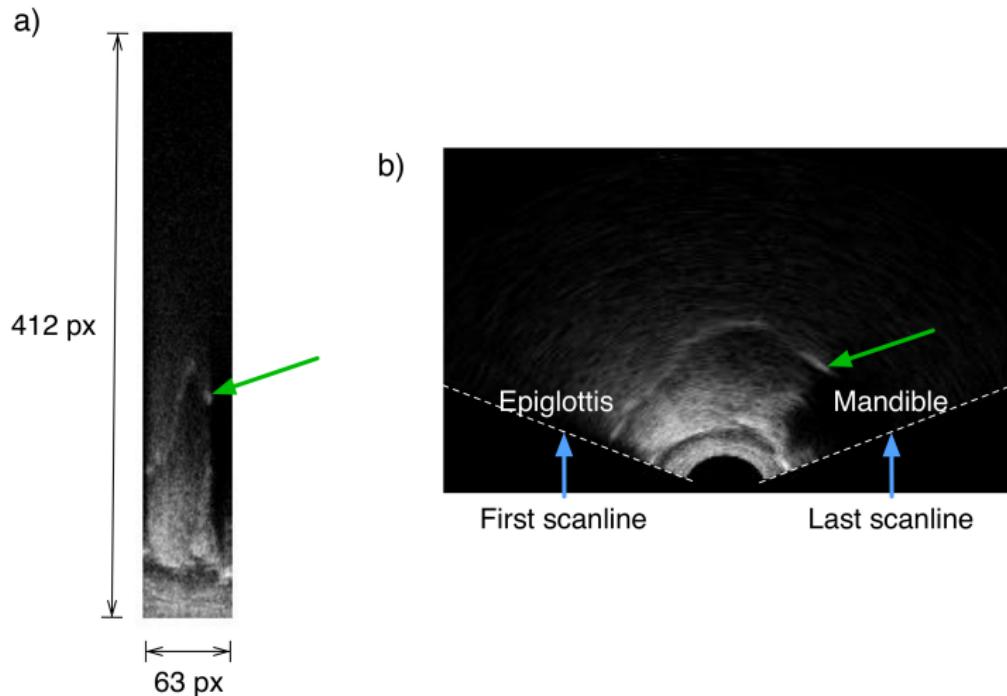


Pixel Difference (PD): Background

- ▶ 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.

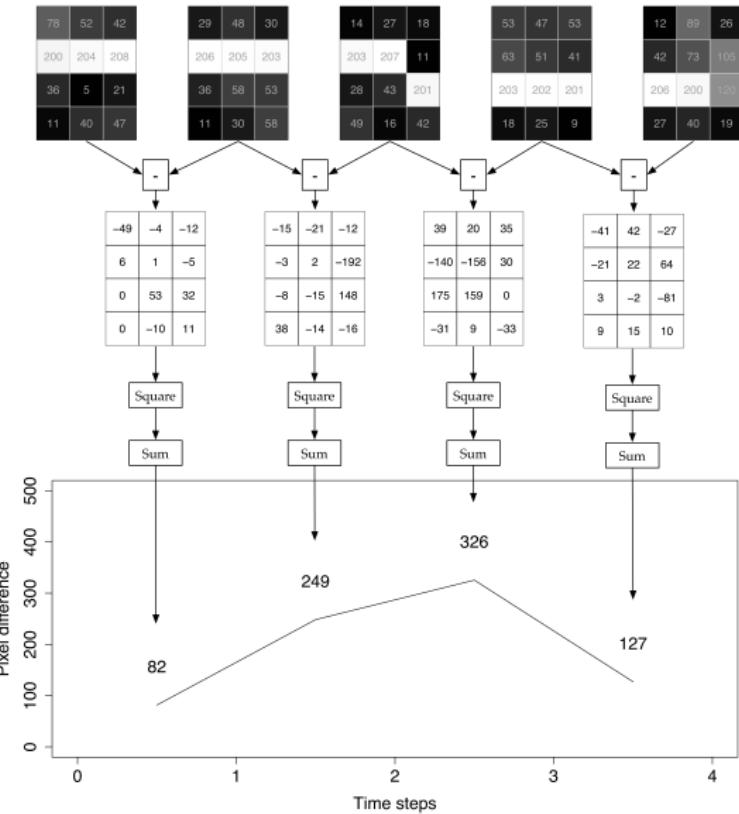


Pixel Difference (PD): The maths

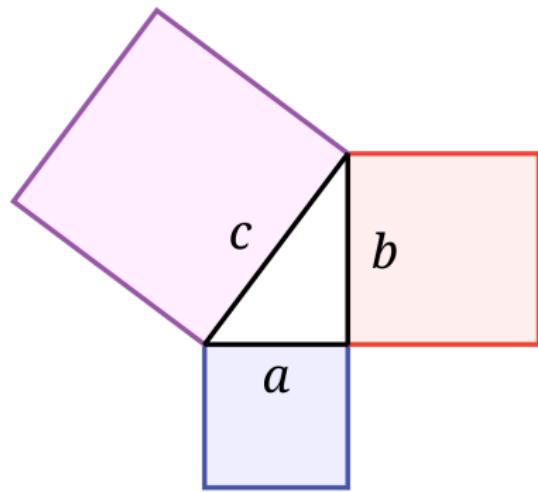
$$I_2(t + 0.5) = \sqrt{\sum_{i,j} (x(i,j, t + 1) - x(i,j, t))^2}$$

- ▶ 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:

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

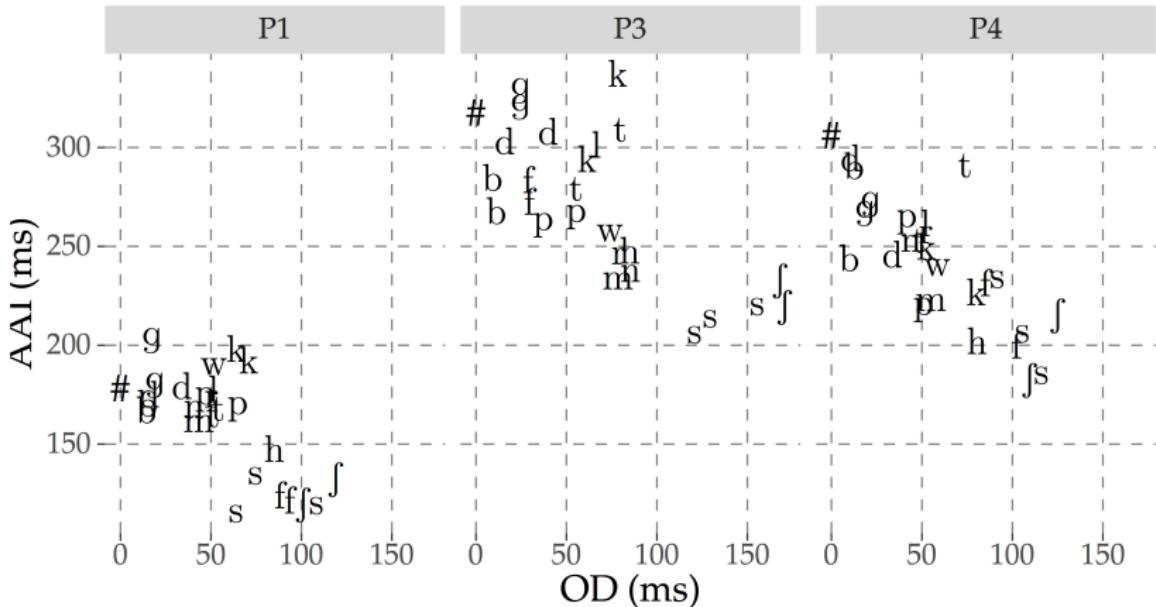
(Euclid 2006)

By en:User:Wapcaplet - Transwikied from en:. Originally created by en:User:Michael Hardy, then scaled, with colour and labels being added by en:User:Wapcaplet, transformed in svg format by fr:Utilisateur:Steff, changed colors and font by de:Leo2004, CC BY-SA 3.0,

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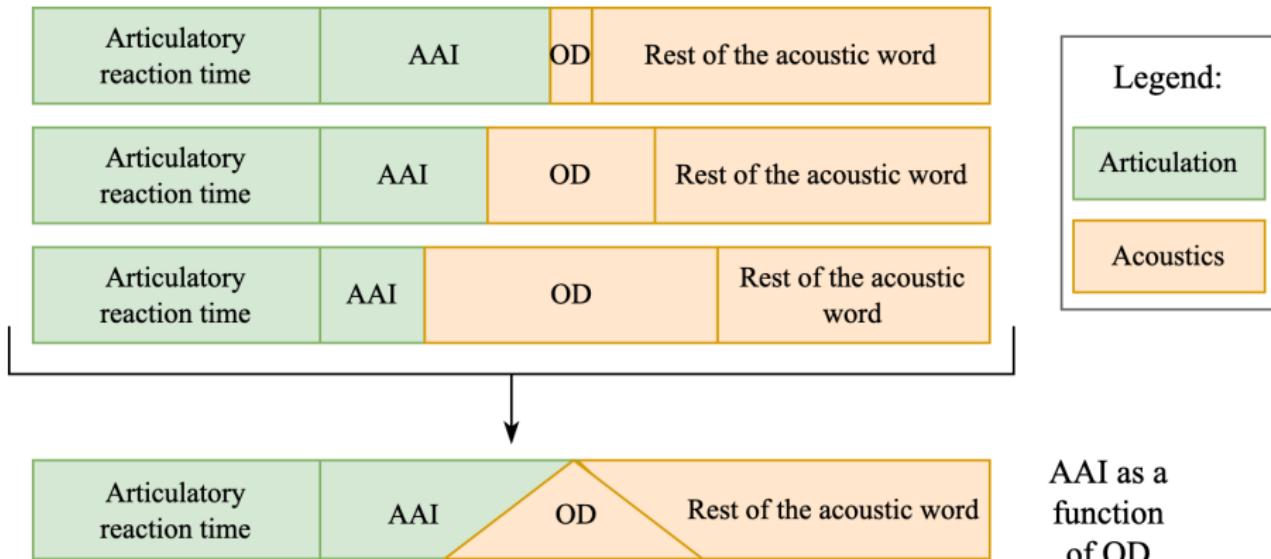
Developments with PD

Delayed naming results: Articulatory to Acoustic Interval

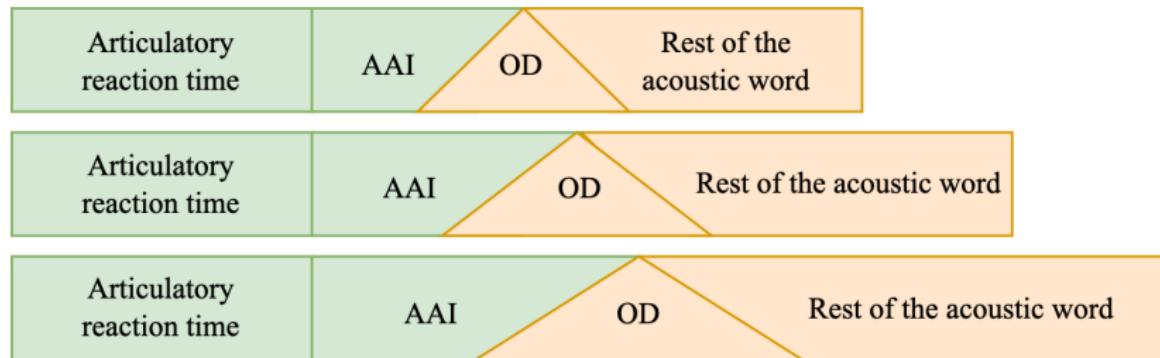


Medianised within participant, over several repetitions and over the vowels /a,i,o/. Over all analysable n = 1386: 439 from P1, 672 from P3, and 275 from P4.

Theory: Effect of OD on AAI

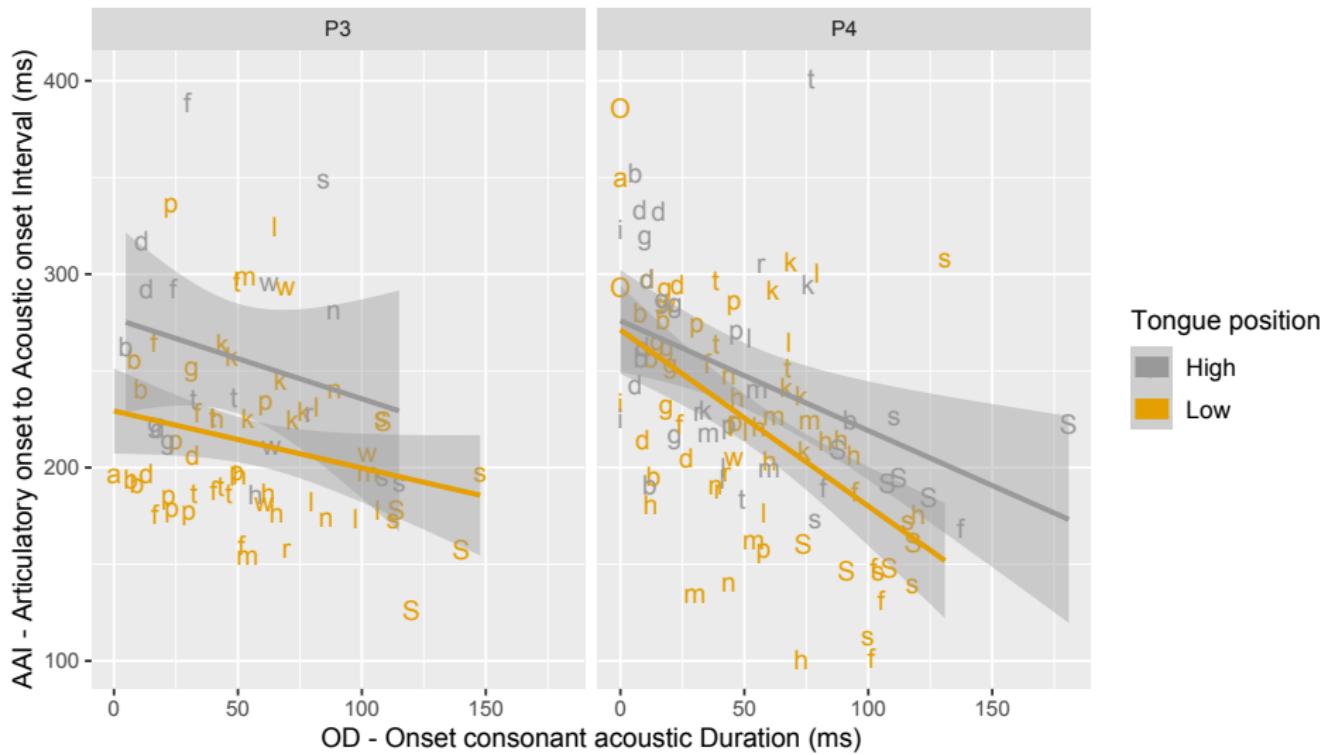


Theory: Effect of articulatory rate on AAI



Starting position

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



References

- Drake, E., Schaeffler, S., and Corley, M. (2013). ARTICULATORY EVIDENCE FOR THE INVOLVEMENT OF THE SPEECH PRODUCTION SYSTEM IN THE GENERATION OF PREDICTIONS DURING COMPREHENSION. In *Architectures and Mechanisms for Language Processing (AMLaP)*, Marseille.
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- Palo, P. (2019). *Measuring Pre-Speech Articulation*. PhD thesis, Queen Margaret University, Edinburgh.
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Thank you! Questions?