Probing AM detection in noise with reverse correlation

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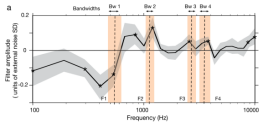
Auditory revcorr studies (full diagram on https://dbao.leo-varnet.fr/)

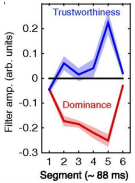
high level

low level

supralinguistics

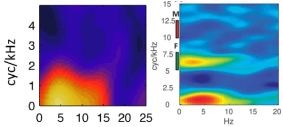
[Ponsot et al., 2018a, 2018b]





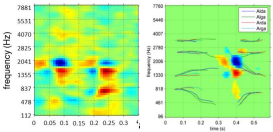
sentence recognition

[Venezia et al., 2016, 2019]



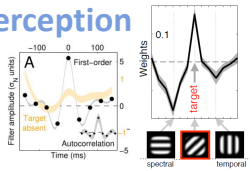
phoneme categorization

[Varnet et al., 2013, 2015]



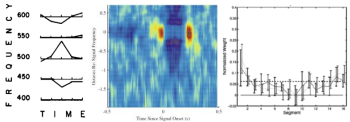
modulation perception

[Ponsot et al., 2020; Joosten & Neri, 2012]



pure-tone detection & loudness perception

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



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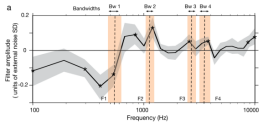

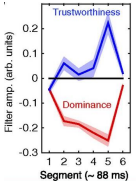

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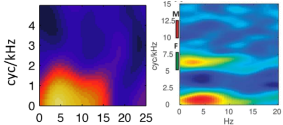

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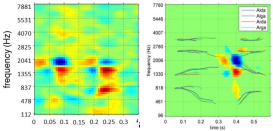

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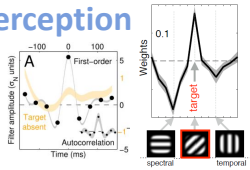

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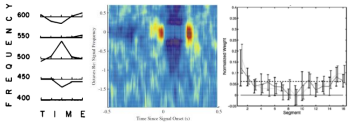
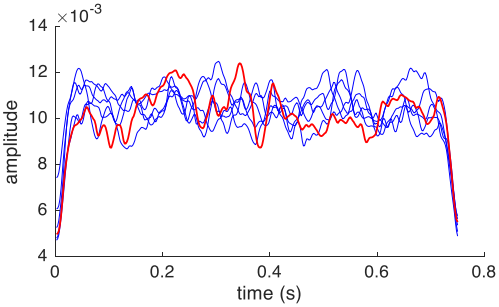


Intrinsic fluctuations and revcorr

- Part of the deleterious effect of a steady noise on AM 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]*
- Revcorr techniques are particularly suitable for exploring the effect of noise on perception *[Ahumada & Lovell, 1971; Varnet et al., 2013]*



Envelopes for 6 realizations of a white noise, band-filtered in the 660 - 1470 Hz band

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

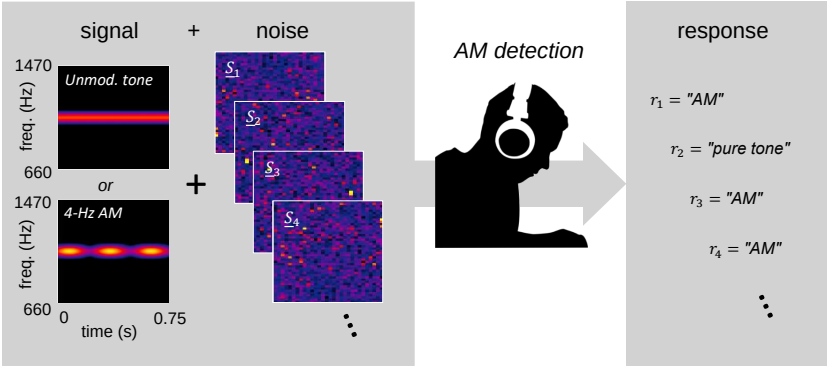
Materials & methods

Signals:
Unmod. tone vs. 4-Hz AM
Duration = 0.75 s
Carrier freq. = 1 kHz
Fixed AM phase

Task: yes/no task in white noise (-10 dB SNR)

Modulation depth (m) adapted from trial to trial to target 75% correct responses

Participants: 6 naive NH listeners + 1 participant with only one NH ear



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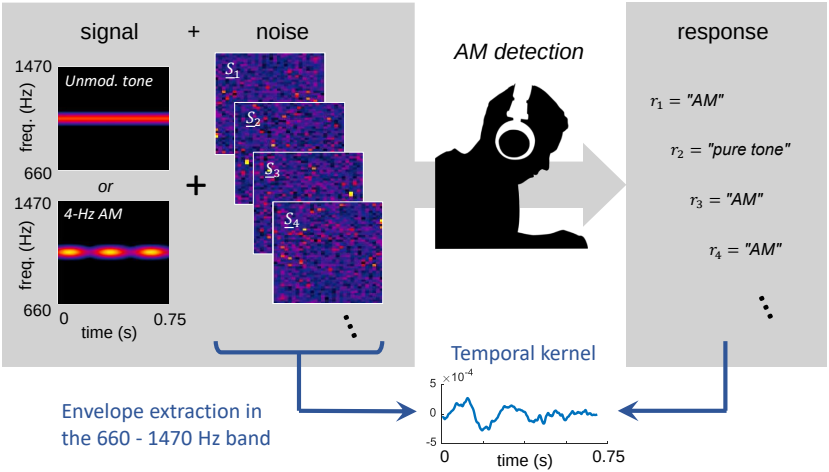
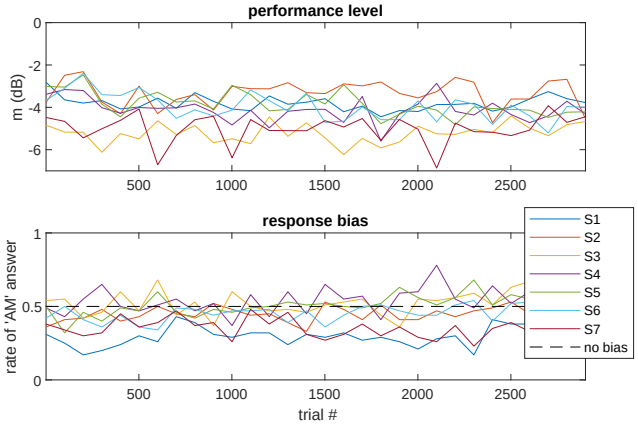


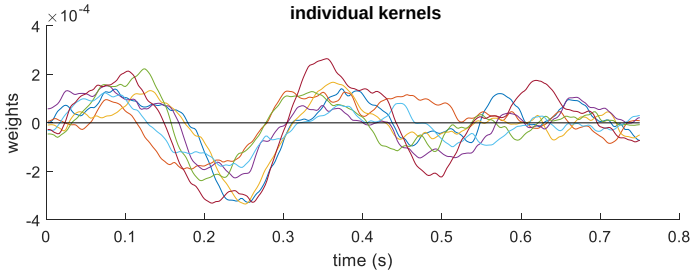
Performance over the course of the experiment

- 3.000 trials per participant ($\approx$ 3h including breaks)
- Stable behavior in terms of performance and bias
- High performance level (mean m $\approx$ -4 dB, at -10 dB SNR)
- Most participants are unbiased!



Temporal kernel (= pattern of intrinsic fluctuations of the noise consistently associated with an 'AM' response)

- Similar pattern for all 7 participants
- **Strong 4-Hz component**



Temporal kernel (= pattern of intrinsic fluctuations of the noise consistently associated with an 'AM' response)

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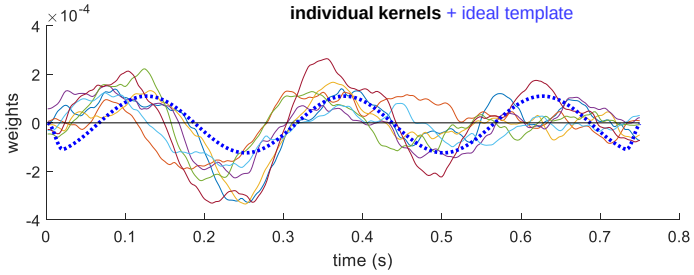

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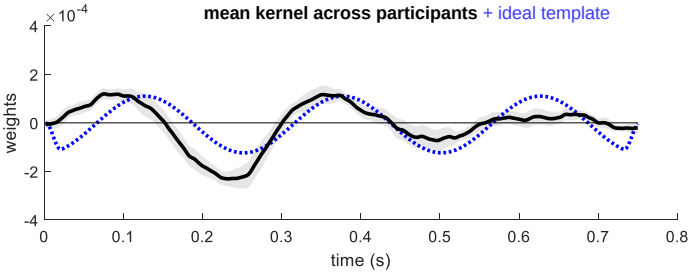

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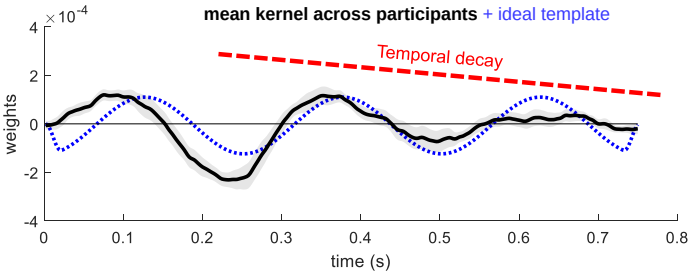

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Differences with the ideal template inform us about the underlying auditory processes

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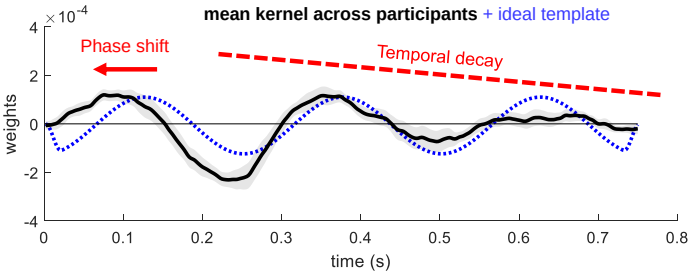

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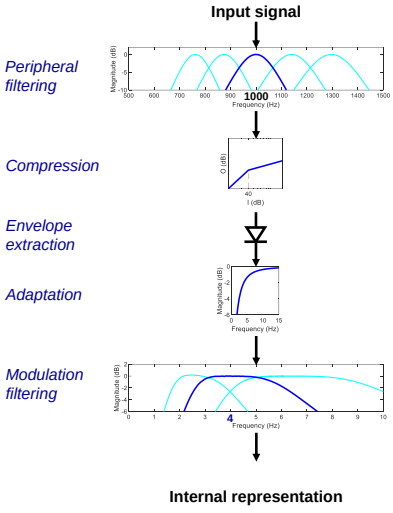
Differences with the ideal template inform us about the underlying auditory processes

Modulation Filterbank Model

The **Modulation Filterbank** model: a simple, widely-accepted front-end model of the auditory system. *[e.g., Dau et al., 1997; Ewert & Dau, 2000; King et al., 2019]*



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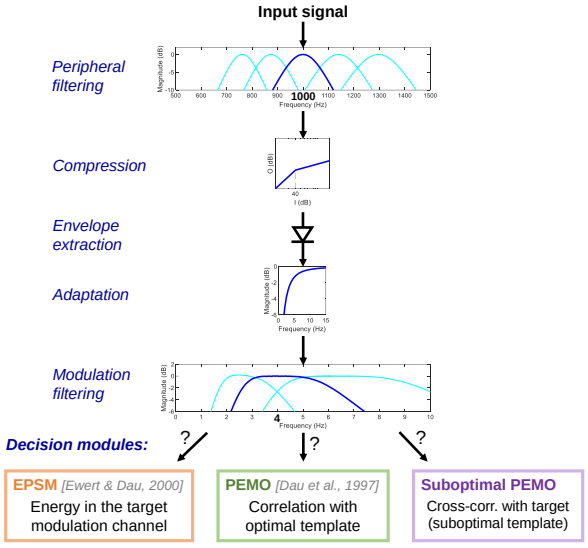
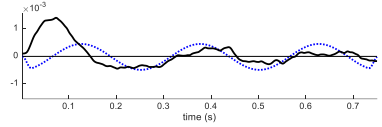
However, no general agreement on how the auditory system converts this internal representation into a decision statistics.

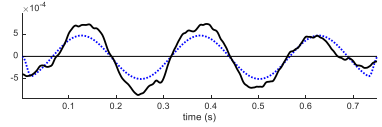


Simulated kernels

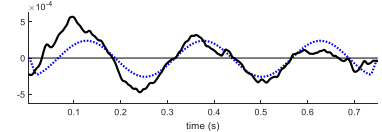
EPSM



PEMO



Suboptimal PEMO



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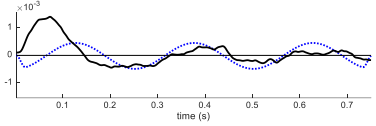

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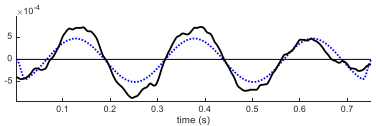

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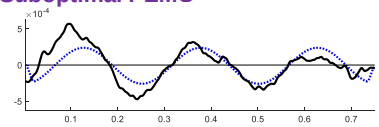
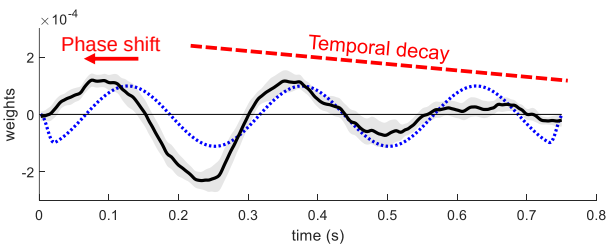


mean kernel accross participants + ideal template



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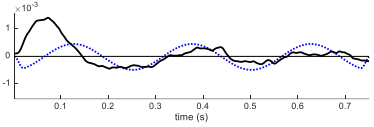

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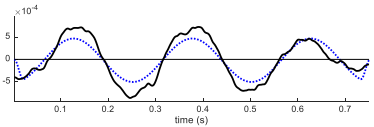

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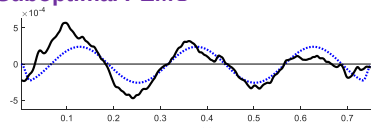

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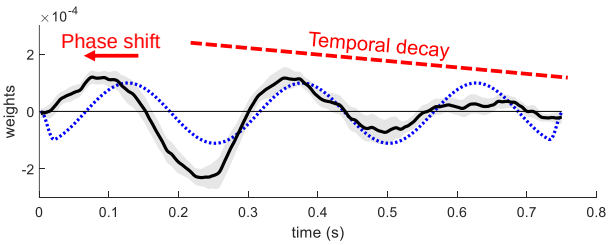
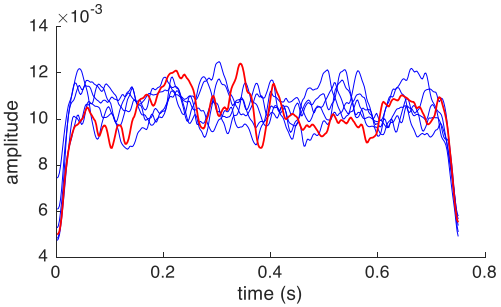


Only **suboptimal PEMO** can reproduce the characteristics of the human kernel, suggesting that the auditory system uses a suboptimal template-matching strategy for this task

Conclusions

- Direct illustration of the **effect of intrinsic fluctuations on perception**: some realizations of the noise have a greater influence than others depending on their exact temporal intrinsic fluctuations
- The **auditory revcorr** technique can be used to **probe internal representations and decision strategies** in real and simulated listeners

- Listeners are able to encode a 4-Hz AM target with its phase, but they use a **suboptimal detection strategy**



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