



Neural oscillations reflect attentional challenges of understanding speech in noise

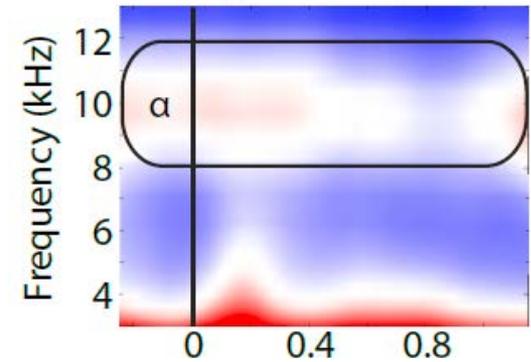
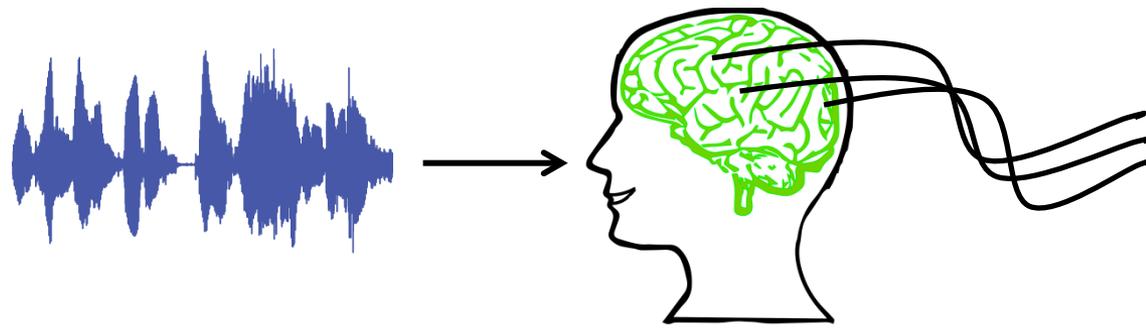
Malte Wöstmann

*Max Planck Research Group "Auditory Cognition",
Max-Planck Institute for Human Cognitive and Brain Sciences, Leipzig,
Germany*

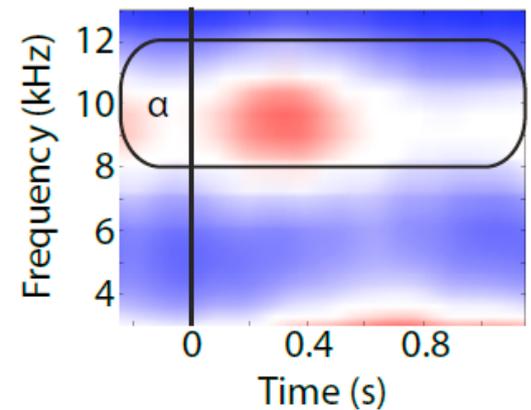
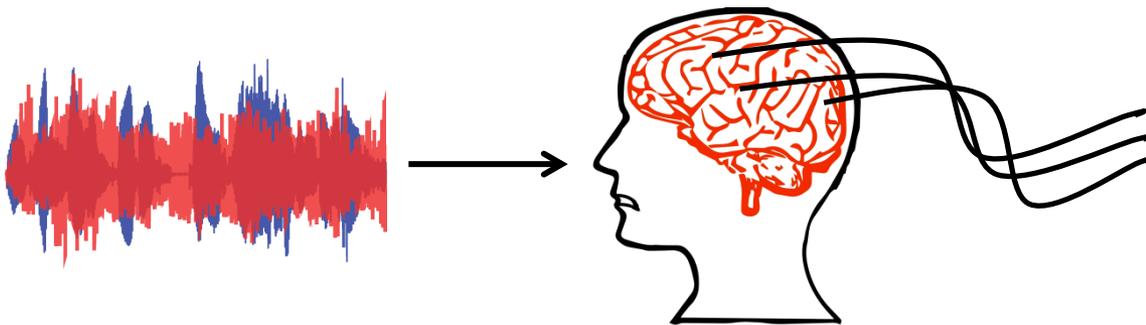


A common observation

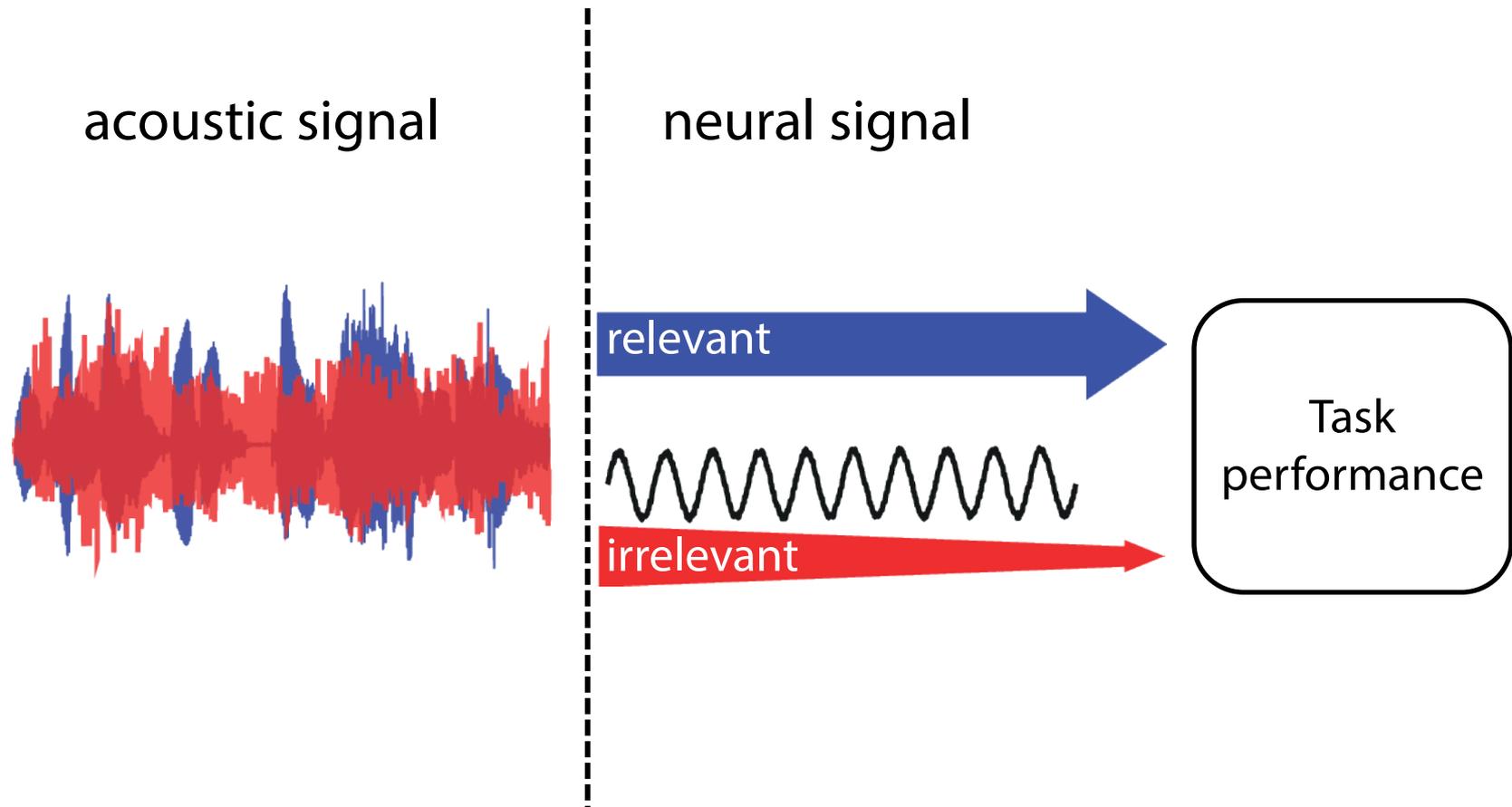
automatic/effortless



effortful/attention-demanding



Functional interpretation



Today's Questions

1) Do alpha power dynamics reflect listening challenges experienced...

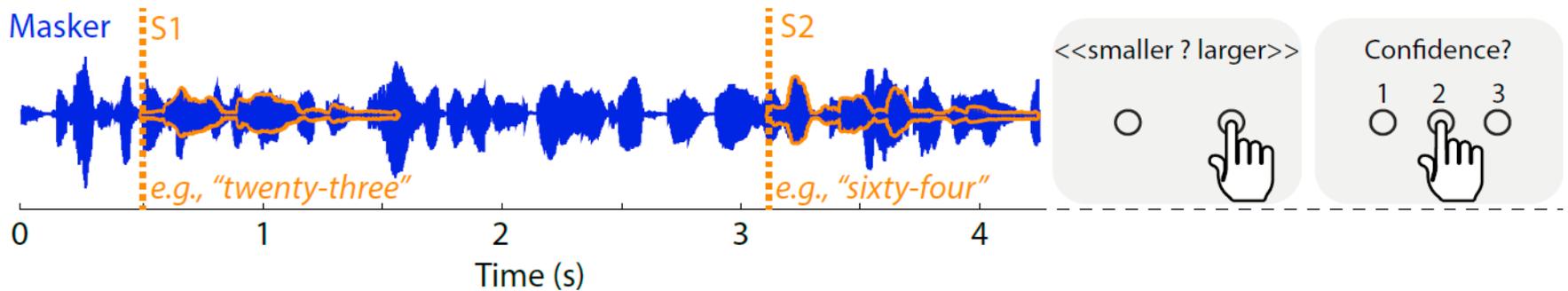
... at an older age?

... with progressive hearing loss?

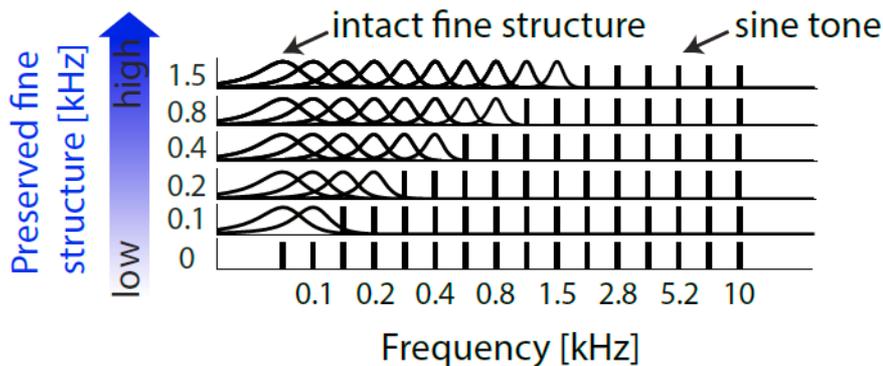
2) "Can alpha oscillations in the brain protect speech signals against interfering distractors?"

Attentional challenges in the ageing listener

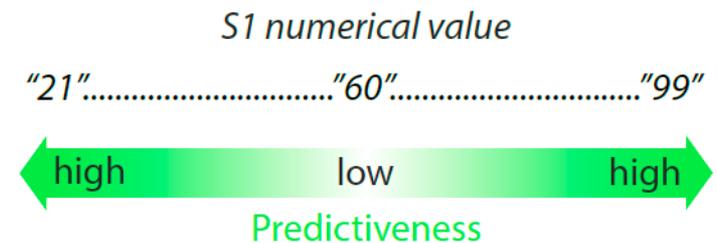
A Trial design for the auditory number comparison task



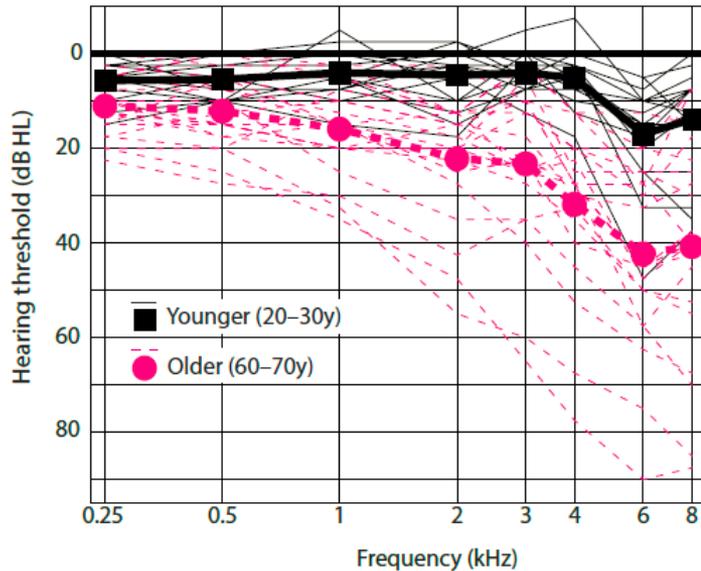
B Manipulation of acoustic detail



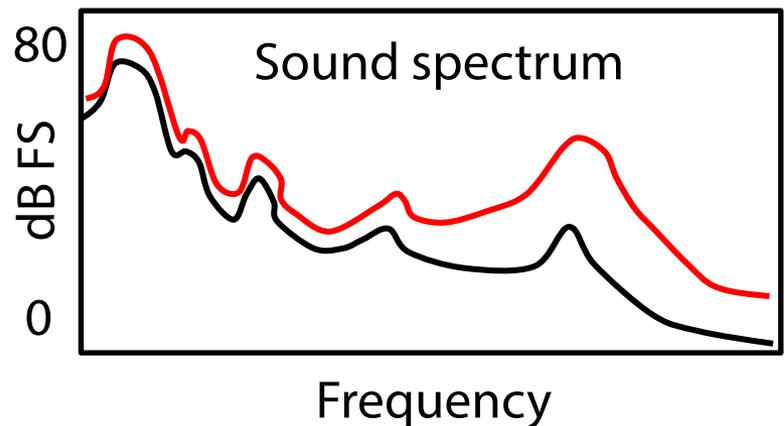
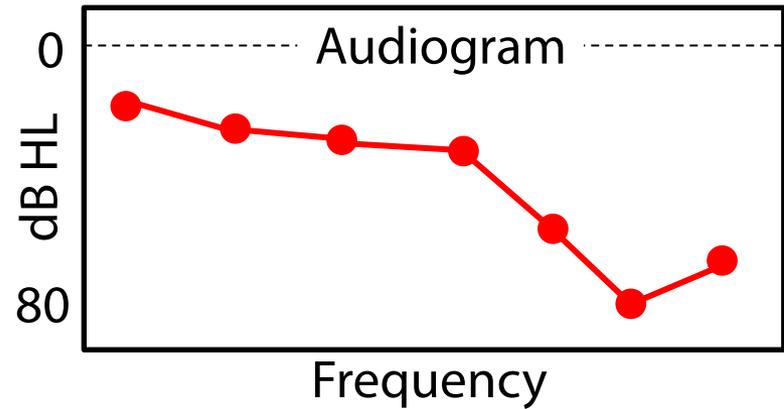
C Manipulation of predictiveness



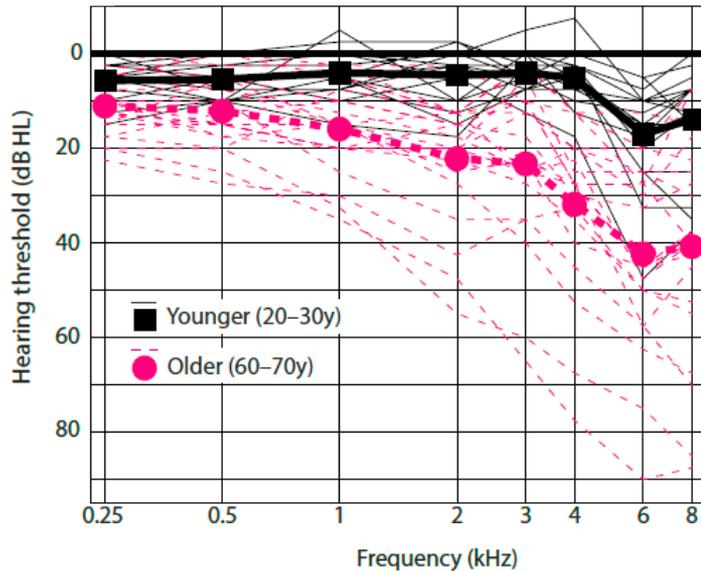
Excluding trivial effects of stimulus audibility



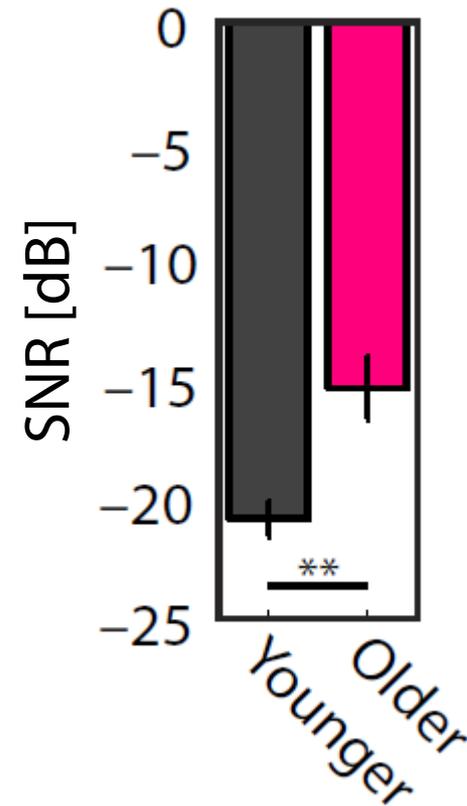
Frequency-specific amplification



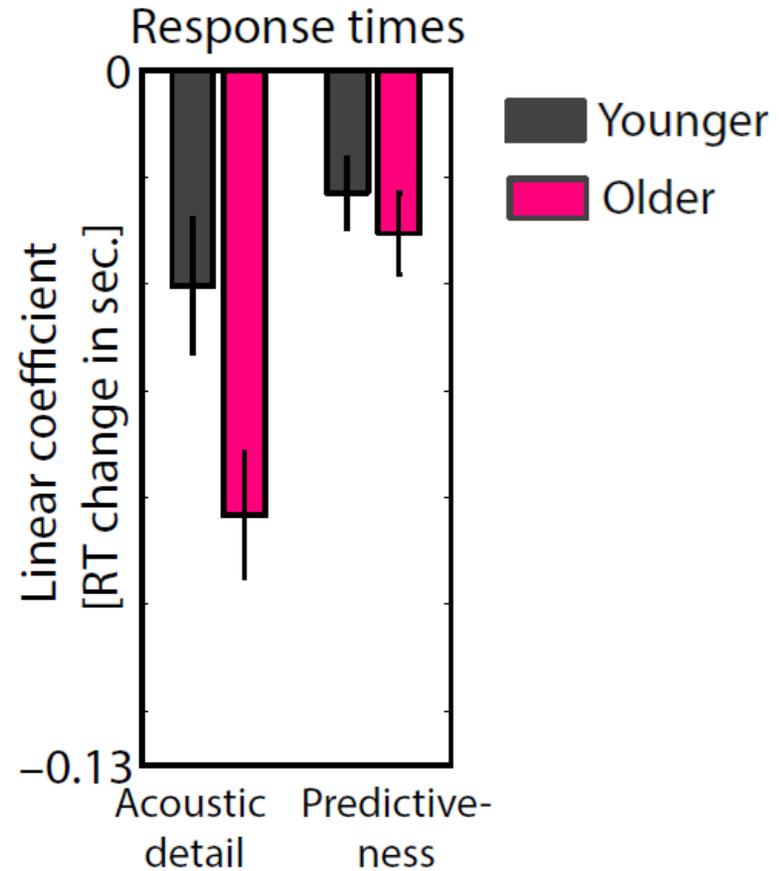
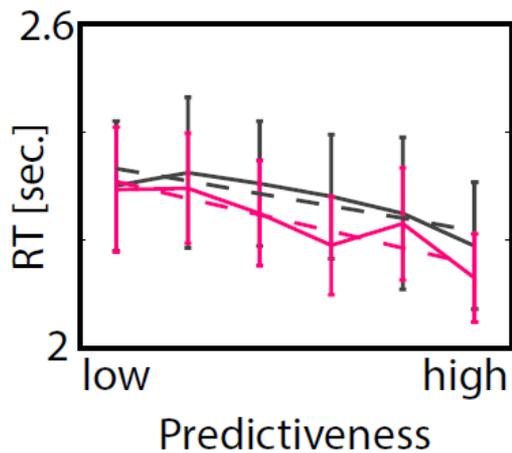
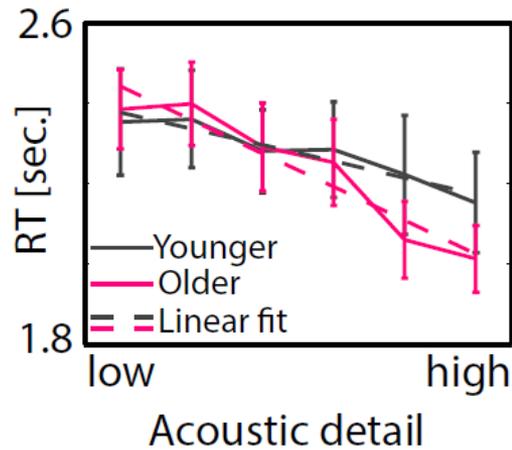
Excluding trivial effects of stimulus audibility



Individual SNR estimation (for ~70 % accuracy)

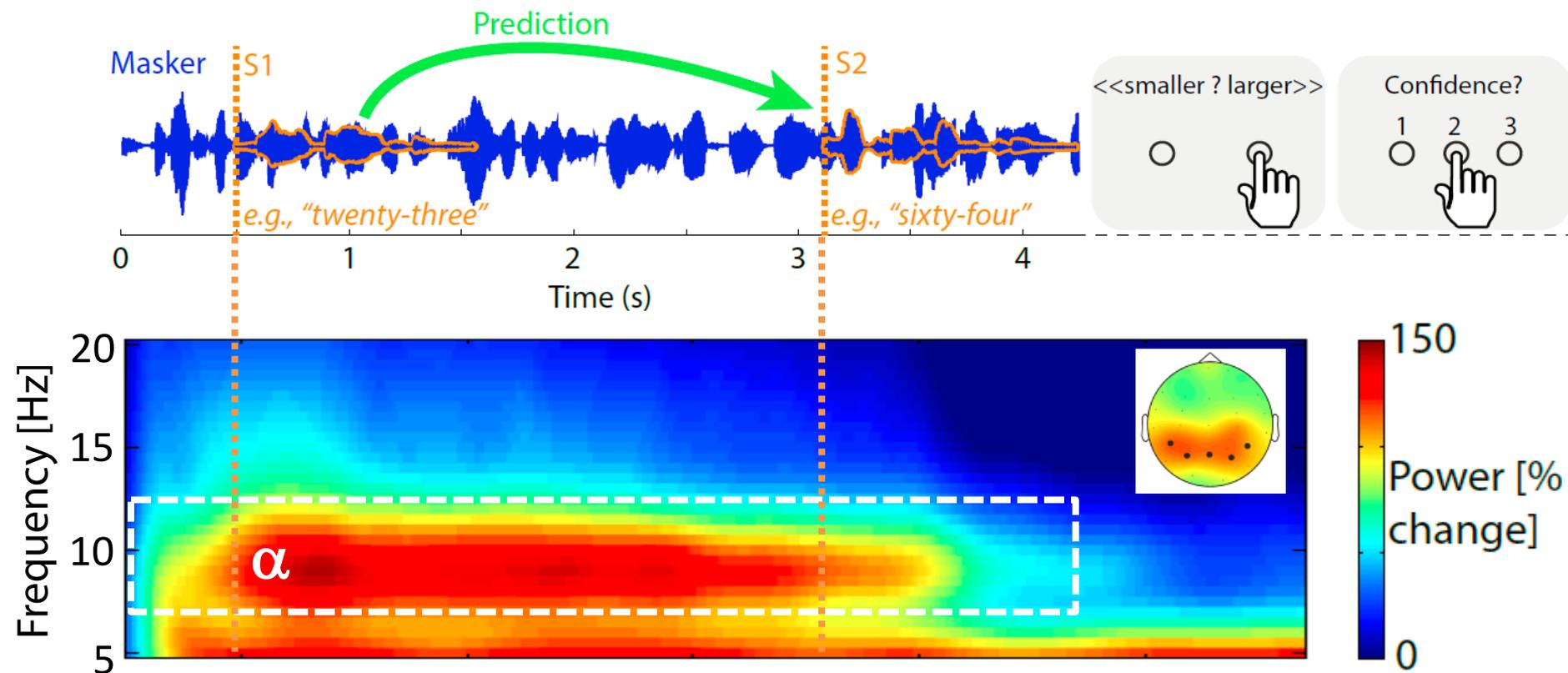


Response times in the number comparison task



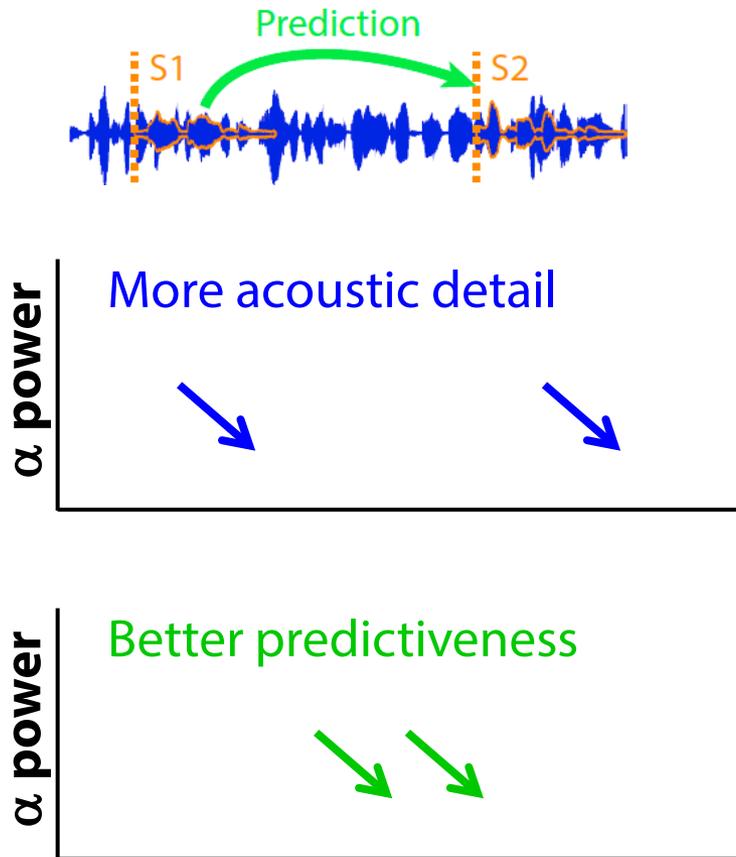
Alpha power during number comparison

A Trial design for the auditory number comparison task



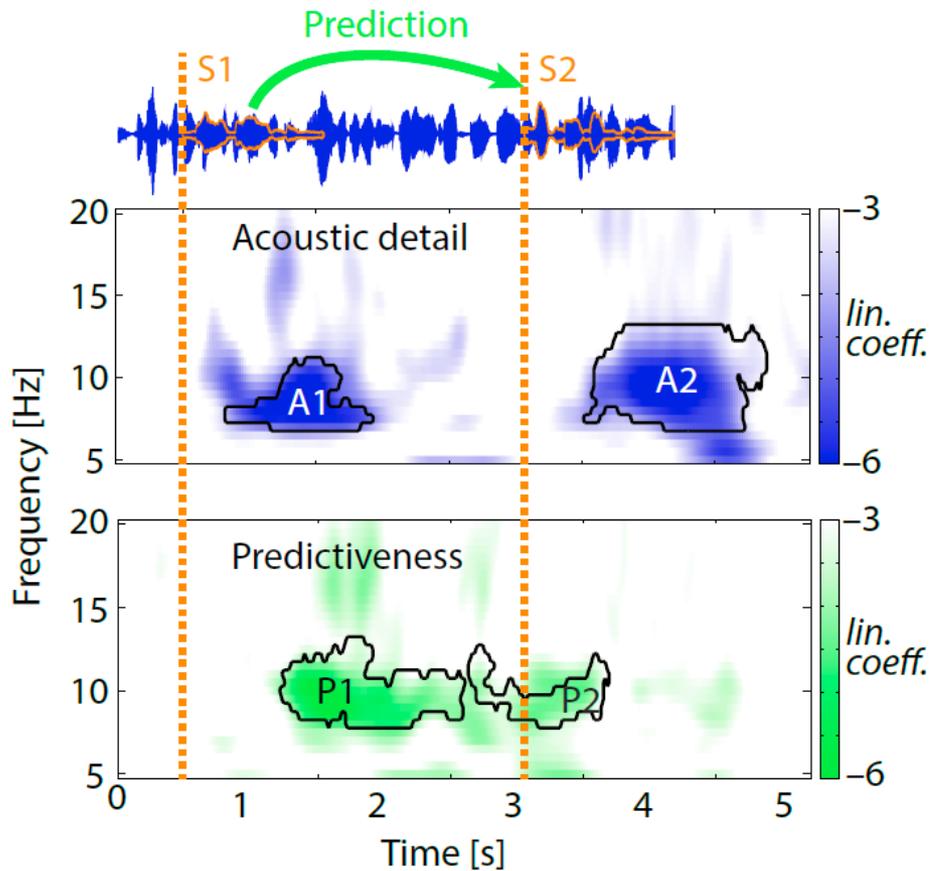
Age-effects on alpha power modulations

A Alpha power modulations

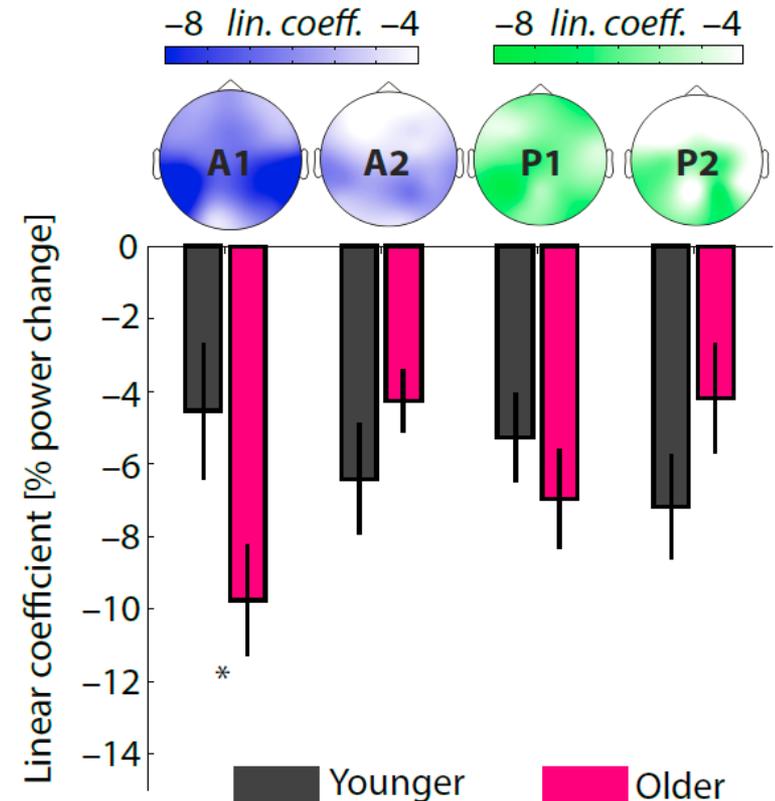


Age-effects on alpha power modulations

A Alpha power modulations



B Effects of age on alpha power modulations



Age-effects on alpha power modulations

A Alpha power modulations



B Effects of age on alpha power modulations



Older listeners' behavior and brain responses were stronger affected by acoustic detail, suggesting a **change in attentional control** with age.

Today's Questions

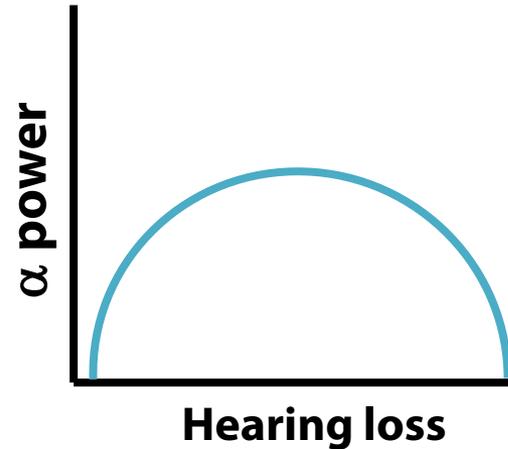
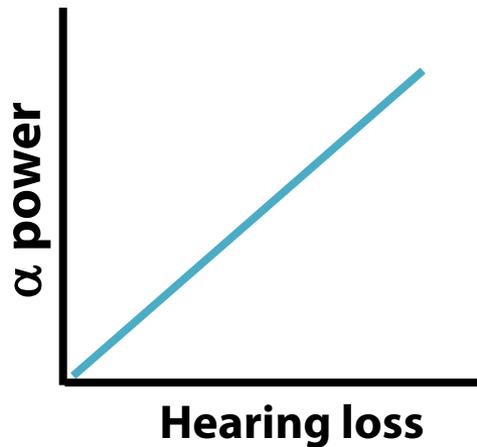
1) Do alpha power dynamics reflect listening challenges experienced...

... at an older age?

... with progressive hearing loss?

2) "Can alpha oscillations in the brain protect speech signals against interfering distractors?"

Does hearing loss affect alpha power dynamics?



P8

Influence of hearing impairment on alpha power during retention of auditory stimuli

Eline Borch Petersen^{1,2}, Malte Wöstmann³, Jonas Obleser³, Stefan Stenfelt², Thomas Lunner^{1,4}

¹Eriksholm Research Centre, Rørtangvej 20, DK-3070 Snekersten, Denmark

²Technical Audiology, Dep. of Clin. and Exptl. Medicine, Linköping University, Sweden

³Max Planck Inst. for Human Cognitive and Brain Sciences, Res. Group 'Auditory Cognition', Leipzig, Germany

⁴Swedish Inst. for Disability Res., Linnaeus Centre, HEAD Linköping University, Sweden

Contact: Eline Borch Petersen, ebp@eriksholm.com



Presented at the 7th Speech in Noise (SpiN) Workshop, Copenhagen, Denmark, January 8-9, 2015



E. Borch-Petersen

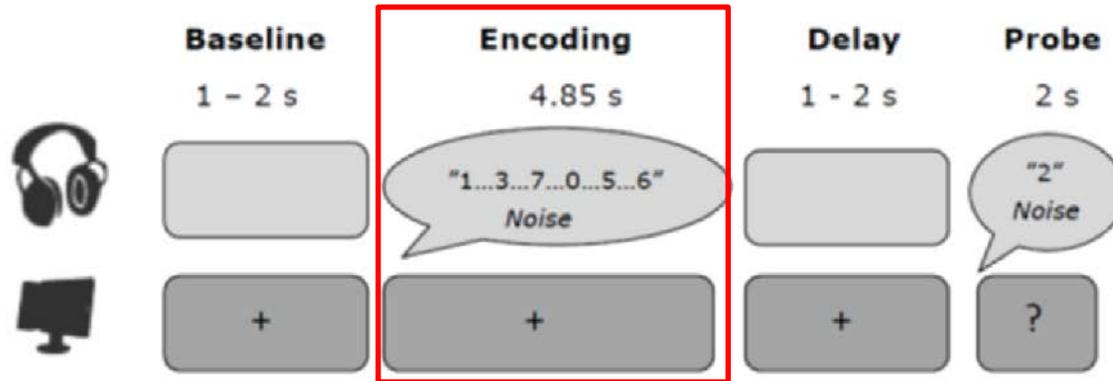


T. Lunner



Borch-Petersen, Wöstmann, Obleser, Stenfelt, Lunner (under review).
See also: Reuter-Lorenz & Cappell (2008). *Curr Dir Psychol Sci*.

Does hearing loss affect alpha power dynamics?



**3 (Memory load:
2, 4, 6 digits)**

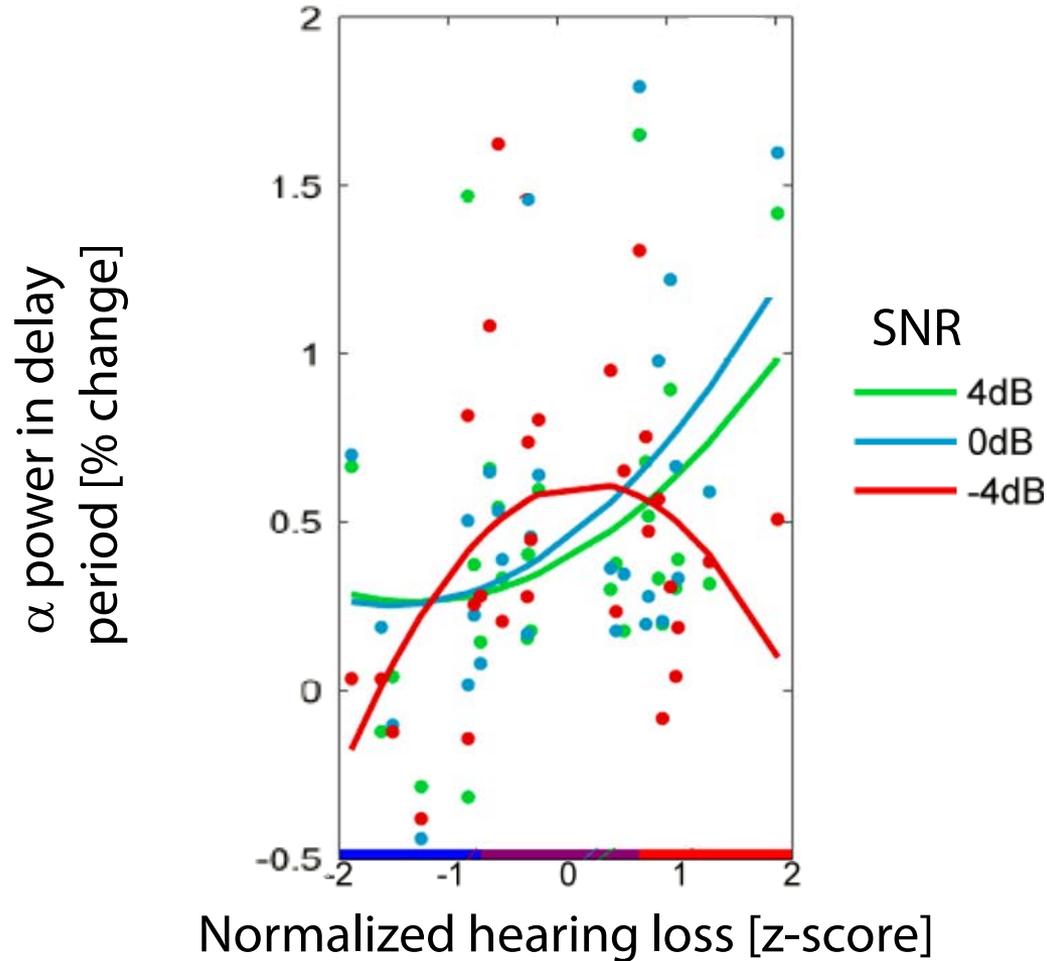
x

**3 (SNR:
4, 0, -4 dB)**



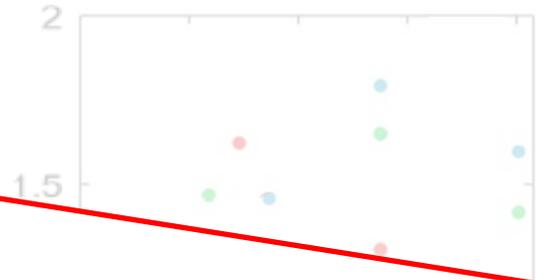
Does hearing loss affect alpha power dynamics?

Highest memory load: 6 items



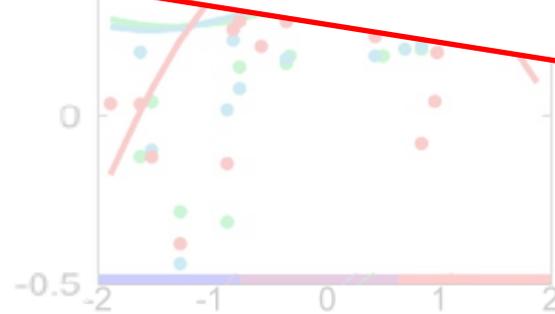
Does hearing loss affect alpha power dynamics?

Highest memory load: 6 items



Alpha power breaks down if the interplay between **signal degradation** and **hearing loss** induces a high task load.

α power



Normalized hearing loss [z-score]

Today's Questions

1) Do alpha power dynamics reflect listening challenges experienced...

... at an older age?

... with progressive hearing loss?

2) "Can alpha oscillations in the brain protect speech signals against interfering distractors?"

Can alpha oscillations in the brain protect speech signals against interfering distractors?

Malte Wöstmann^{1,2}, Antje Strauß¹, & Jonas Obleser¹

¹ Max Planck Research Group "Auditory Cognition", Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany

² International Max Planck Research School on Neuroscience of Communication, Leipzig, Germany

wostmann@cbs.mpg.de

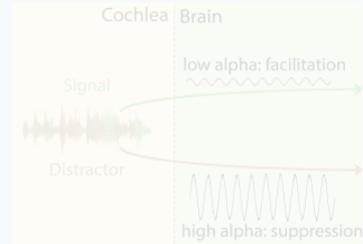


MAX PLANCK INSTITUTE FOR HUMAN COGNITIVE AND BRAIN SCIENCES LEIPZIG

Introduction

- Listening to one talker in the presence of interfering speech- and non-speech noise is demanding and error-prone.
- During the last years, a number of brain imaging oscillations at alpha (~ 10 Hz) frequency might be **task-irrelevant or distracting materials** [1–4]. We presume that alpha activity also plays an important role in processing in noisy environments:
- High alpha** activity in brain regions associated with the distractor could suppress the distractor from interfering during processing stages.
- Low alpha** activity in brain regions associated with the signal could facilitate speech processing.
- We have investigated whether alpha activity in the brain during distractor interference increases (Experiment I) and whether low alpha activity might serve a functional role in facilitating speech processing (Experiment II, preliminary data).

Hypothetical distractor suppression by alpha activity



Methods

Experiment I

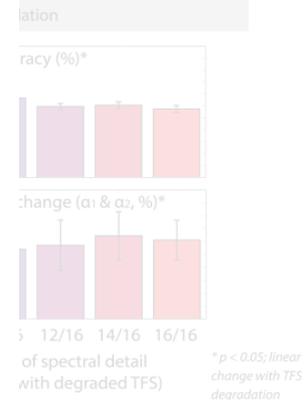
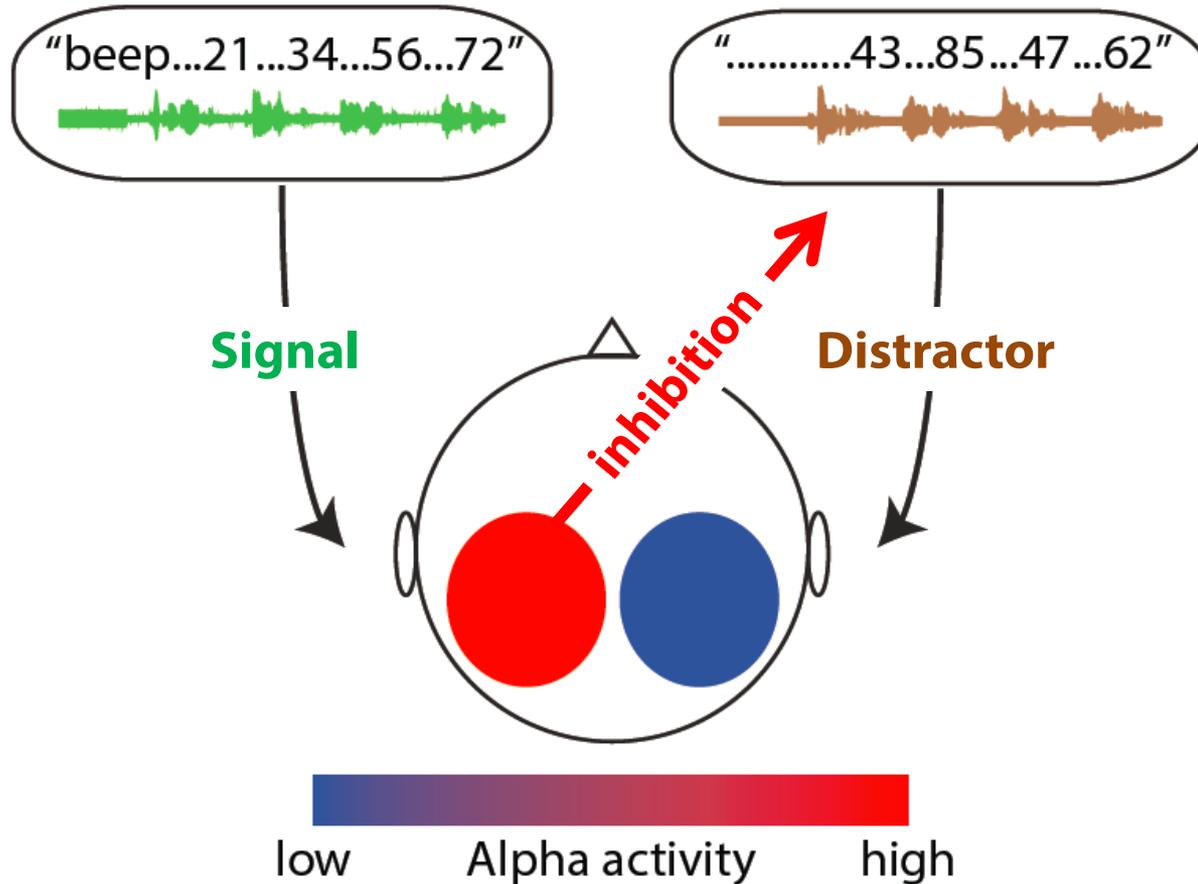
- Auditory number comparison:** 38 participants (S1, S2) while ignoring a distracting talker.
- Task:** Indicate whether second number was same as first.
- Acoustic degradation:** Materials were divided into two conditions: **high spectral detail** (temporal fine structure, TFS) while ignoring a distracting talker [5].
- Distractor interference** was intended to increase with degraded TFS.
- Material adjustments:** Absolute intensities were adjusted to match the loudness of the distractor (CAMEQ, [6]); relative intensity of numbers was adjusted to match the loudness of the distractor (CAMEQ, [6]).

Experiment II

- Dichotic listening** [7]: Six participants listened to four spoken numbers on one ear while ignoring four simultaneously presented numbers on the other ear (presentation rate: 0.67 Hz; broadband background noise, SNR: 5 dB).
- Cueing:** To-be-attended ear was cued with 1 kHz tone.
- Task:** Select numbers from the attended ear in a subsequently presented array of probes.
- Response types:** **Target:** select number from to-be-attended ear; **Distractor:** select number from to-be-ignored ear; **"False alarm":** select number not presented on either ear.

Results

Experiment I



number comparison suggests an important role of alpha oscillations for speech processing in complex noise.

- Alpha activity increased stronger during the encoding of the to-be-attended numbers (during α_1 & α_2) when distractor interference (TFS degradation) was more severe.
- Findings support the hypothesis that alpha oscillations inhibit processing of interfering distractors to facilitate processing of task-relevant signals (here: numbers).

Participants were well able to selectively listen to and recall numbers from the to-be-attended ear.

- Participants' tendency to select distractors rather than to make "false alarms" ($p = 0.085$) demonstrates the vulnerability of the signal on the attended ear for distractor interference.
- In almost half of the trials (~ 45 %) participants performed without errors, while (mostly one or two) errors were committed in the remaining trials, presumably due to an insufficient protection of targets via alpha oscillations.

References

- Obleser J, Mazaheri A (2010). *Front Hum Neurosci*, 4:186
- Kerlin J, Shahin A, Miller L (2010). *J Neurosci*, 30:2
- Obleser J, Wöstmann M, Hellberd N, Wilsch A, Maess B (2012). *J Neurosci*, 32:36
- Roux F, Uhlhaas P (2013). *TICS*, 18:1
- Hopkins K, Moore B (2008). *J Acoust Soc Am*, 123:3
- Moore B, Alcantara J, Glasberg B (1998). *Br J Audiol*, 32:3
- Broadbent D (1954). *J Exp Psych*, 47:3

Can alpha oscillations in the brain protect speech signals against interfering distractors?

Malte Wöstmann^{1,2}, Antje Strauß¹, & Jonas Obleser¹

¹ Max Planck Research Group "Auditory Cognition", Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany

² International Max Planck Research School on Neuroscience of Communication, Leipzig, Germany

wostmann@cbs.mpg.de



Introduction

- Listening to one talker in the presence of interfering speech- and non-speech noise is demanding and error-prone.
- During the last years, a number of brain imaging oscillations at alpha (~ 10 Hz) frequency might be **task-irrelevant or distracting materials** [1–4]. We presume that alpha activity also plays an important role in processing in noisy environments:
- High alpha** activity in brain regions associated with the distractor could suppress the distractor from interfering during processing stages.
- Low alpha** activity in brain regions associated with the signal could facilitate speech processing.
- We have investigated whether alpha activity in the brain during distractor interference increases (Experiment I) and whether low alpha activity might serve a functional role in facilitating speech processing (Experiment II, preliminary data).

Hypothetical distractor suppression by alpha activity



Methods

Experiment I

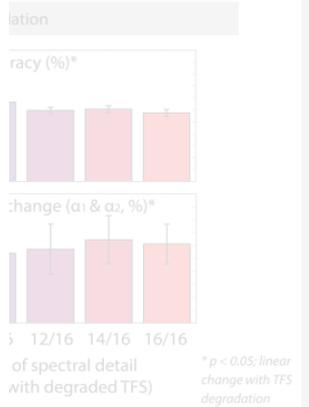
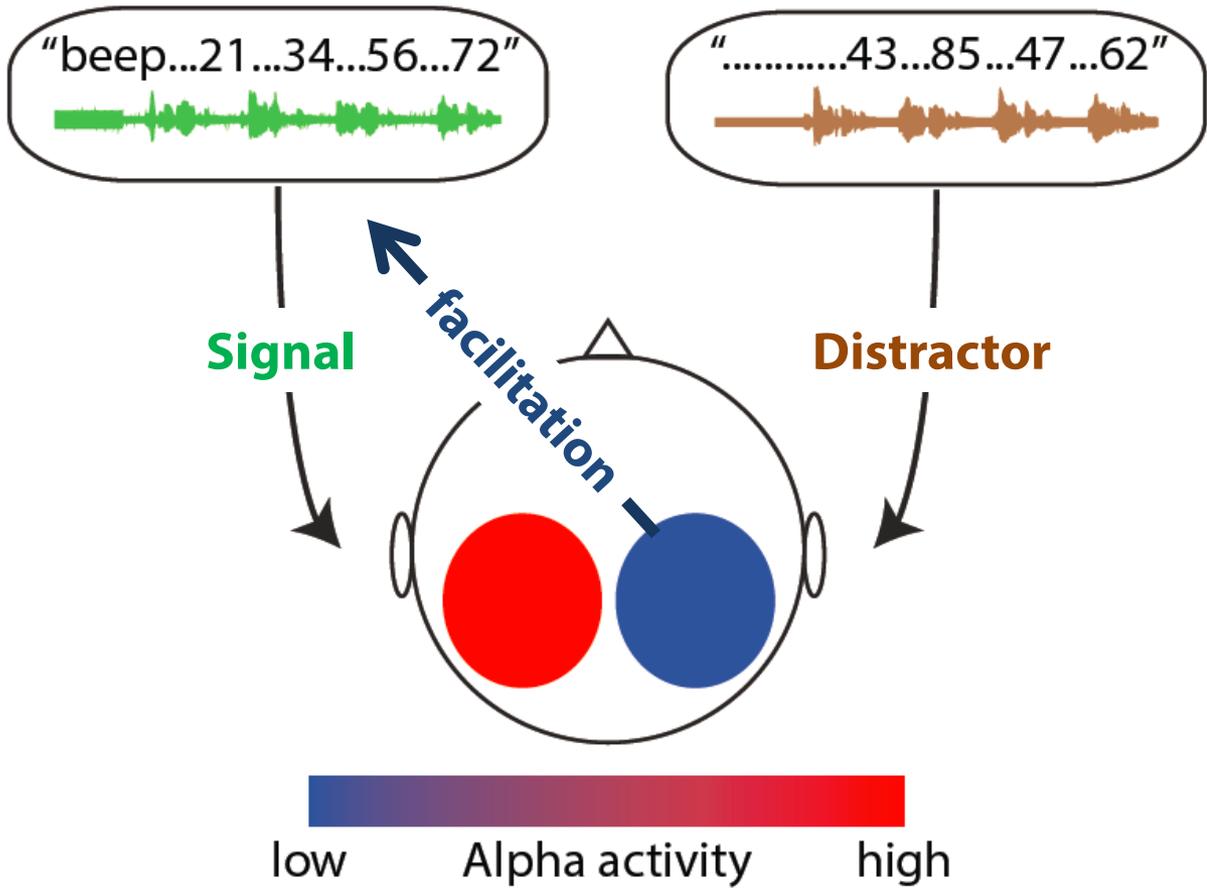
- Auditory number comparison:** 38 participants (S1, S2) while ignoring a distracting talker.
- Task:** Indicate whether second number was same as first.
- Acoustic degradation:** Materials were divided into two conditions: **high spectral detail** (temporal fine structure, TFS) while ignoring a distracting talker [5].
- Distractor interference** was intended to increase with degraded TFS.
- Material adjustments:** Absolute intensities were adjusted to match the loudness of the distractor (CAMEQ, [6]); relative intensity of numbers was set to 10% (CAMEQ, [6]); relative intensity of numbers was set to 10% (CAMEQ, [6]).

Experiment II

- Dichotic listening** [7]: Six participants listened to four spoken numbers on one ear while ignoring four simultaneously presented numbers on the other ear (presentation rate: 0.67 Hz; broadband background noise, SNR: 5 dB).
- Cueing:** To-be-attended ear was cued with 1 kHz tone.
- Task:** Select numbers from the attended ear in a subsequently presented array of probes.
- Response types:** **Target:** select number from to-be-attended ear; **Distractor:** select number from to-be-ignored ear; **"False alarm":** select number not presented on either ear.

Results

Experiment I



Conclusions

- number comparison suggests an important role of alpha oscillations for speech processing in complex noise.
- Alpha activity increased stronger during the encoding of the to-be-attended numbers (during α1 & α2) when distractor interference (TFS degradation) was more severe.
- Findings support the hypothesis that alpha oscillations inhibit processing of interfering distractors to facilitate processing of task-relevant signals (here: numbers).
- Participants were well able to selectively listen to and recall numbers from the to-be-attended ear.
- Participants' tendency to select distractors rather than to make "false alarms" (p = 0.085) demonstrates the vulnerability of the signal on the attended ear for distractor interference.
- In almost half of the trials (~ 45 %) participants performed without errors, while (mostly one or two) errors were committed in the remaining trials, presumably due to an insufficient protection of targets via alpha oscillations.

[1] Obleser J, Wöstmann M, Hellberd N, Wilsch A, Maess B (2012). *J Neurosci*, 32:36

[2] Kerlin J, Shahin A, Miller L (2010). *J Neurosci*, 30:2

[3] Obleser J, Wöstmann M, Hellberd N, Wilsch A, Maess B (2012). *J Neurosci*, 32:36

[4] Roux F, Uhlhaas P (2013). *TICS*, 18:1

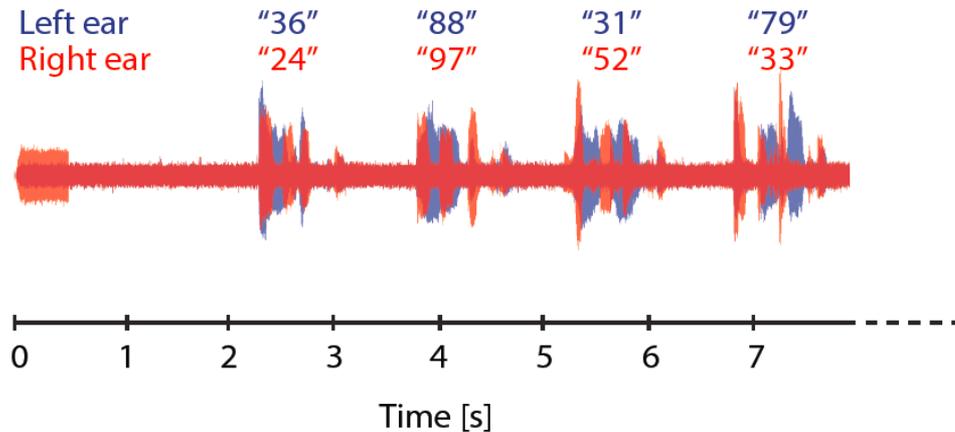
[5] Hopkins K, Moore B (2008). *J Acoust Soc Am*, 123:3

[6] Moore B, Alcantara J, Glasberg B (1998). *Br J Audiol*, 32:3

[7] Broadbent D (1954). *J Exp Psych*, 47:3

Auditory spatial attention task

Dichotic listening; n = 19; (20 – 35 years)



99	24	36	68
33	71	79	52
88	97	42	31

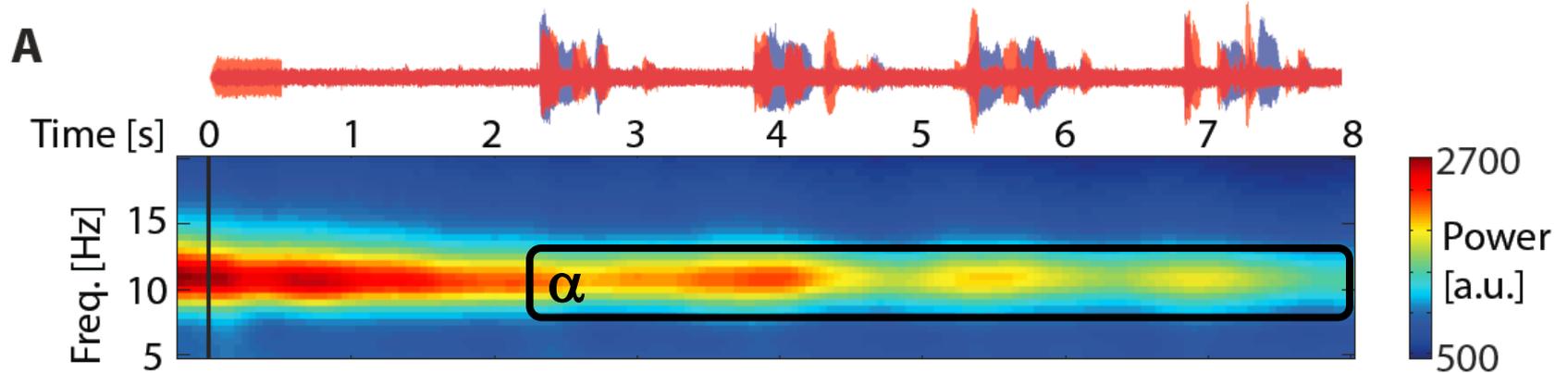
— Hit



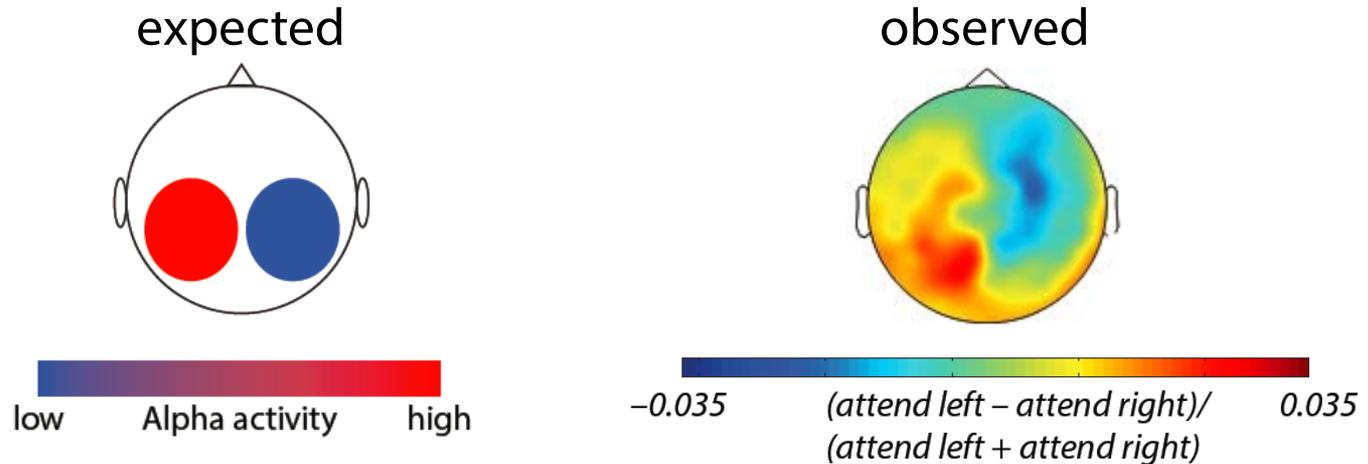
CORRECT TRIAL: 4 Hits; INCORRECT TRIAL: < 4 Hits

Alpha power lateralization

Absolute power



α (~10 Hz) lateralization

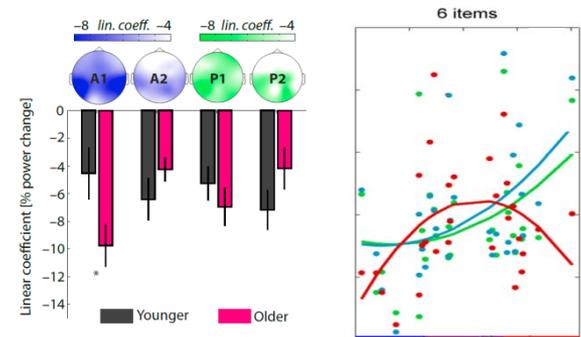
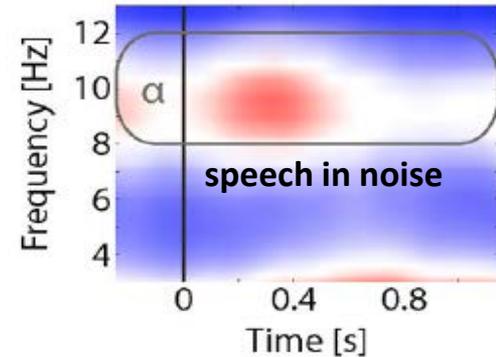


Summary

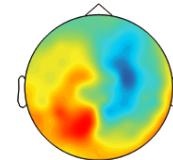
Processing degraded speech is **attention-demanding** and enhances **alpha power**.

Alpha dynamics reflect (1) changes in listening behavior at an **older age**, and (2) interactions between **signal degradation** and compensated **hearing loss**.

Lateralized alpha oscillations signify successful **attentional selection** of task-relevant speech.



Stimulation (2.3–7.9 s)



Thanks to...



MAX
PLANCK
INSTITUTE FOR
HUMAN
COGNITIVE AND BRAIN SCIENCES
LEIPZIG



Auditory Cognition Group

Jonas Obleser	Sung-Joo Lim
Björn Herrmann	Anna Wilsch
Molly Henry	Antje Strauß
Alex Brandmeyer	Dunja Kunke



E. Borch-Petersen & T. Lunner



Erich Schröger,
University of Leipzig



 Linköping University

 Eriksholm Research Centre
PART OF OTICON