

Auditory reverse correlation: a choose-your-own-adventure presentation

Géraldine Carranante, Léo Varnet

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Laboratoire des Systèmes Perceptifs

Auditory reverse correlation: a choose-your-own-adventure presentation

Géraldine Carranante. Léo Varnet

Laboratoire des Systèmes Perceptifs, École Normale Supérieure Paris

LSP meeting, 18/01/2024

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Choose-your-own-adventure books: a concept originally proposed by Raymond Queneau ("Un conte à votre façon"), and later extended to books, card games, video games, movies...

...and now to scientific presentations!



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...and now to scientific presentations!



Rules of the game:

- As we proceed with the presentation, we will encounter crossroads where you
 must choose between different paths.
- Two options represented by colors will appear on the slides: raise the colored panel corresponding to your choice.
- Majority wins.

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Introduction

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...and now to scientific presentations!



Rules of the game:

As we proceed with the presentation, we will encounter crossroads where you

Time to choose

- It's crystal clear, let's begin!
- I'm lost, can you repeat?

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Auditory revcorr

spectrotemporal locations of

The cue-weighting strategies w

frequency loss, and 15 HI lists

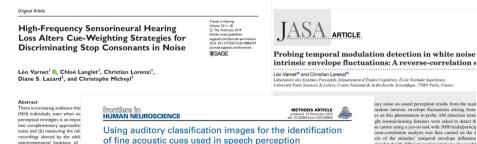
amplification to compensate for

than on the low-frequency cur

differences in internal noise. Ir

Reverse correlation (aka revcorr) is the perfect tool to reveal perceptual cues used in a psychophysical task, based on purely behavioral data... in particular for auditory categorization tasks. [Varnet et al. 2013, 2015; Varnet & Lorenzi, 2022; Osses & Varnet, 2023]

Core idea: adding random fluctuations to the stimulus and measure how they affect the participant's responses on a trial-by-trial basis.



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Introduction

ne carrier using a ves-no task with 3000 trials/particin verse-correlation analysis was then carried on the d ects of the stimulus' temporal envelope influences simulated with different implementations of a modul nan listeners were able to track the position of AM r showed a marked temporal decay and a consistent p

Léo Varnet 12+, Kenneth Knoblauch3, Fanny Meunier 1,24 and Michel Hoen 1,2 1 Neuroscience Research Centre, Brain Dynamics and Cognition Team INSERM LITIDS CNRS LIMR5292 Lynn, France I Ecolo Dectorale Neuroscianose et Comitine Università de Luce Università Luce 1 Luce Espece

3 Intervative Neuroscience Department Stem Cell and Brain Research Institute INSERM LIBER Ross France A Laboratoire and la Laboratoire Commission Commission CAURC LIB (RECORD Liver France)

Auditory revcorr

Reverse correlation (aka revcorr) is the perfect tool to reveal perceptual cues used in a psychophysical task, based on purely behavioral data... in particular for auditory categorization tasks. [Varnet et al. 2013, 2015; Varnet & Lorenzi, 2022; Osses & Varnet, 2023]

Time to choose

- Tell me more about previous auditory revcorr studies
- No, I just want to build my own auditory revcorr experiment

Original Article **High-Frequency Sensorineural Hearing** Loss Alters Cue-Weighting Strategies for Discriminating Stop Consonants in Noise

Léo Varnet . Chloé Langlet . Christian Lorenzi .

Diane S. Lazard², and Christophe Micheyl³

Trends in Hearing Volume 23: 1-18 (f) The Author(s) 2019 Article reuse guidelines: sameouth com/lournals, permissions DOL 10 1177/2331316519884707 journals.sageeub.com/home.his SAGE

Using auditory classification images for the identification

of fine acoustic cues used in speech perception

Léo Varnet 12+, Kenneth Knoblauch3, Fanny Meunier 1,24 and Michel Hoen 1,2

3 Intervative Neuroscience Department Stem Cell and Brain Research Institute INSERM LIBER Ross France A Laboratoire and la Laboratoire Commission Commission CAURC LIB (RECORD Liver France)

I Ecolo Dectorale Neuroscianose et Comitine Università de Luce Università Luce 1 Luce Espece

1 Neuroscience Research Centre, Brain Dynamics and Cognition Team INSERM LITIDS CNRS LIMR5292 Lynn, France



Probing temporal modulation detection in white noise intrinsic envelope fluctuations: A reverse-correlation s

Léo Varnetal and Christian Lorenzib Laboratoire des Systèmes Percentifs Département d'Études Cognitives École Normale Sunérieure

Université Paris Sciences & Lettres. Centre National de la Recherche Scientifique, 75005 Paris, France

Abstract

There is increasing evidence that (NH) individuals even when we perceptual strategies is an impor two complementary approaches noise and (b) measuring the rela recordings altered by the addispectrotemporal locations of The cue-weighting strategies w frequency loss, and 15 HI lists amplification to compensate for than on the low-frequency cur

differences in internal noise. Ir

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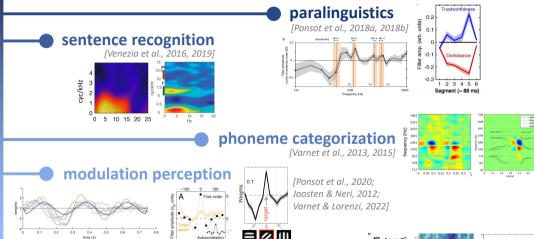
ary noise on sound perception results from the masl random intrinsic envelope fluctuations arising from es on this phenomenon to probe AM detection strate ght normal-hearing listeners were asked to detect th ne carrier using a yes-no task with 3000 trials/particing verse-correlation analysis was then carried on the d ects of the stimulus' temporal envelope influences simulated with different implementations of a modul nan listeners were able to track the position of AM t showed a marked temporal decay and a consistent p plated data, this was interpreted as an evidence for nyelone fluctuations. © 2022 Acoustical Society of Ar

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Introduction

Auditory revcorr studies (full diagram on https://dbao.leo-varnet.fr/)



pure-tone detection & loudness perception

[Ahumada & Lovell, 1971; Shub & Richards, 2009; Ponsot et al. 2013]







The interpretation of the resulting "kernel" varies:

- Some say it is a direct image of our mental representations [e.g. Ponsot et al 2018]
- Others that it is merely a trace of the auditory processes [Varnet & Lorenzi, 2022]
- The most radical psychophysicists argue that it should rather be seen as a transparent descriptor of the data, not the system [Neri, 2018]

There is also a large heterogeneity in the experimental parameters (e.g., yes/no or 2AFC? CI or Bubbles?)

We are currently preparing a review of the philosophical and practical aspects of reverse correlation.

	Authors			Ref id	Auditory process Ta	ısk f		N stimuli categor	N trials	N alternatives	N participants	CI/bubble	Performances		CI model	
Spectro-Temporal Weighting of Loudness	Oberfeld, Heeren, Ren	2012	PLoS ONE	499	Loudness perceptio	n	1	2 (low mean / hig	3003 for the spe	x 2 (soft / loud) x 2	5 listeners x 2 lal	CI	grand mean of A	fixed	multiple logistic	5
Temporal loudness weights for sounds with it	Ponsot, Susini, Saint Pi	2013	Journal of the Ad	1175	Loudness coding In	tensity discrimi	1	2 (low mean / hig	200 * 6 blocks f	c 2 (soft / loud)	8	CI	not reported	fixed	logistic regressio	i
Spectral weights for overall level discriminati	Doherty, Lutfi,	1996	Journal of the Ad	622	Loudness coding In	tensity discrimi	2	2 (low mean / hig	1000	2 (soft / loud)	11 normal heari	CI	d'=1	adjusted individu	linear regression	5
Stimulus Features in Signal Detection	Ahumada, Lovell,	1971	Journal of the Ad	42	pure-tone detect To	ne-in-noise del	1	2 (tone absent, to	50 X 32 repetition	2 (tone absent, t	10 (exp 1), 7 (exp	CI		fixed to XXX?	linear regression	v
Time and frequency analyses of auditory sign	Ahumada, Marken, Sai	1975	Journal of the Ad	43	pure-tone detect To	ne-in-noise de	1	2 (tone absent, to	400 X 8 repetitio	2 (tone absent, t	. 6	CI	mean d'=1,9	fixed to XXX?	linear regression	v
Psychophysical spectro-temporal receptive fi	Shub, Richards,	2009	Hearing Research	494	pure-tone detect To	ne-in-noise del r	non	1 (in a free runni	NA (10 blocks)	NA	2 for condition 1	CI	?	fixed to 0 dB	Conditional avera	2
Identification of stimulus cues in narrow-ban	Schönfelder, Wichman	2013	Journal of the Ad	1164	pure-tone detect To	ne-in-noise del	1	2 (tone absent, to	~20k-22k	2 (tone absent, t	. 6	CI	60%-90% depen	fixed (4 different	logistic regressio	v
Dynamic Reweighting of Auditory Modulation	Joosten, Shamma, Lore	2016	PloS One	676	modulation perci de	rtection of loud	1	2	5.5k±2.8k (incre	. 2	10	CI	74%±6% (increm	Fixed individually	Conditional avera	5
Human pitch detectors are tuned on a fine so	Joosten, Neri,	2012	Biological Cyberi	294	pure-tone detect Fr	equency discrir	2	2 (5,5kHz target i	>7000 in 100 tri	2	7+EJ (and an add	CI	74%+/-5% SD, d	indivivually fixed	conditional avera	ð
Mechanisms of Spectrotemporal Modulation	Ponsot, Varnet, Wallac	2021	Trends in Hearin	8	modulation perci sp	ectro-tempora	2	2 (mod present, r	nod absent)	2 (modulation p	resented in 1st / 2	CI	XXX	indivivually fixed	conditional avera	s
Probing temporal modulation detection in wi	Varnet & Lorenzi	2022	Journal of the Ad	oustica	modulation perci Si	nusoidal AM de	1	2	3000	2	8	CI	fixed 70,7% (me	m adaptative	Conditional avera	v
Speech Reductions Cause a De-Weighting of	Varnet, Meunier, Hoen	2016	Interspeech	786	phoneme percep co	insonant catego	1	4	1000	2	7	CI	mean 60.2% +/-	adjusted individu	Conditional avera	Ė

Auditory revcorr review

The interpretation of the resulting "kernel" varies:

Speech Reductions Cause a De-Weighting of Warnet, Meunier, Hoen 2016 Interspeech 786 phoneme percen consonant category

- Some say it is a direct image of our mental representations [e.g. Ponsot et al 2018]
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We are currently preparing a review of the philosophical and practical aspects of reverse correlation.

Time to choose

- Yay! philosophy!
- Can you be more specific? Give us some examples of how revcorr can be applied to speech perception.

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"Cracking the speech code": finding the auditory primitives of speech comprehension



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Decoding speech

"Cracking the speech code": finding the auditory primitives of speech comprehension

- Which acoustic cues underlie the segmentation of the speech signal into words?
- Which acoustic cues allow listeners to differentiate one phoneme from another?



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"Cracking the speech code": finding the auditory primitives of speech comprehension

- Which acoustic cues underlie the segmentation of the speech signal into words?
- Which acoustic cues allow listeners to differentiate one phoneme from another?

No easy answer, due to the spectrotemporal complexity of natural speech.



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No easy answer, due to the spectrotemporal complexity of



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Time to choose

- Let's talk about segmentation cues!
- Let's talk about phonetic cues!

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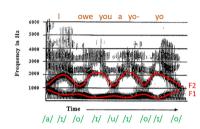
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Decoding speech

How do listeners find the boundaries between words in continuous speech? (e.g. "I owe you a yoyo")

- lexical cues [McClelland & Elman, 1986]
- phonotactic cues [McQueen, 1998]

... but that's not the whole story!





ARTICLE

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Prosodic cues to word boundaries in a segmentation task assessed using reverse correlation

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We are able to discriminate between **phonemically identical sentences**

Dis, à m'aimer, consens, va! / Dis à mémé qu'on s'en va.
— "Andrea c'est toi", Boby Lapointe





Je suis la sève héritée. Je suis lasse et vérité. Je suis la sévérité. – "L'Oracle". Jean Cocteau

Dans ces meubles laqués, rideaux et dais moroses, Danse, aime, bleu laquais, ris d'oser des mots roses. — "Le Coffret de santal", Charles Cros



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C'est la mie / c'est l'amie – [Spinelli et al., 2007]

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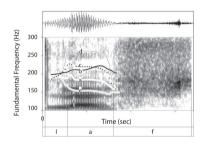
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Standard approach for identifying segmentation cues: manipulating acoustic content



By artificially modifying the f_0 on a specific phonetic segment and running a perceptual experiment, we can demonstrate that this particular information is a cue for segmentation [Spinelli,

Grimault, Meunier & Welby, 2010].

Limitations of this hypothesis-driven approach: potential cues tested one at a time

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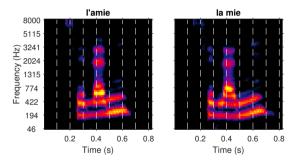
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L'amie/La mie experiment [Osses et al., 2023]

Topic: Acoustic cues for the segmentation of a speech sentence into words. **Targets**: 2 phonetically identical sentences /selami/ (t_0 ="c'est l'amie" and t_1 ="c'est la mie"), equalized in duration and rms [Spinelli al., 2010].



The targets were divided into 100-ms segments. Then, the f_0 trajectory in each segment was replaced by a random f_0 trajectory and each segment was compressed or stretched by a random amount, using WORLD [Morise et al., 2016].

Stimuli: 800 target sounds resynthesised with random f_0 and segment lengths.

Task: Indicate whether the target was "c'est l'amie" or "c'est la mie".

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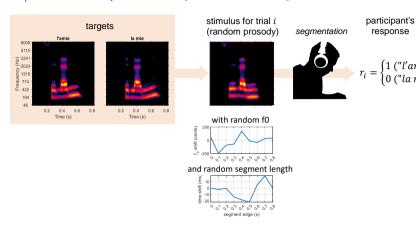
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L'amie/La mie experiment [Osses et al., 2023]



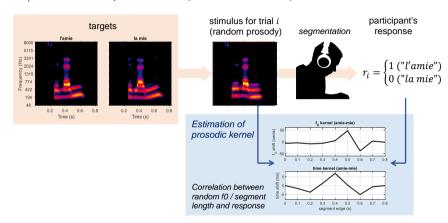
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L'amie/La mie experiment

response

L'amie/La mie experiment [Osses et al., 2023]



We obtain two kernels (f_0 kernel and time kernel), indicating which aspects of the prosody are used as segmentation cues.

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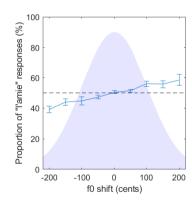
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Results: effect of f_0 on /a/ segment

 There is a systematic effect of the random f₀ at 0.5 s (/a/ segment) on the response of participants.



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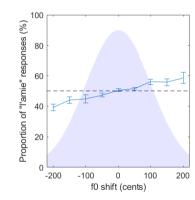
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Results: effect of f_0 on /a/ segment

- There is a systematic effect of the random f_0 at 0.5 s (/a/ segment) on the response of participants.
- This is in line with the notion of "early f_0 rise" in French prosody: a high f_0 on the first vowel of a content word is a cue for segmentation.

[Spinelli et al. 2010; Welby, 2007]



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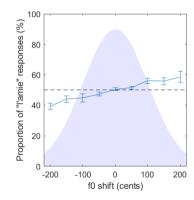
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 [Spinelli et al. 2010; Welby, 2007]
- The strength of this relationship corresponds to the 0.5-s weight in the f_0 kernel.



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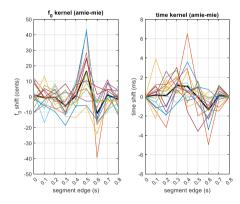
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Results: prosody kernels

 Considerable variability at the group level (N=16)



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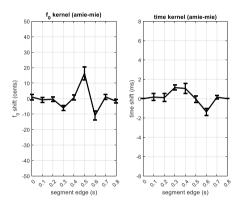
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Results: prosody kernels

- Considerable variability at the group level (N=16)
- Nevertheless, a clear prosodic pattern emerges



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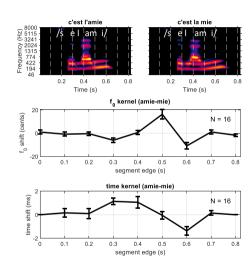
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Results: prosody kernels

- Considerable variability at the group level (N=16)
- Nevertheless, a clear prosodic pattern emerges
- Two main segmentation cues can be identified: the relative f₀ of vowels /e/, /a/ and /i/ and relative duration of vowels /e/ and /i/.
- Again, consistent with previous findings obtained using hypothesis-driven methods [Spinelli et al. 2010; Welby, 2007; Shoemaker, 2014]



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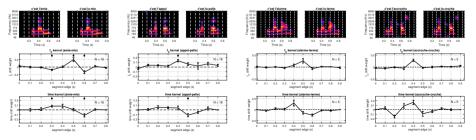
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- Similar results were found for other pairs of ambiguous stimuli.
- Secondary cues seem to depend on the phonetical content of the targets (e.g. duration of the second syllable).



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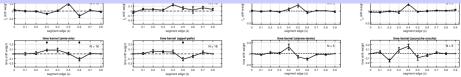
L'amie/La mie experiment

Results

- Similar results were found for other pairs of ambiguous stimuli.
- Secondary cues seem to depend on the phonetical content of the targets (e.g. duration of the second syllable).

Time to choose

- Wait! You said "L'amie"? Why not "L'ami"? Or "L'ami-e"
- Can we move on to the study of phonetic cues?



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L'amie/La mie experiment



Gender-fair language and masculine bias [Spinelli, Chevrot & Varnet, 2023]

A recent psycholinguistics study on grammatical gender, gender-fair language and perceptual biases. Collaboration with Elsa Spinelli from LPNC (Grenoble).



TYPE Original Research
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Elena Dubenko,

Neutral is not fair enough: testing the efficiency of different language gender-fair strategies

Elsa Spinelli¹, Jean-Pierre Chevrot² and Léo Varnet³*

¹Laboratoire de Psychologie et NeuroCognition, Université Grenoble Alpes, CNRS, Grenoble, France, ²Laboratoire Lidilem, Université Grenoble Alpes, Grenoble, France, ³Laboratoire des Systèmes Perceptifs, Choose your own adventure

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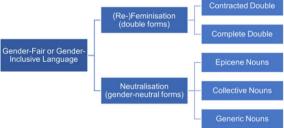
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In languages with grammatical gender, such as French, it has been evidenced that using masculine forms as a generic reference induces a bias favoring masculine specific representations [Brauer & Landry, 2008; Gygax et al., 2008; Xiao et al., 2022].

Two main strategies to counteract these gender biases [Tibblin et al., 2022]:

- Neutralization (e.g. gender-unmarked forms such as "l'enfant")
- Re-feminization (e.g. contracted double forms such as "un e enfant")



Here, we explored the relative efficiency of these strategies.

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Gender-fair language

Gender-fair language and masculine bias [Spinelli, Chevrot & Varnet, 2023]

Sentence evaluation paradigm: decide whether a second sentence starting with a gendered personal pronoun ("il" or "elle") is a sensible continuation of the first sentence written in a gender-fair form (gender-unmarked form or contracted double form).

Examples of stimuli

Gender-unmarked: L'otage ne mange pas depuis 10 jours. Elle a perdu beaucoup de poids.

Contracted double: Un·e otage ne mange pas depuis 10 jours. Elle a perdu beaucoup de poids.

Filler sentence: Le lion est le roi de la savane. Il doit aller chercher les enfants à l'école.

Response time is measured from the onset of the second sentence.

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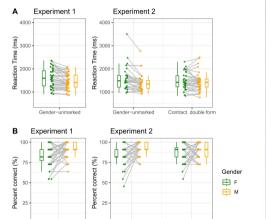
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Gender-fair language and masculine bias [Spinelli, Chevrot & Varnet, 2023]

Longer response times for sentences beginning with "elle" compared to "il" in the Gender-unmarked condition, but not in the Contracted double condition.

Gender-unmarked forms do not fully neutralize the masculine bias, while contracted double forms (here using the mid-dot) are more effective in promoting gender balanced representations.



Gender-unmarked

Gender-unmarked

Condition

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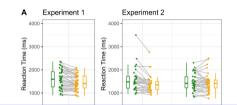
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Conclusion



Contract double form

Longer response times for sentences beginning with "elle" compared to "il" in the Gender-unmarked condition, but not in

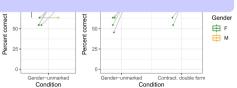


the Contracted dauble condition Time to choose

By the way, what do we mean when we talk about "mental representations"?

Yeah, I have the same question actually

mid-dot) are more effective in promoting gender balanced representations.



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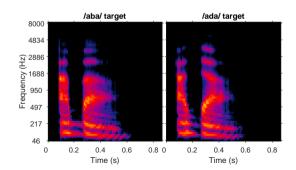
Gender-fair language

Aba/Ada experiment [Osses & Varnet, 2023]

Topic: perception of stop consonants /b/ and /d/. **Targets**: 2 VCV sounds (t_0 =/aba/ and t_1 =/ada/) from the Oldenburg Logatome Corpus [Wesker et al., 2005], equalized in duration and rms.



Alejandro Osses



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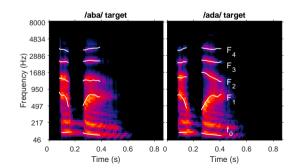
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Topic: perception of stop consonants /b/ and /d/. **Targets**: 2 VCV sounds (t_0 =/aba/ and t_1 =/ada/) from the Oldenburg Logatome Corpus [Wesker et al., 2005], equalized in duration and rms.



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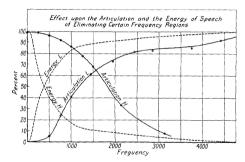
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One solution: using reduced speech

• Low-/high-pass filtered speech [Fletcher, 1922]



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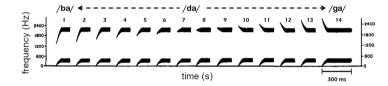
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One solution: using reduced speech

- Low-/high-pass filtered speech [Fletcher, 1922]
- Synthetic speech continuum [Liberman et al., 1954]



 \rightarrow Proof that the **F2 onset** is a cue for categorizing /b/-/d/-/g/?

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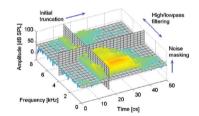
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One solution: using reduced speech

- Low-/high-pass filtered speech [Fletcher, 1922]
- Synthetic speech continuum [Liberman et al., 1954]
- 3-Dimensional Deep Search [Li & Allen, 2012], etc...



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One solution: using reduced speech

- Low-/high-pass filtered speech [Fletcher, 1922]
- Synthetic speech continuum [Liberman et al., 1954]
- 3-Dimensional Deep Search [Li & Allen, 2012], etc...

Problem: the speech comprehension system shows very efficient **strategy adaptation**.

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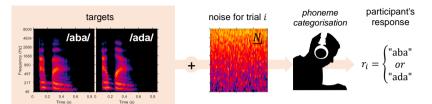
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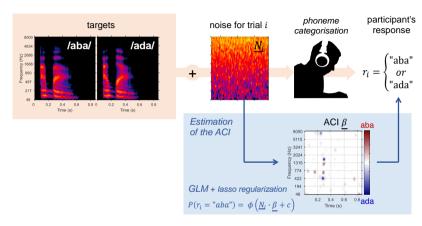
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Auditory Classification Image (ACI): time-frequency matrix of decision weights. Shows how a specific noise configuration can mislead the participant.

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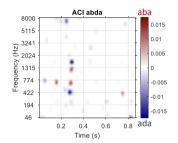
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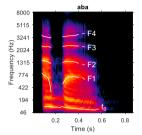
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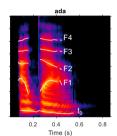
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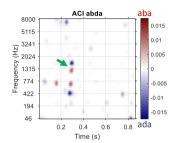
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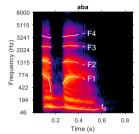
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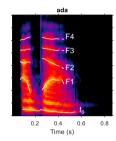
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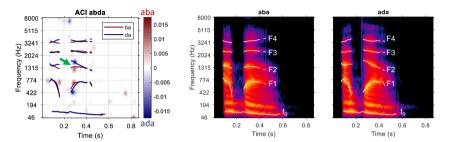
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• The analysis successfully identified the **main cue** for the task (F2 onset), consistent with the phonetics literature [Liberman et al., 1954]...

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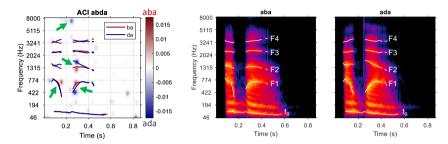
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- The analysis successfully identified the **main cue** for the task (F2 onset), consistent with the phonetics literature [Liberman et al., 1954]...
- ...as well as several **secondary cues** (e.g., F1 onset).

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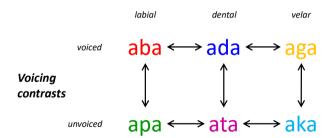
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Stop consonants experiment [Carranante et al., in prep.]

- Discrimination task in noise
- 6 target sounds (plosive C in context /aCa/)
- 7 participants × 7 contrasts, 4.000 trials/condition

Place of articulation contrasts



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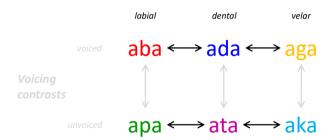
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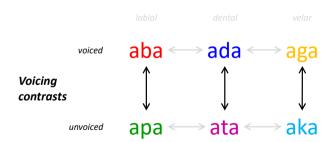
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Place of articulation contrast



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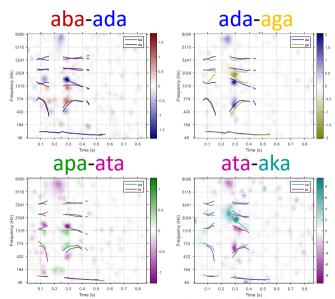
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Place of articulation cues:

- F2 onset
- F1 onset
- release burst (/d/ and /t/)
- coarticulation on F1 and F2



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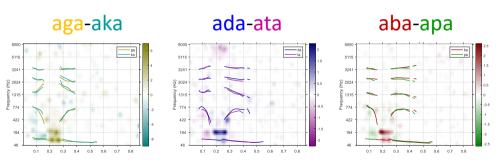
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Voicing cues:

- voicing bar
- F1 onset
- release burst (only for /t/)



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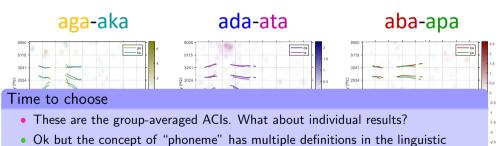
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Group-averaged ACIs

Voicing cues:

- voicing bar
- F1 onset
- release burst (only for /t/)

litterature. How do you deal with that?



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Individual ACIs

- Group-averaged ACIs is not the only relevant result of revcorr
- Individual ACIs show robust individual strategy (i.e. acoustic cues) used by the participant in the task
- It confirms that most participants use several cues to discriminate a single phoneme (redundancy of acoustic cues)
- The mean results hide some interindividual diversity

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Interindividual diversity

- some participants use some acoustic cues and not others
- how could we explain this diversity when the group of participants is homogeneous? (NH participants, french locutors).

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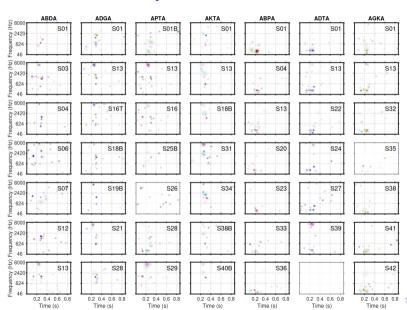
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Interindividual diversity



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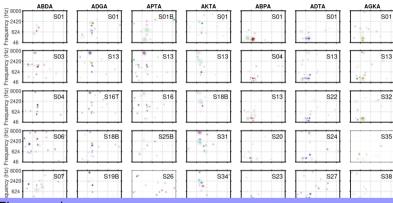
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Conclusion

√) Q (→ 28/53)

Interindividual diversity



Time to choose

- Wow! You totally convinced me, I'm ditching my past research to move to auditory revcorr experiments! How can I get started?
- Yeah, I have the same question actually

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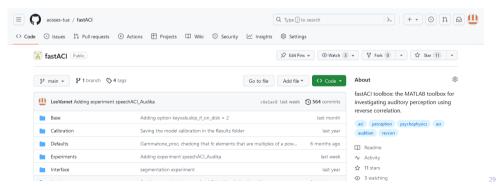
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The fastACL toolbox

Code available on GitHub as an open-source MATLAB toolbox with documentation and demo experiments [Osses & Varnet, 2021]: https://github.com/aosses-tue/fastACI

All experiments can be replicated within the toolbox and all analyses and figures can be exactly reproduced (fully reproducible workflow).

Connects with other open-source projects such as **WORLD-Straight** or the **Auditory Modelling Toolbox**.



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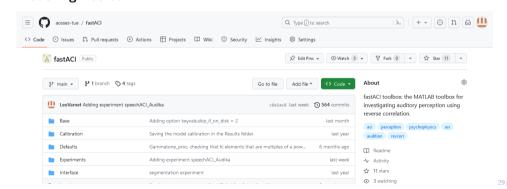
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The fastACI toolbox

Code available on GitHub as an open-source MATLAB toolbox with documentation and demo experiments [Osses & Varnet, 2021]: https://github.com/aosses-tue/fastACI

Time to choose

- How does it work? I want to know more.
- Yeah yeah, cut the sales crap. I want to see what it really does.



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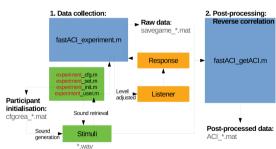
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A basic text-based **interface** allows the participants to enter their responses. Optionally, the participant can be replaced by a model from AMT [Majdak et al, 2021].

The base functions and subfunctions from the fastACI environment ensure the data collection and analysis.



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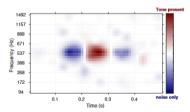
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The fastACL toolbox

A few experiments are available natively:

- speechACI_Logatome-aCCa-S43M [Carranante et al., in prep]
- segmentation [Osses et al., 2023]
- speechACI_Logatome-abda-S43M [Osses & Varnet, 2023]
- modulationACI [Varnet & Lorenzi, 2022]
- speechACI_varnet2015 [Varnet & Lorenzi, 2015]
- speechACI_varnet2013 [Varnet & Lorenzi, 2013]
- ...and even ahumada1975 [Ahumada, Marken, & Sandusky, 1975]



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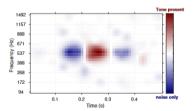
The fastACI toolbox

A few experiments are available natively:

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- segmentation [Osses et al., 2023]
- speechACI_Logatome-abda-S43M [Osses & Varnet, 2023]
- modulationACI [Varnet & Lorenzi, 2022]

Time to choose

- I'm curious about this segmentation experiment
- I'm curious about this speechACI_Logatome-abda-S43M experiment



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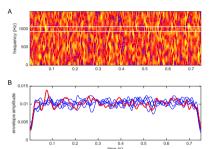
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Intrinsic fluctuations and revcorr

Part of the deleterious effect of a steady noise on speech perception is due to the confusion of useful modulations in the signal with **intrinsic envelope fluctuations** arising from the filtering of noise into cochlear critical bands [Dau et al., 1997, 1999]

Using the revcorr method to **probe internal representations of sounds** by relating random envelope fluctuations of masking noise with the response of listeners on a trial-by-trial basis



Envelopes for 6 realizations of a white noise, bandpass-filtered between 935 and 1068 Hz

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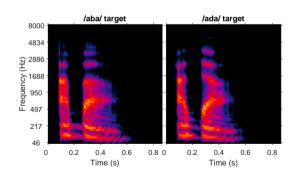
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Topic: perception of stop consonants /b/ and /d/.

Targets: 2 VCV sounds ($t_0=/aba/$ and $t_1=/ada/$) from the Oldenburg Logatome Corpus [Wesker et al., 2005], equalized in duration and rms.

Stimuli: Target sounds in additive white noise (+2 non-stationary background conditions).

SNR adapted continuously to ensure a correct response rate of 70.7%.



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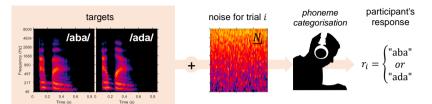
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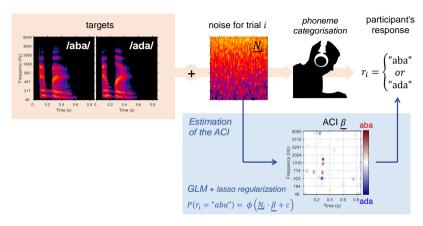
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Auditory Classification Image (ACI): time-frequency matrix of decision weights. Shows how a specific noise configuration can mislead the participant.

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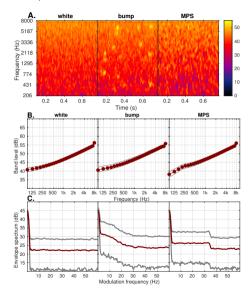
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Three different types of noise:

- white noise
- bump noise (white noise with spectrotemporal regions of enhanced energy, randomly distributed)
- MPS noise (white noise low-pass filtered in the modulation domain)

Each participant performs 4.000 categorizations in each of the 3 noise conditions (12.000 trials \approx 4h30)

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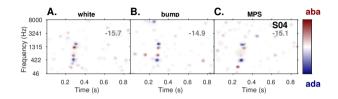
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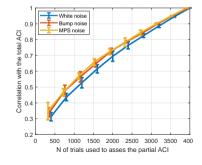
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Fitting procedure





Effects of type of noise:

- The final images are similar overall, with some minor differences
- The two types of noises with enhanced envelope fluctuation converge more rapidly
- ightarrow Towards an adaptive bump noise?

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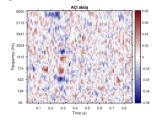


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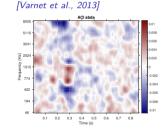
Comparing 3 different fitting procedures on the same set of data (4.000 trials in the bump noise condition).

Simple correlation

[Ahumada, 1996]

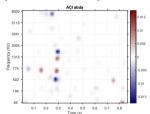


GLM with L2 penalty



GLM with L1 penalty on a Gaussian Pyramid basis

[Osses & Varnet, 2023]

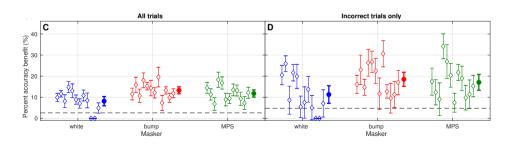


$$P(r_i = \text{``aba''}) = \Phi(\underline{N}_i^T \cdot \underline{ACI} + c)$$
 (1)

Fitting procedure

The predictive performance of the model is quite low because the GLM does not include any information about the target sound. The effect of noise fluctuations alone explains $\approx 8\text{-}12\%$ of the participants' responses

 \Rightarrow The estimation of the ACI relies only on a small subset of the data.



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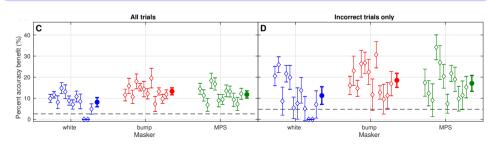
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The predictive performance of the model is quite low because the GLM does not include any information about the target sound. The effect of noise fluctuations alone

Time to choose

- Ok that's all well and good, but what's the point of this research?
- Yeah I have the same question actually



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Definition(s) of mental representation

- Old intuition: the mind works with ideas or images that ressemble things of the world they represent [Aristotle, De anima]
- Computational model of the mind (XXe cent.): the mind manipulates internal states with symbolic content, that are "about" things of the world (aboutness = intentionality of the mind) [Brentano, 1874; Fodor, 1975]
- these states are called *mental* or *internal* representations



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Definition(s) of mental representation

There are several ways to understand the concept of MENTAL REPRESENTATION:

- "standard interpretation" of classical computational theories: internal representation = content of propositional attitudes.
- structural representations: scale-model of the world like "maps", in order to produce surrogate reasoning [Ramsey, 2007; Swoyer, 1991].

We defend that the relevant interpretation for revcorr studies is Ramsey's structural representation. [Carranante and Varnet, sub.]

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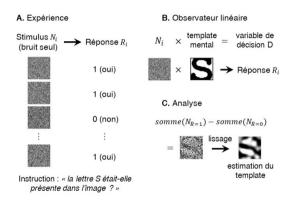
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Defense of structural representations

CI are mostly interpreted via the linear observer model [Murray, 2011, Gosselin et al., 2003]



In this model, the perceptual system uses the *template* to "confront it" to the incoming sensory information in order to detect the signal in it.

The template represents key caracteristics of the signal, used for its detection.

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Defense of structural representations

LOB templates show all the caracteristics of a structural representation:

- They are "scale models" of the task-relevant environment (like a map)
- They are used for surrogate reasoning
- They provide scientific explanation of perceptual systems at Maar's algorithmic level of explanation [Maar, 1982]

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- They are "scale models" of the task-relevant environment (like a map)
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Time to choose

- Now that this is clear, what can you say about these representations in your revcorr psycholinguistic experiments?
- Facing several ways to understand a fondamental concept in science is frequent.
 Let's explore some epistemological tools to evaluate the best version of a concept for a scientific investigation.

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Some examples of conceptual plurality

Some examples from my own experience: perception [Carranante, 2020], soundscape [Grinfeder, 2022], phoneme

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Some examples from my own experience: perception [Carranante, 2020], soundscape [Grinfeder, 2022], phoneme

- Morning star" and "Evening star" and the concept of VENUS
- The 2 concepts of PLANET in 2006, before Pluto's classification as a DWARF PLANET [O'Madagain and Egré, 2019]
- The case of SPECIES:
 - 24 to 26 concepts of SPECIES
 - 3 main concepts: PHYLOSPECIES, BIOSPECIES, ECOSPECIES, i.e. lineage individuated by respectively phylogenetic, interpreeding and ecological approaches of species taxonomies. [Brigandt, 2010, 2012; Dupré, 1981; Ereshefsky, 1992, p.678; Grant, 19811
- 1 the 3 concepts of CONCEPTS [Machery, 2009]

Scientific concepts (1/3)

What is a **scientific concept**? A representational tool to talk about a category or class of things / phenomena / mechanisms, used in scientific theories and research.

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Scientific concepts (2/3)

A scientific concept can be analyzed through 3 defining traits:

- its **intension** (definition, inferential role)
- its **extension** (reference)
- its **epistemic goal**(s): the particular problem scientists are trying to solve by using this concept [Brigandt, 2012]

Exemples of epistemic goals:

- EG of NATURAL SELECTION: to account for evolutionary adaptation
- EG of EVOLUTIONARY NOVELTY: explaining the evolutionary origin of novelty.
- EG of HOMOLOGY: explaing the origin of similar morphological structures in different species. [Brigandt, 2010, 2012; Gouvea and Brigandt, 2023]

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Scientific concepts (3/3)

What is a **good** scientific concept?

- A functional tool, which provides good scientific explanations
- Epistemic utility theory: a good scientific belief is a belief with a good balance between plausibility and informativeness [Huber, 2008]
- Concept utility: Inclusiveness / Homogeneity
- A good scientific concept is a category inclusive enough to be informative;
 sufficiently homogeneous to support plausible inferences [O'Madagain and Egré, 2019]

What makes a concept **better** than another?

- Epistemic virtues: concept utility, operationalization
- Non-epistemic virtues: intelligibility, foster social justice, simplicity, sharability, ...

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Defining a situation of conceptual plurality

- A situation of conceptual plurality arises when a scientist works with a concept that they thought was univocal but discovers that there are at least 2 versions of the concept used in their field.
- C_1 and C_2 are two versions of C if they differ in at least one of the 2 elements : intension $(I(C_n))$ or extension $(E(C_n))$.

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The 4 strategies

- selection of the best concept (e.g PLANET)
- unification/integration into a new concept (e.g. VENUS)
- eliminativism / replacement (e.g. CONCEPT)
- pluralism (e.g. SPECIES, PERCEPTION)

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The 4 strategies

- selection of the best concept (e.g PLANET)
- unification/integration into a new concept (e.g. VENUS)
- eliminativism / replacement (e.g. CONCEPT)
- pluralism (e.g. SPECIES, PERCEPTION)

What is the best strategy?

All 4 strategies are relevant depending on the scientific context (contextualist thesis).

[Carranante, in prep.]

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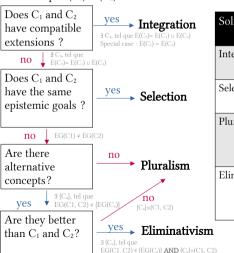
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For C_n, well-formed scientific concepts Initial step : $I(C_1) \neq I(C_2)$



Solution	Context in which it is the <i>best</i> solution
Integration	Compatible extension
Selection	 Incompatible extensions Same epistemic goals
Pluralism	Incompatible extensions Different epistemic goals There is no better alternative concept
Eliminativism	Different extension Different epistemic goal There are better alternative concepts

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The case of phoneme

There are two main understandings of the concept PHONEME:

- The historical definition of phoneme [Jakobson, 1942], as the smallest element of language that influences the meaning of words and sentences. This is a **linguistic** theorical construct. This is neither a mental object nor an acoustic object.
- A psycholinguistic definition: phonemes are mental representations, activated by some acoustic properties in specific context.

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- A psycholinguistic definition: phonemes are mental representations, activated by some acoustic properties in specific context.

Time to choose

- How do you study phonemes with revcorr?
- I actually have the same question

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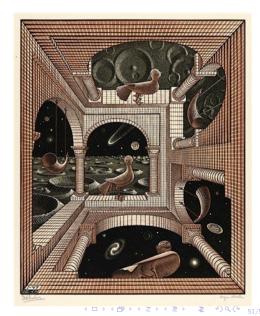
Conclusion

Conclusion

A fruitful collaboration between psychophysics and philosophy.

A philosophy of science "in the lab"

A psychophysical approach with a special care for the definition of concepts.



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Thanks for your attention!







Léo Varnet, Géraldine Carranante, Alejandro Osses









Fanny Meunier, Étienne Gaudrain, Elsa Spinelli, Maria Giavazzi

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