



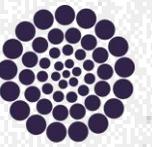
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Influence of age and perceptual training on cortical auditory processing

Zaida Escila Martínez Moreno

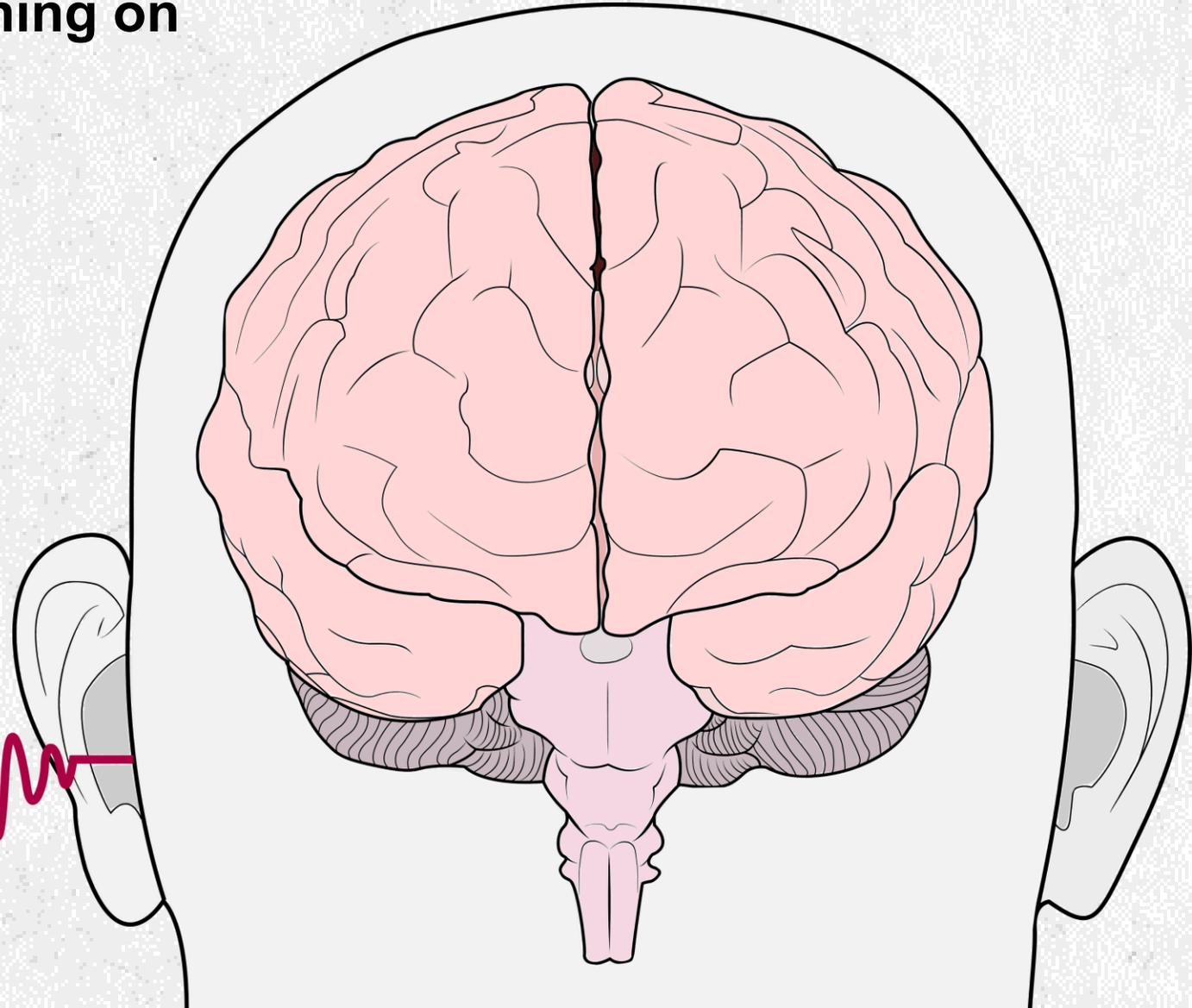
Ph.D. Oral Defense

August 8th, 2025

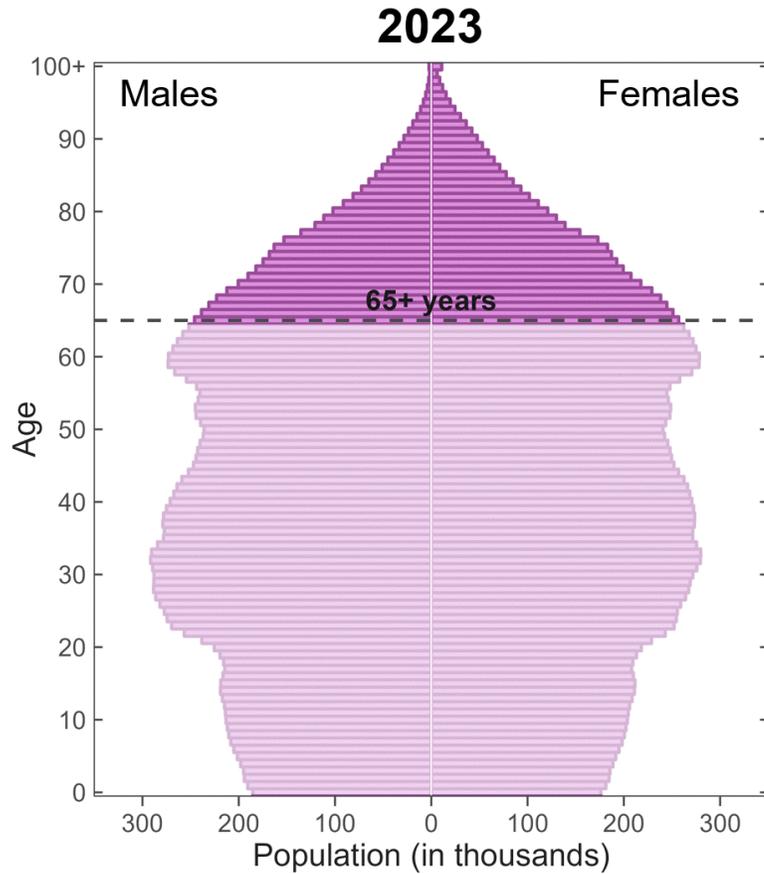
Supervisors:

Etienne de Villers-Sidani

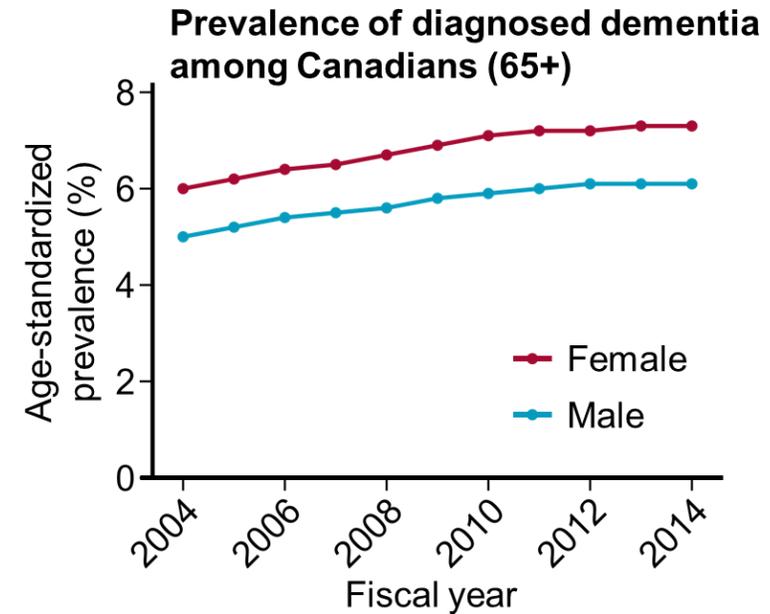
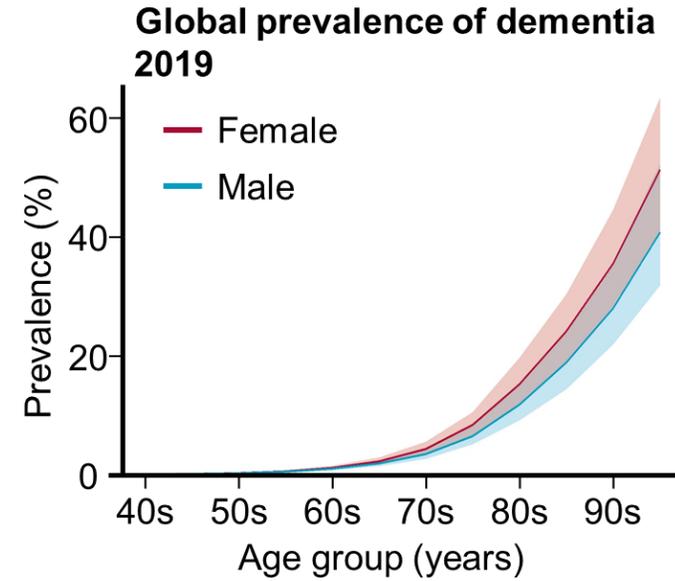
Sylvain Baillet



An aging population

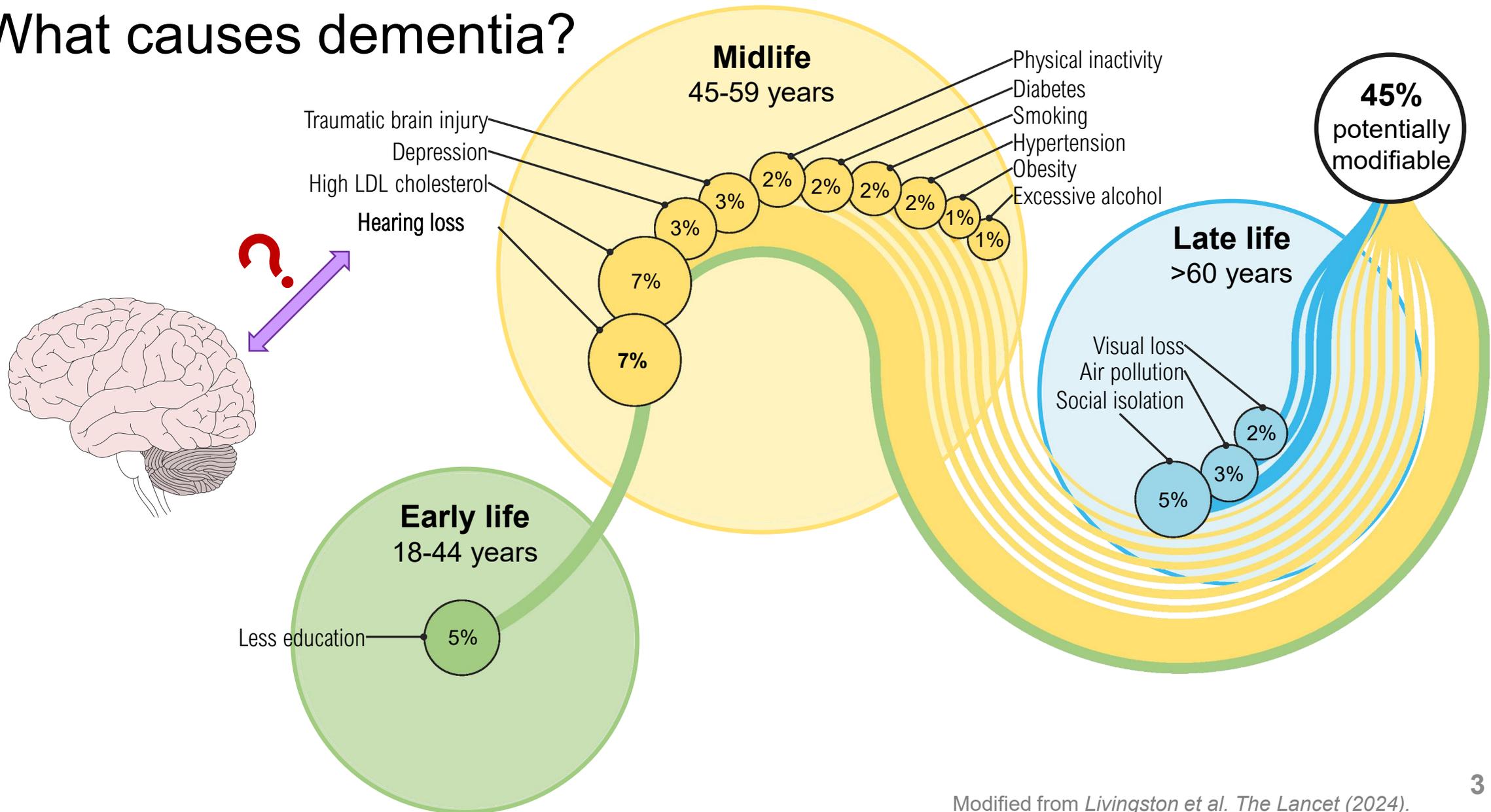


United Nations (2024).

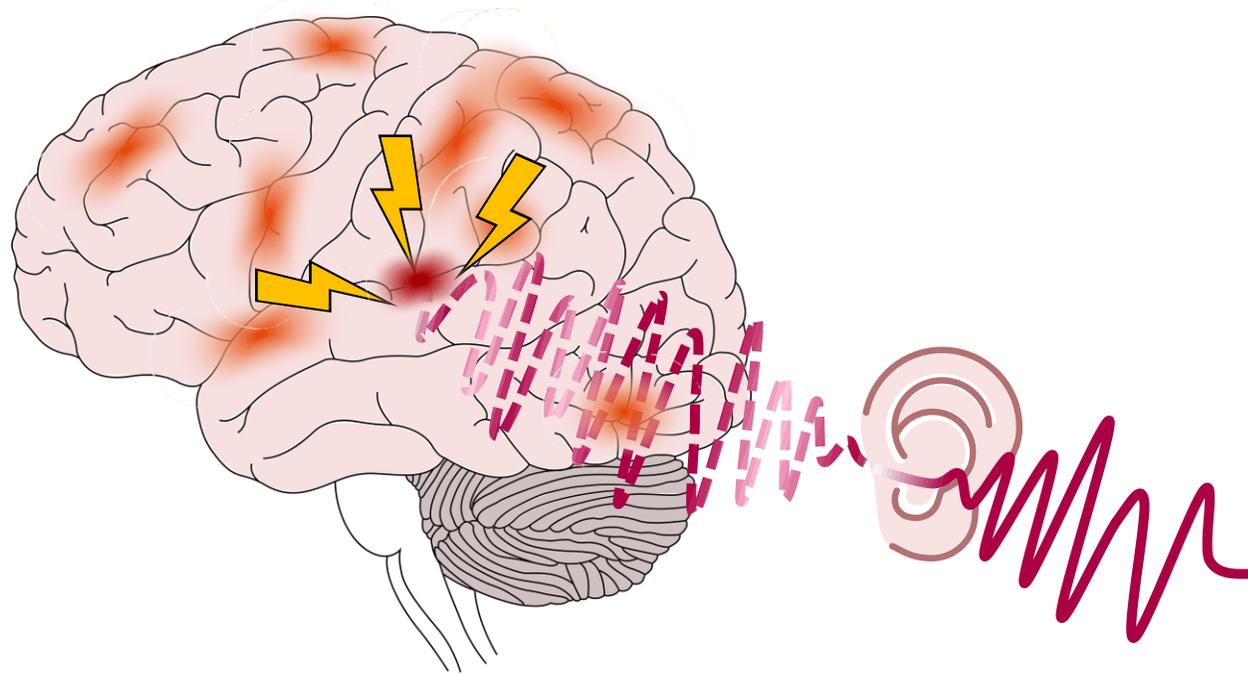


Modified from Nichols et al (2022) and Public Health Agency of Canada (2017).

What causes dementia?



From hearing loss to cognitive decline



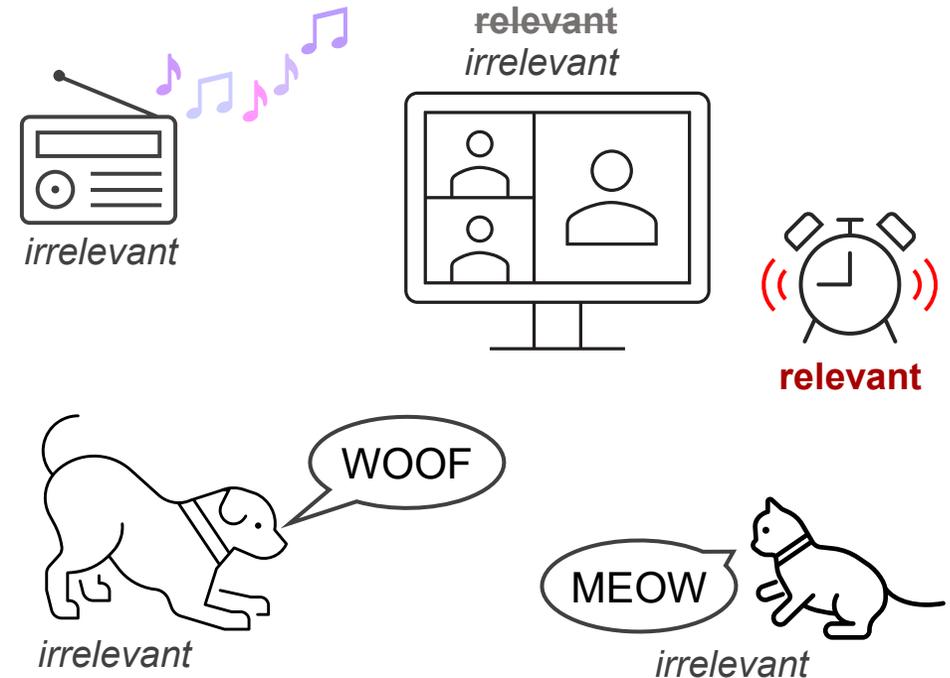
Perceptual hypothesis:

- Degraded input = \uparrow memory and attention needed
- Extra mental effort = interference with other functions
- Chronic hearing deficit = brain changes + \downarrow cognition

Improving auditory perception

Perceptual training:

Improves the recognition of **relevant** from *irrelevant* information through practice.



Benefits of auditory perceptual learning

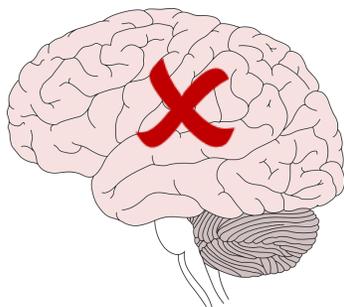


healthy older adults

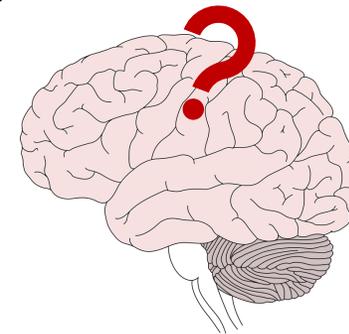
- ↑ Speech perception
- ↑ Working memory
- ↑ Problem solving
- ↑ Cognitive control
- ↑ **Attention**



older adults with hearing loss



How does the brain change with auditory training?



older adults

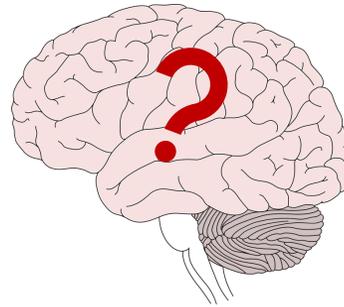
OR



young adults



Main research question



attention networks?
auditory cortex?



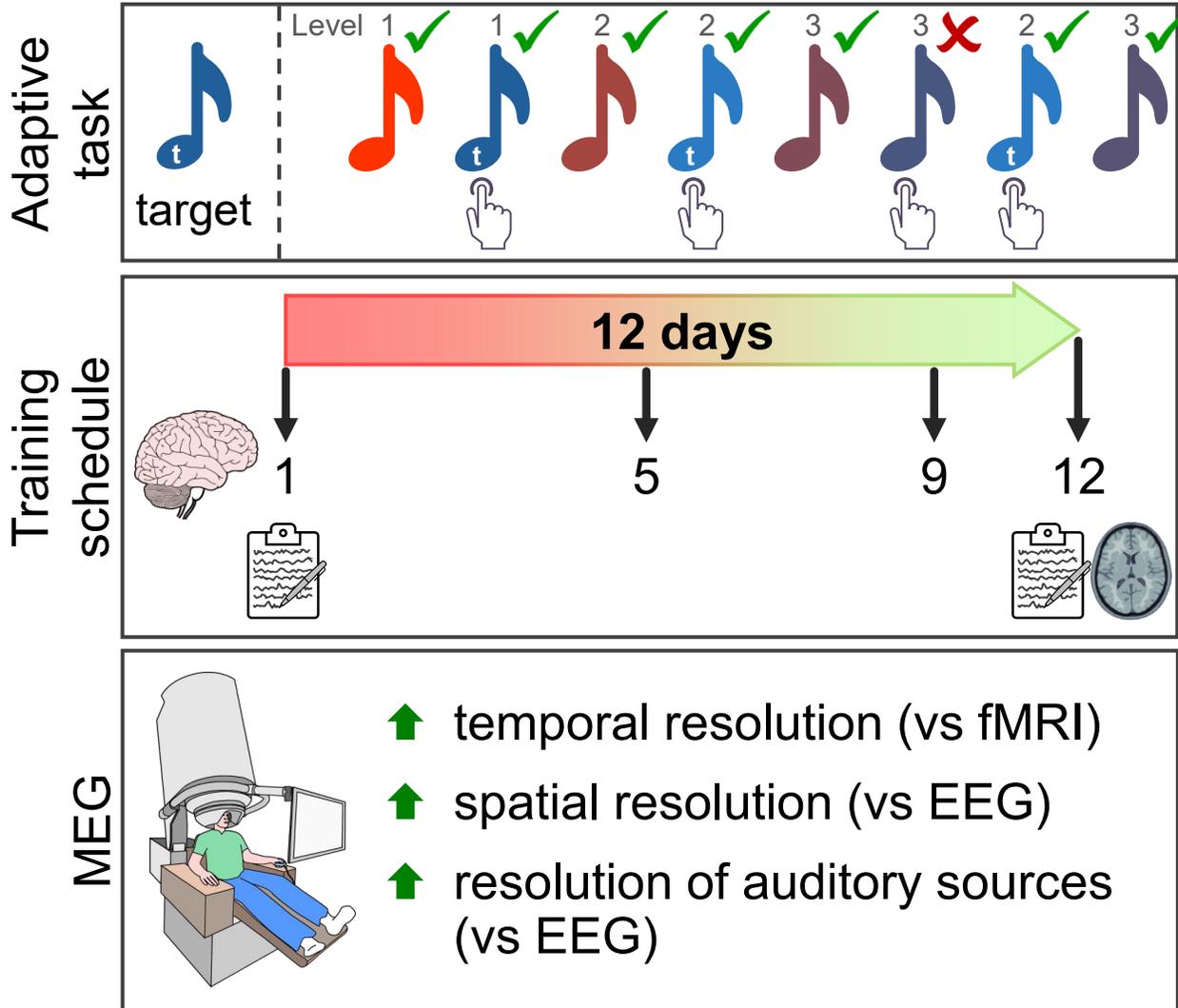
older
adults

vs



young
adults

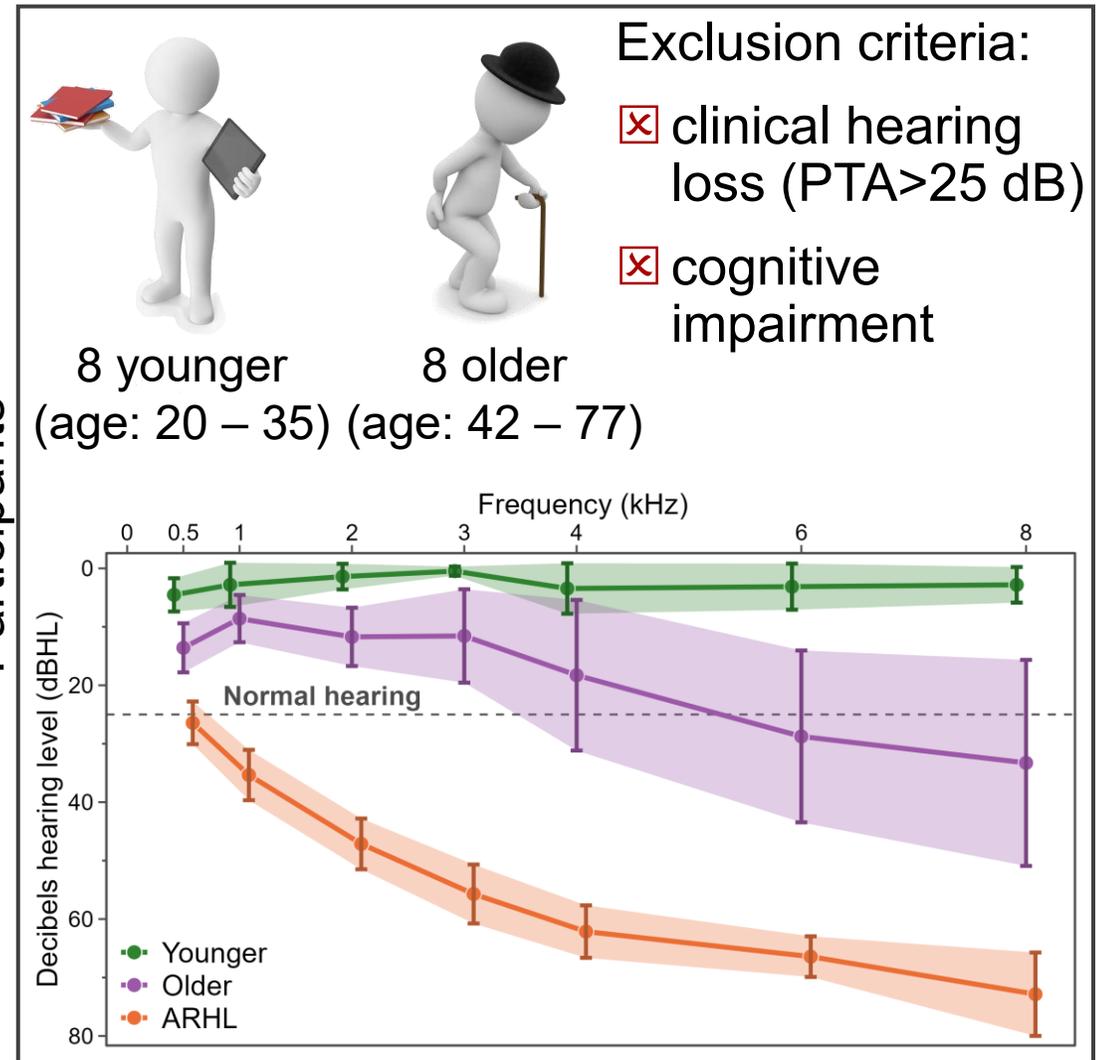
How?



How?

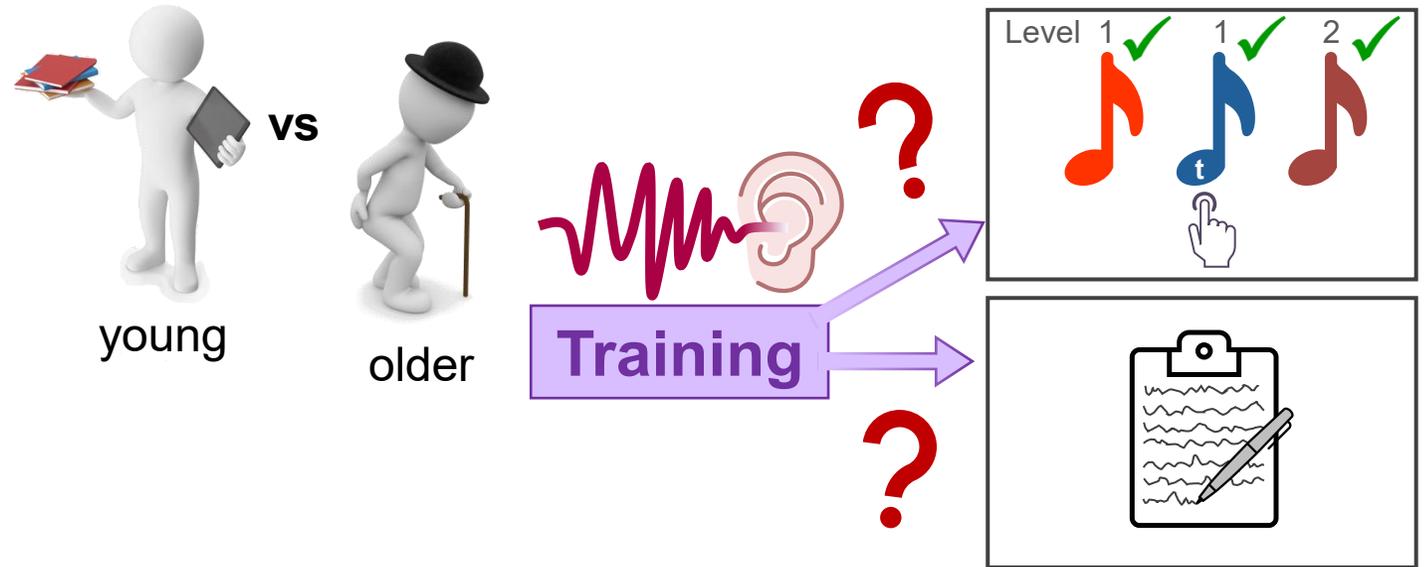


Demographic	Younger	Older
n	8	8
Gender (n)	5 ♀	4 ♀
Hand dominance	1 left	0 left
Age	23.4 ± 5.3	61.6 ± 13.8
Education (years)	16.4 ± 2.8	18.0 ± 3.3
Languages (n)	2.3 ± 0.9	2.0 ± 1.3
Language Proficiency Index (LPI)	1.9 ± 0.4	1.6 ± 0.8
Musicality index (MI)	42.2 ± 40.1	4.3 ± 4.2
Pure Tone Average (PTA): 0.5, 1, 2, 4 kHz	3.0 ± 3.6	13.0 ± 6.8
Full range PTA	2.5 ± 2.2	17.8 ± 10.5
Higher freq. PTA (4, 6, 8 kHz)	2.8 ± 3.2	26.4 ± 18.0

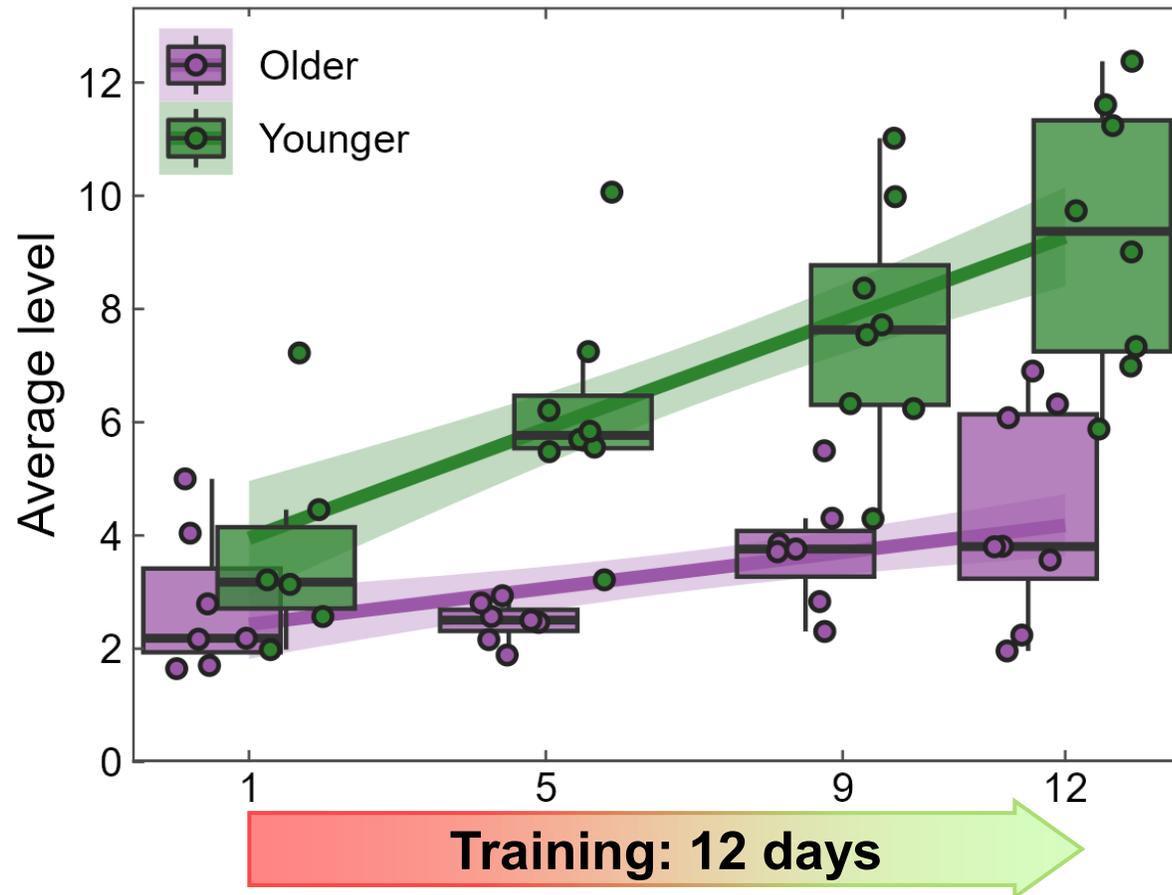


Summary

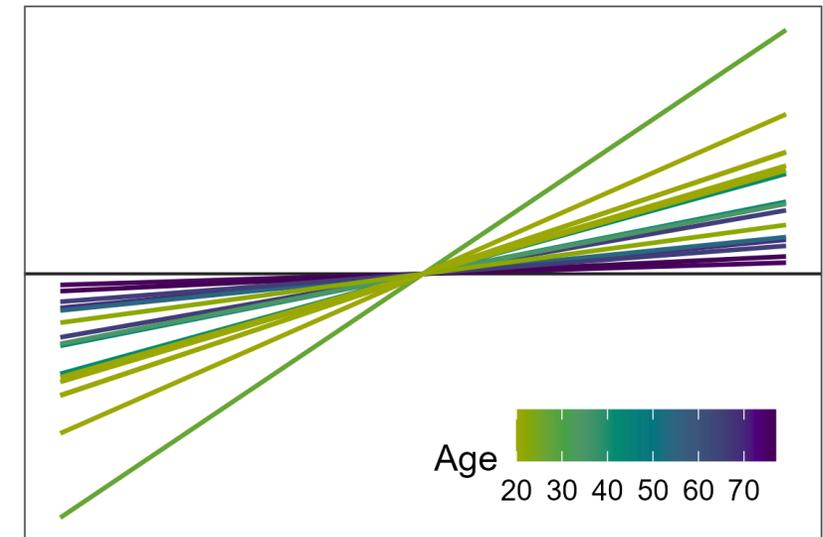
1. Do participants improve in the task?
What are the benefits of training?



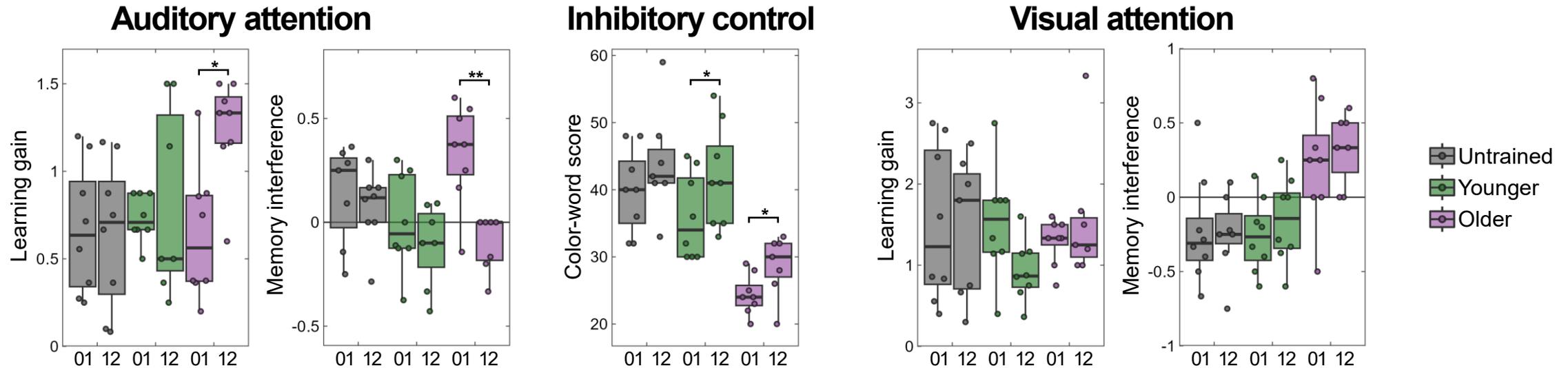
Do all participants improve in the auditory task with training?



- Both groups improve with training.
- Age-differences in performance



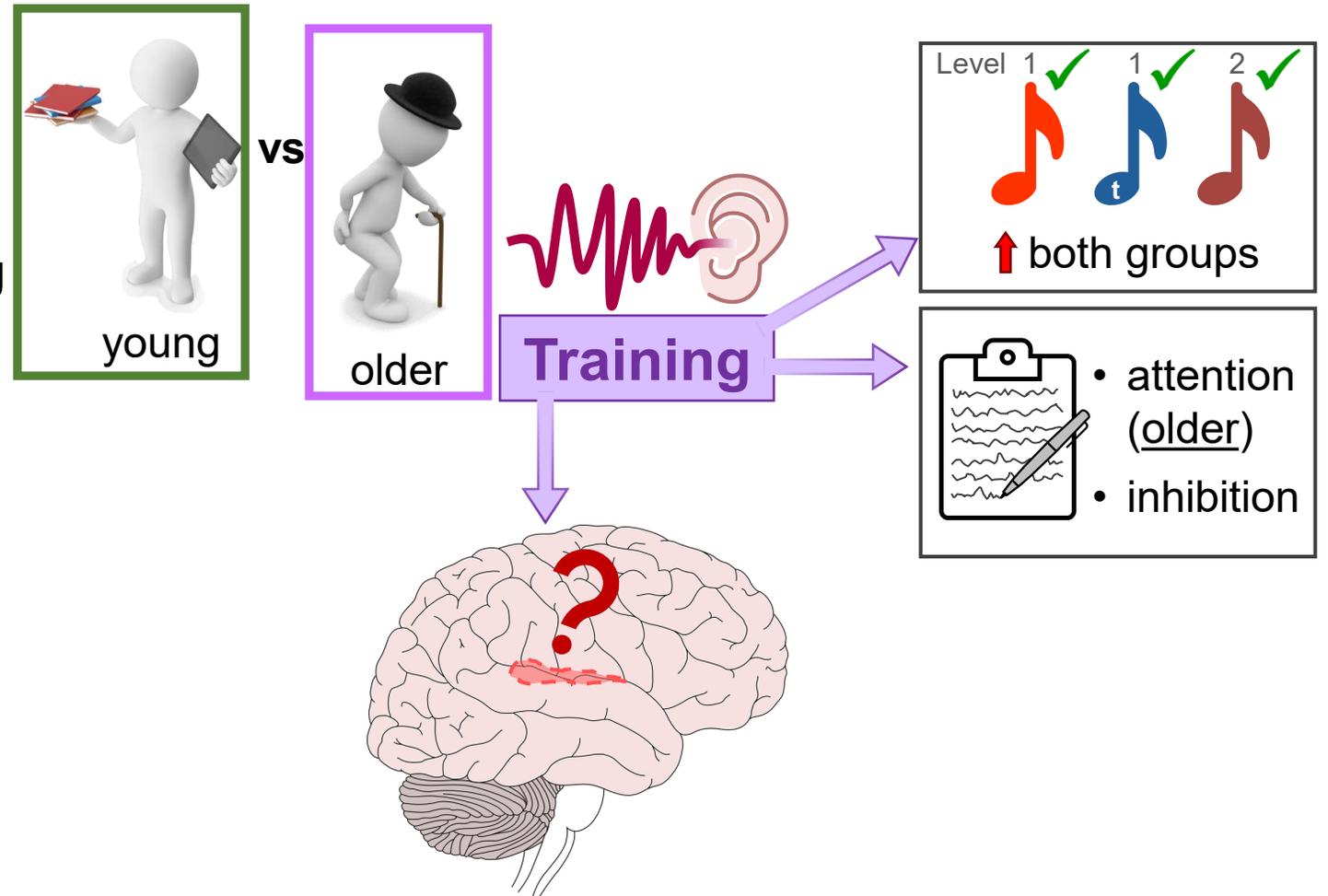
Does this auditory training have effects on other cognitive functions?



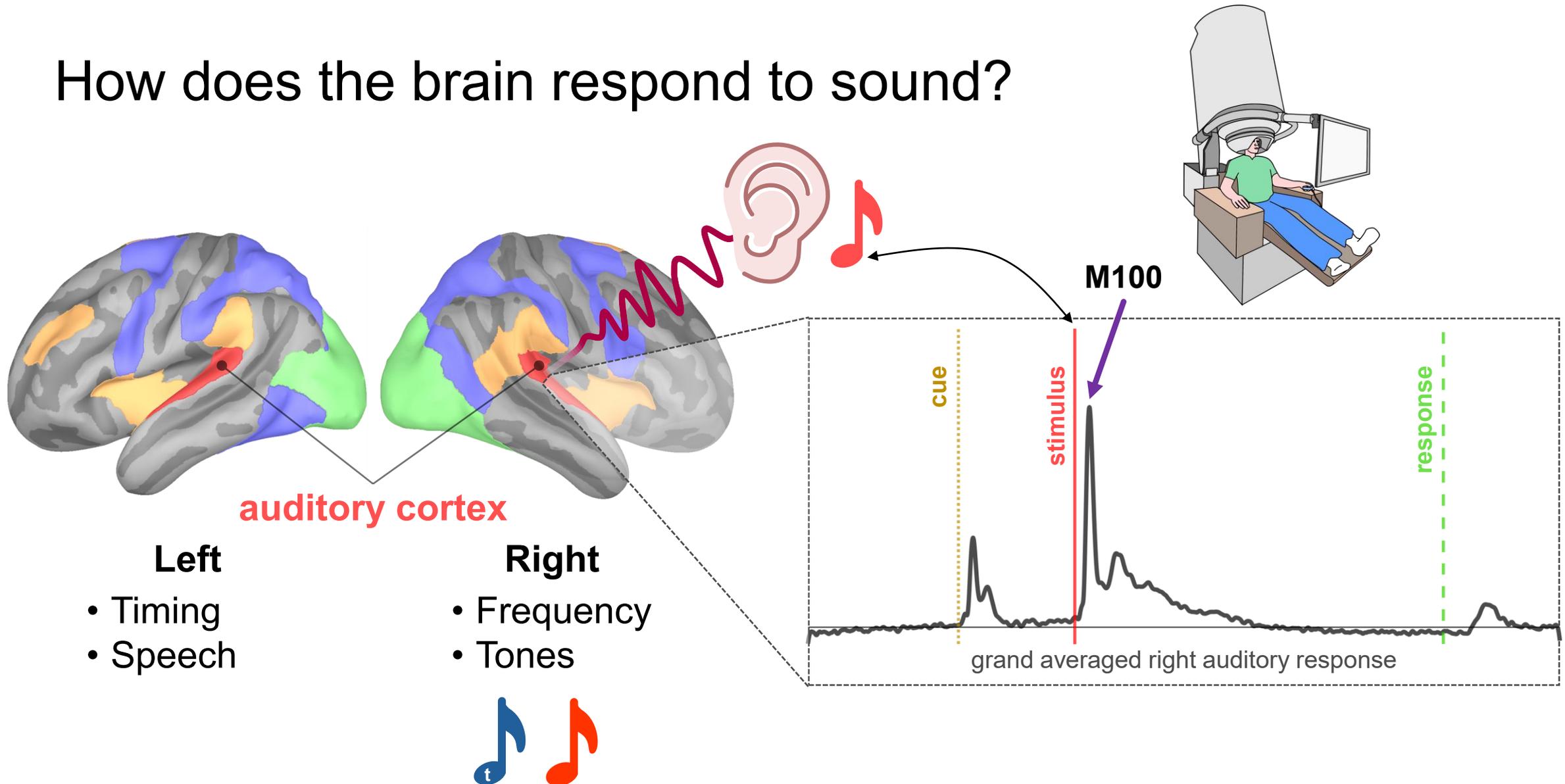
- No changes in the untrained group.
- Only older adults showed better auditory attention with training.
- Both trained groups showed improvements in inhibition control.
- No changes on visual attention: training doesn't affect other modalities.

Summary

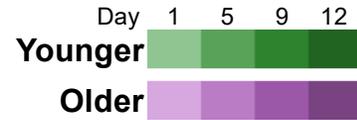
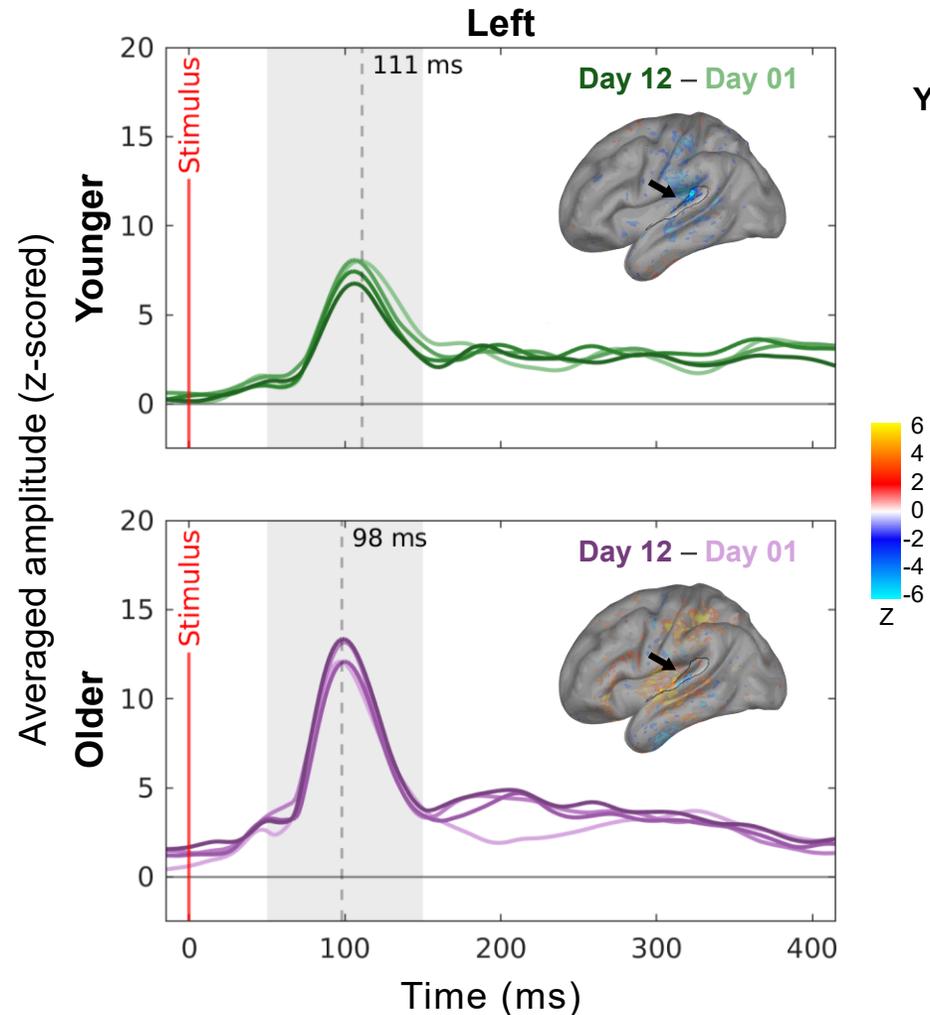
1. Both groups improved in the training task and showed cognitive gains.
2. What is changing in the auditory cortex?
Is it different between age groups?



How does the brain respond to sound?

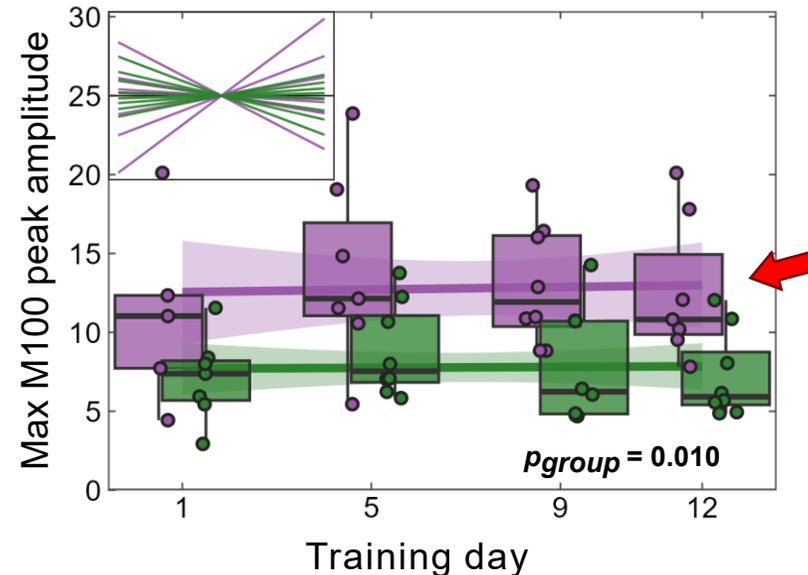


How is the training reflected on the auditory cortex?



LEFT

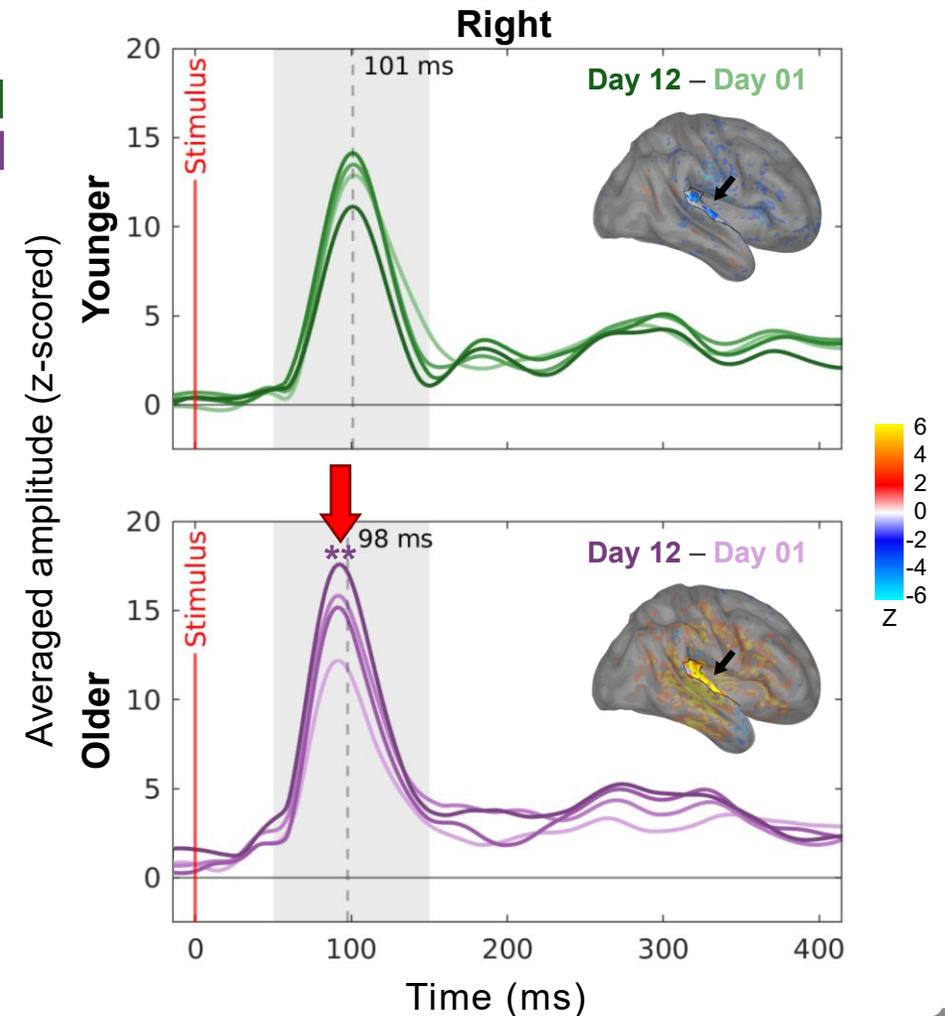
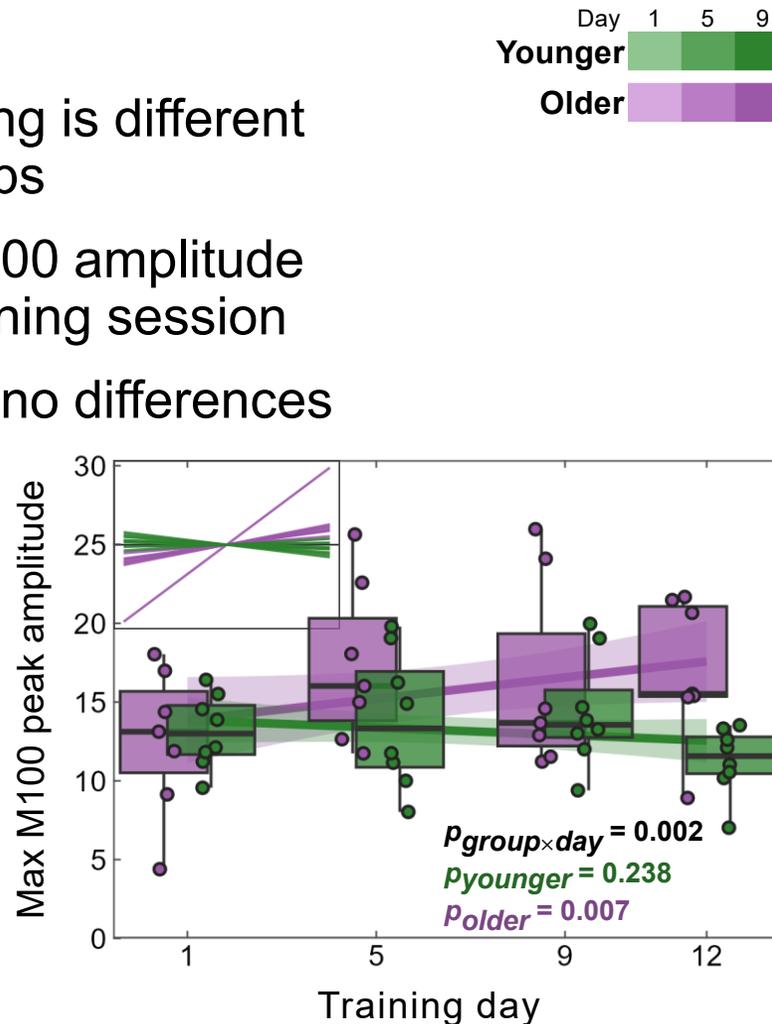
- No effect of training
- Higher activation in older adults



How is the training reflected on the auditory cortex?

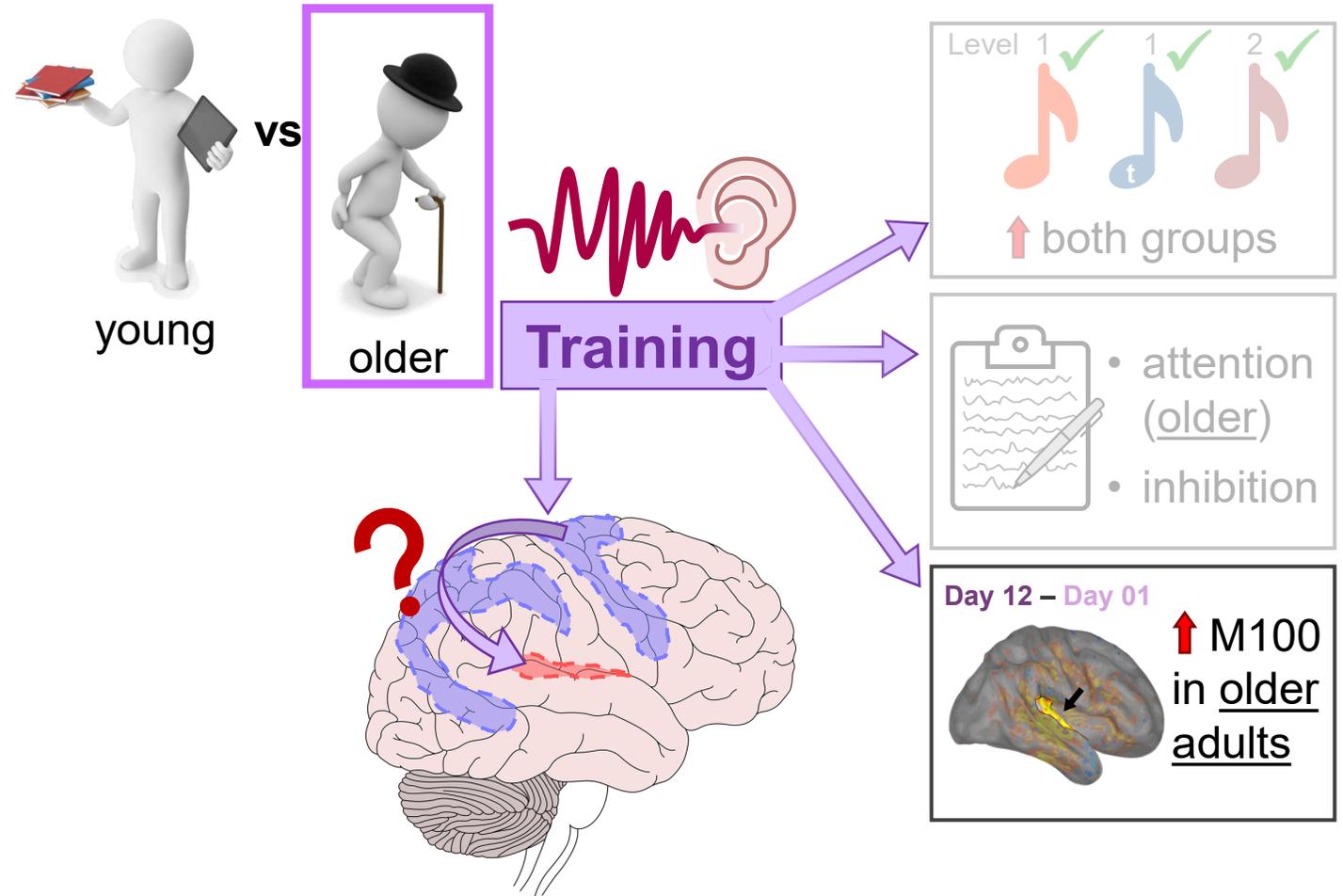
RIGHT

- The effect of training is different between age groups
- In older adults, M100 amplitude increased with training session
- In younger adults, no differences were found.

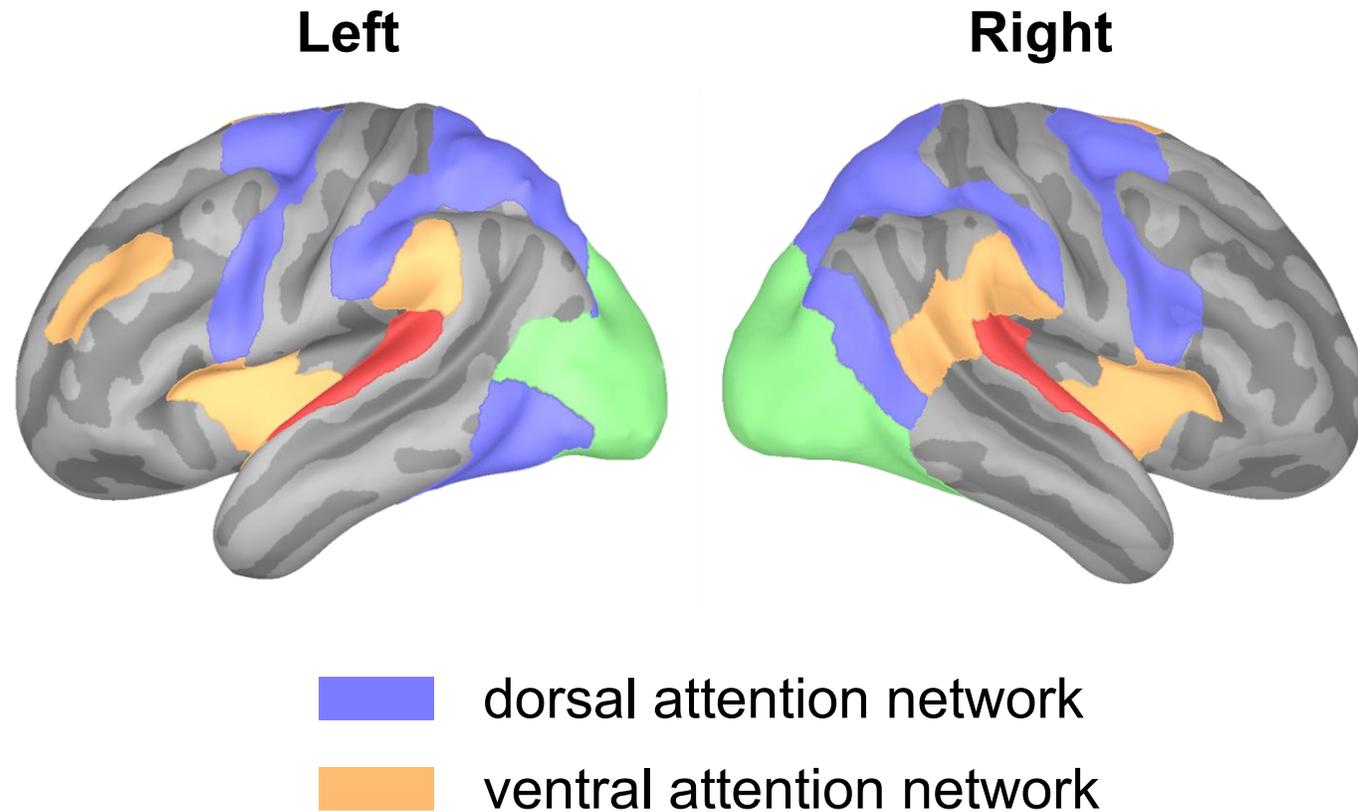


Summary

1. Both groups improved in the training task and showed cognitive gains.
2. Auditory cortex shows increased activation with training only in older adults.
3. Do attention networks change in younger adults with training?
Are attention networks responsible for auditory changes in older adults?
How do they differ with age?



Are attention networks controlling the allocation of perceptual resources?



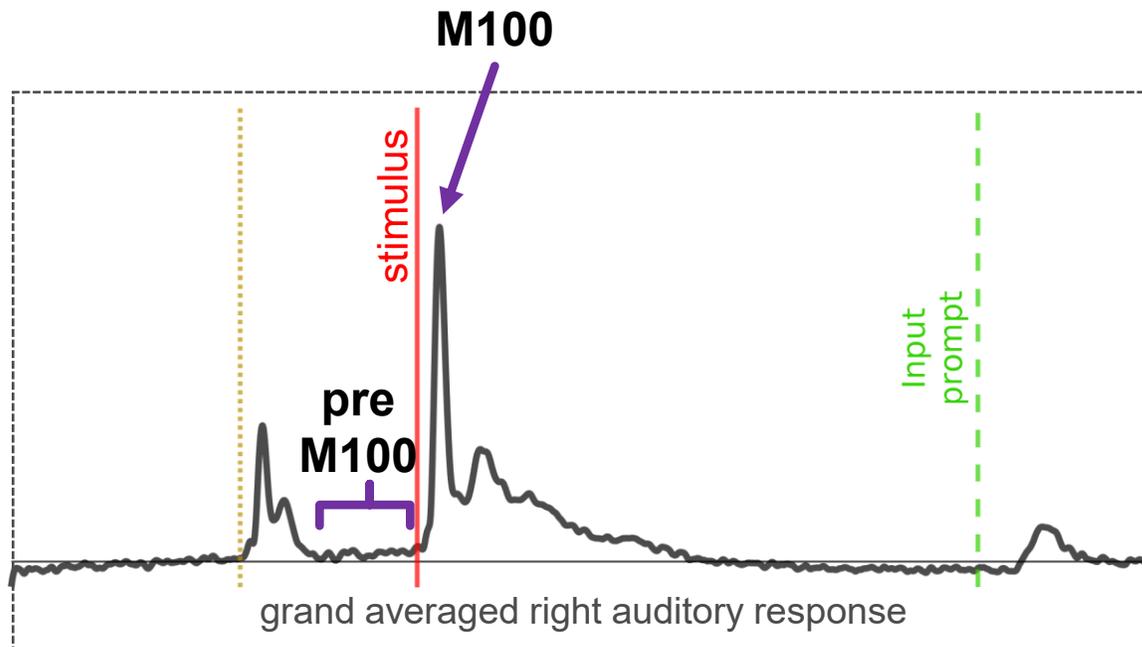
Dorsal attention network

- Voluntary attention
- Controls the use of brain resources based on goals
- Prepares to receive an expected stimulus

Ventral attention network

- Involuntary attention
- Responds to unexpected stimulus

Are attention networks controlling the allocation of perceptual resources?

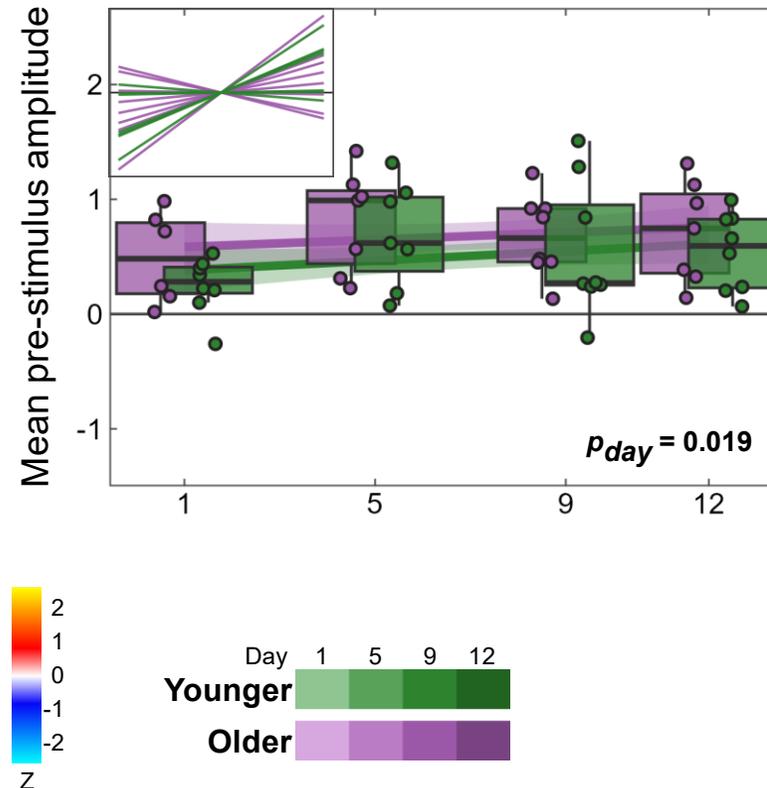
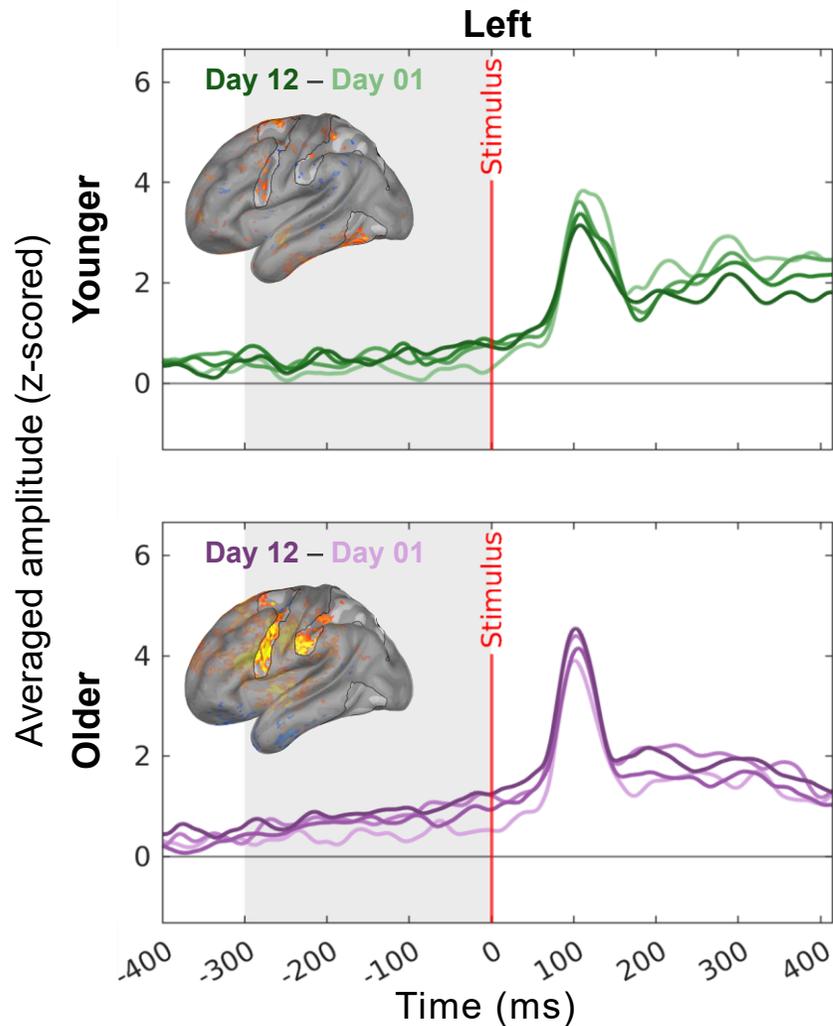


Dorsal attention network

- Voluntary attention
- Controls the use of brain resources based on goals
- Prepares to receive an expected stimulus

preM100: -300 to 0 ms

Is DAN activated before the M100 response?



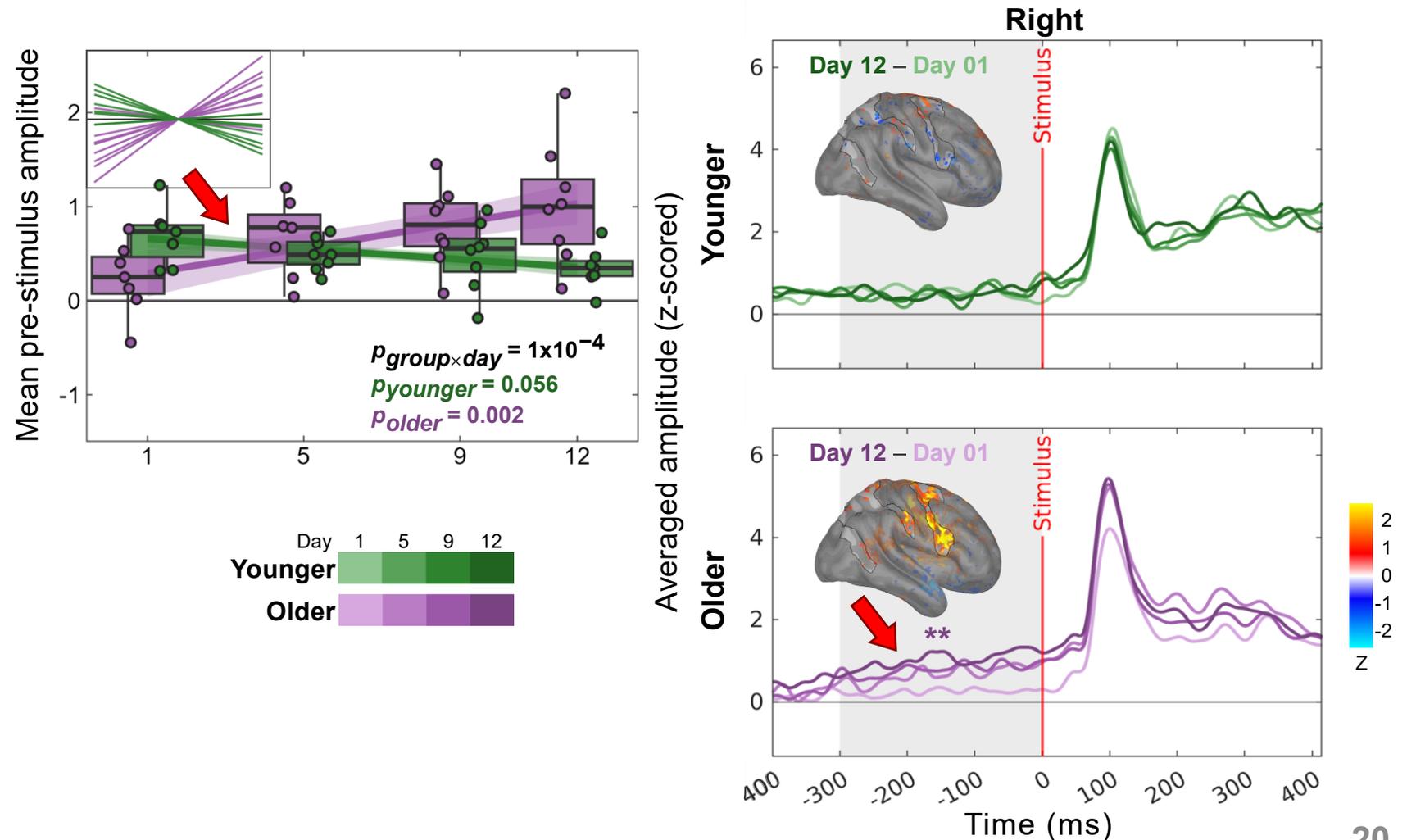
LEFT

- No changes in activation with training
- No differences between groups

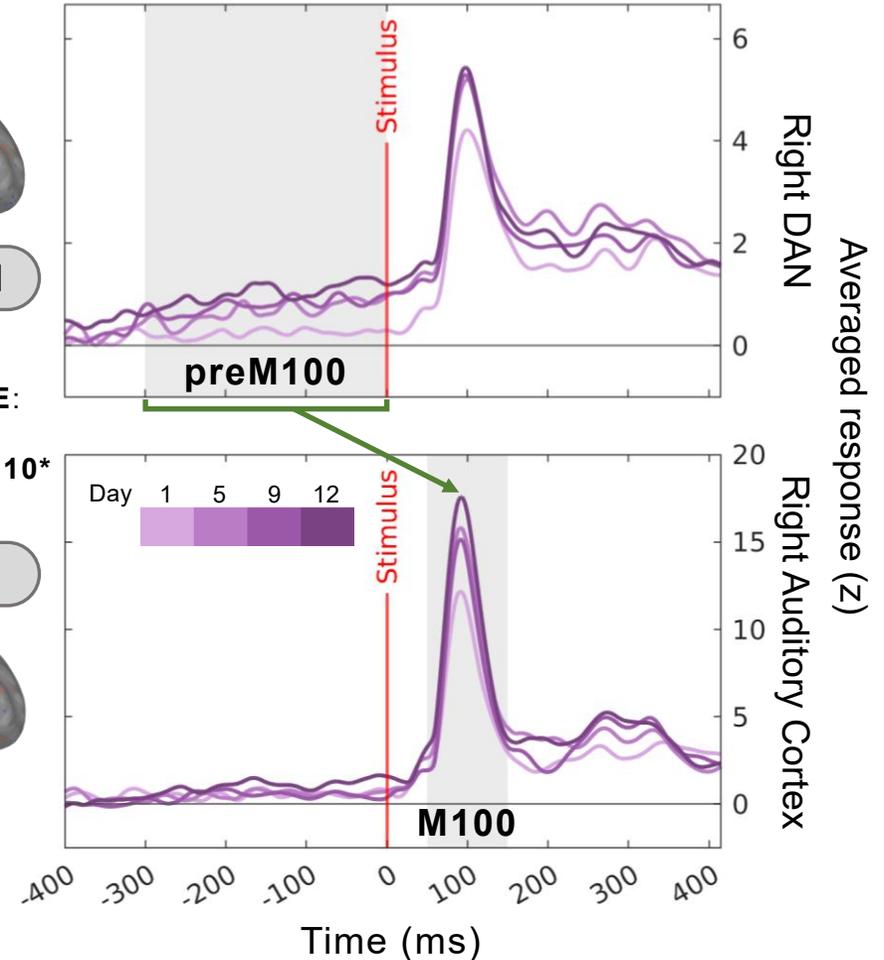
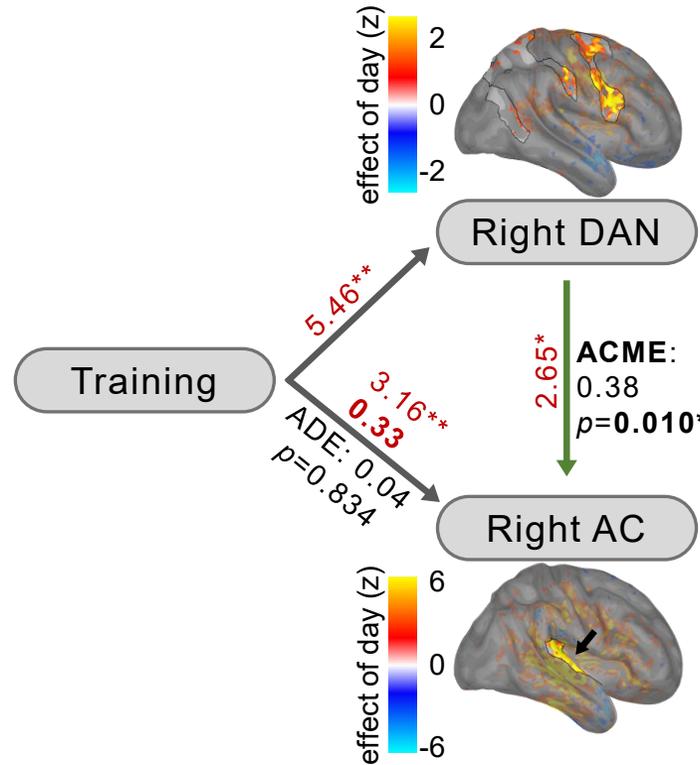
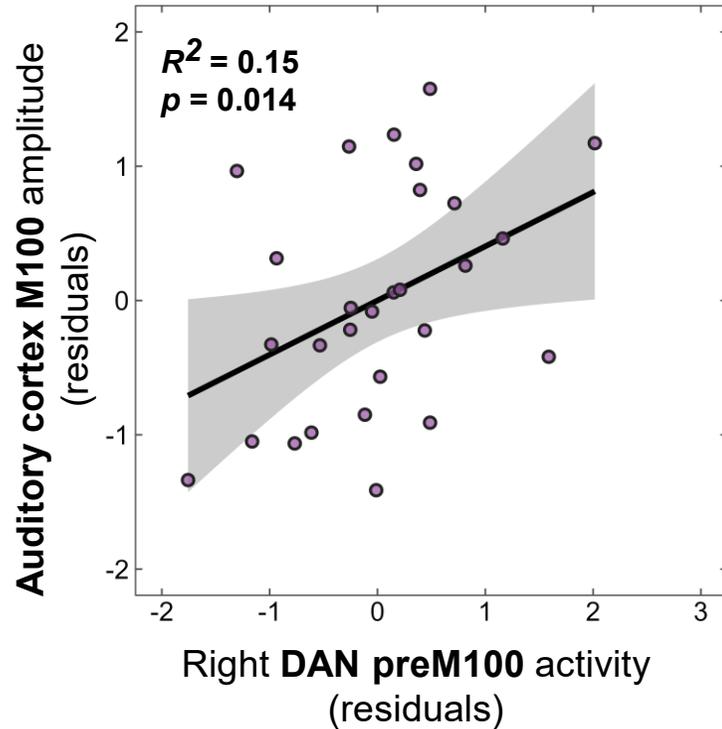
Is DAN activated before the M100 response?

RIGHT

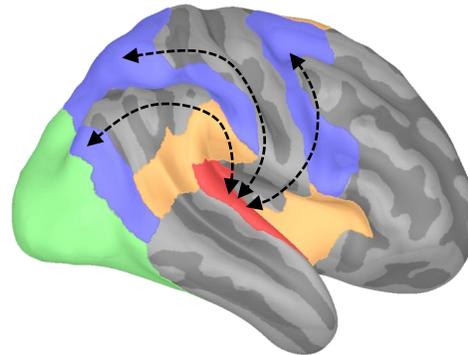
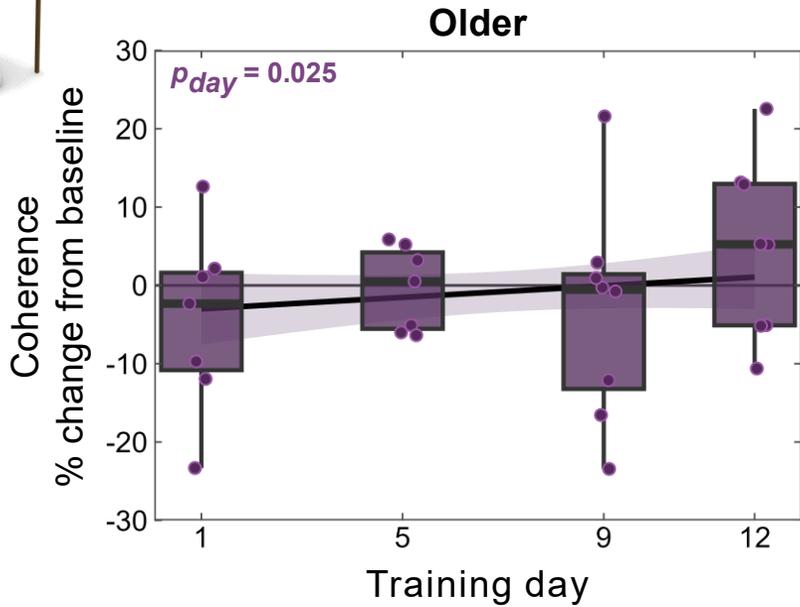
- Differences in activation between groups
- Increased activation in older adults
- Decreased activation in younger adults



What is the relationship between DAN preM100 and auditory M100 activity?

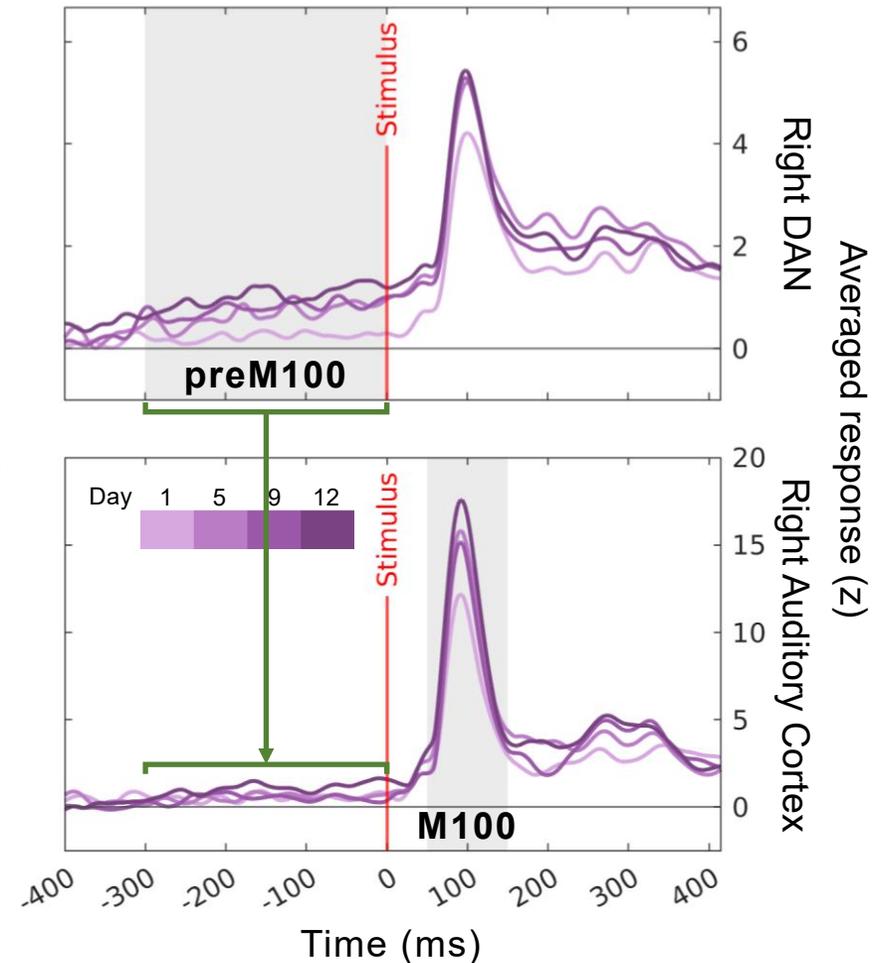


Are there changes in connectivity between DAN and auditory cortex in the preM100 period?

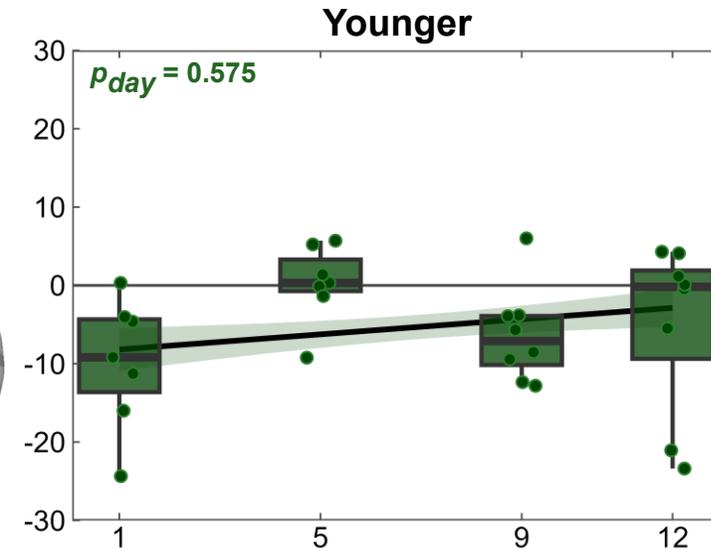
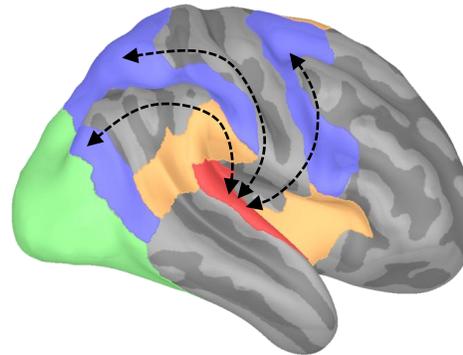
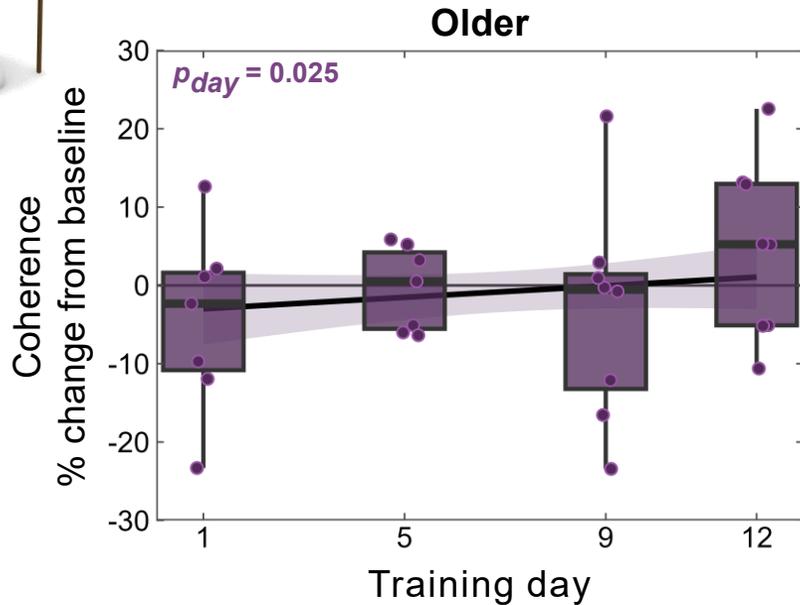


Older: increase in connectivity between auditory cortex and dorsal attention network

Younger: no changes



Are there changes in connectivity between DAN and auditory cortex in the preM100 period?

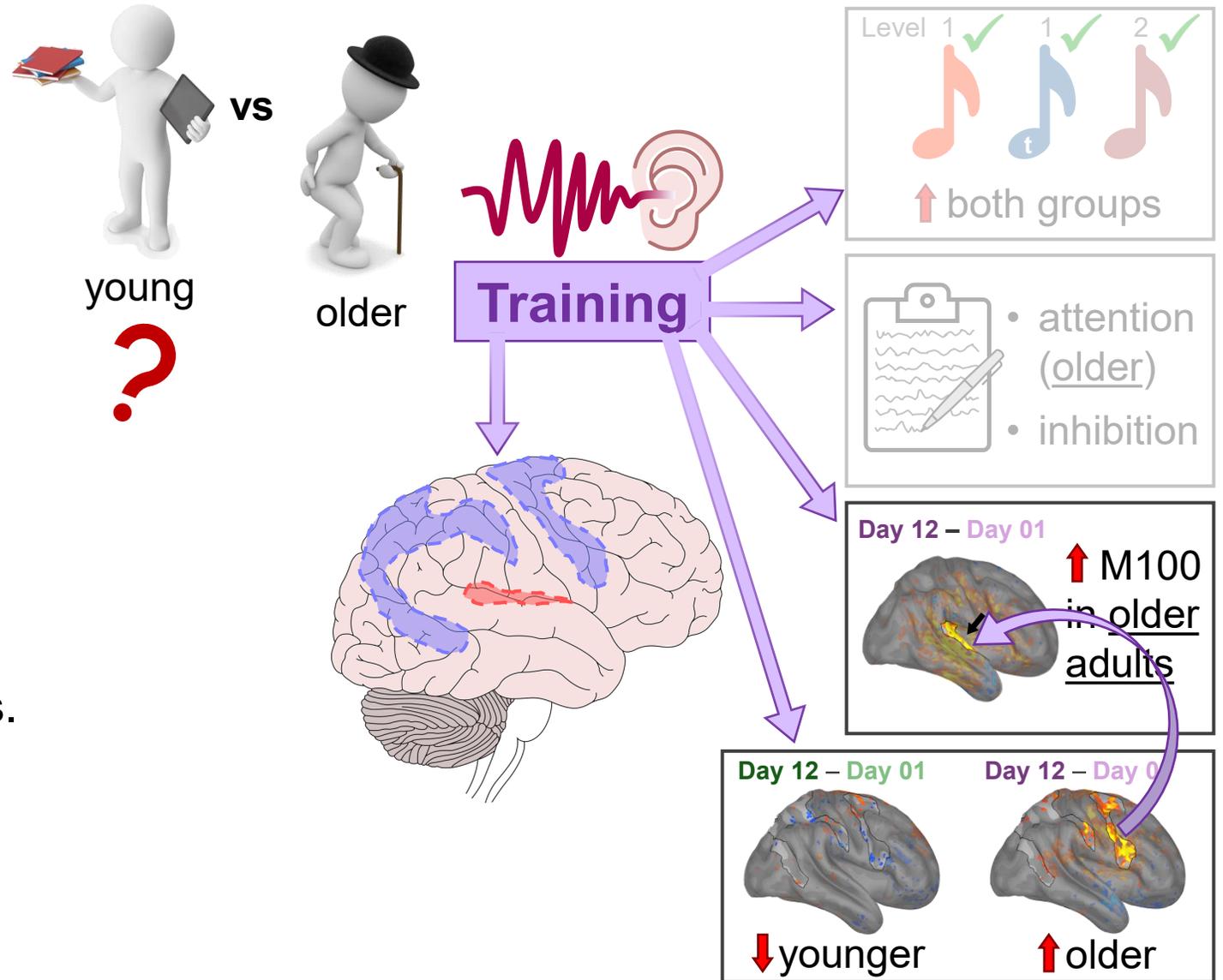


Older: increase in connectivity between auditory cortex and dorsal attention network

Younger: no changes

Summary

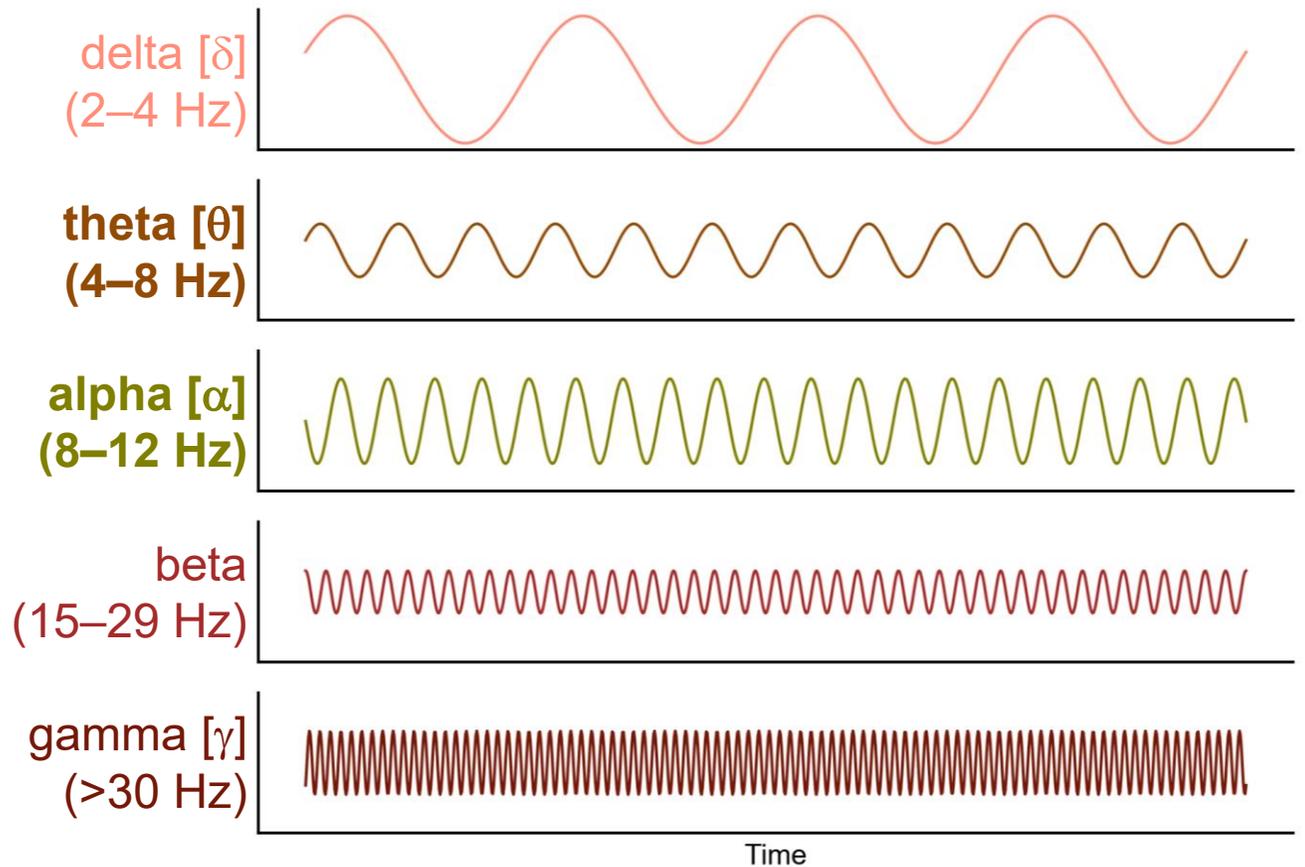
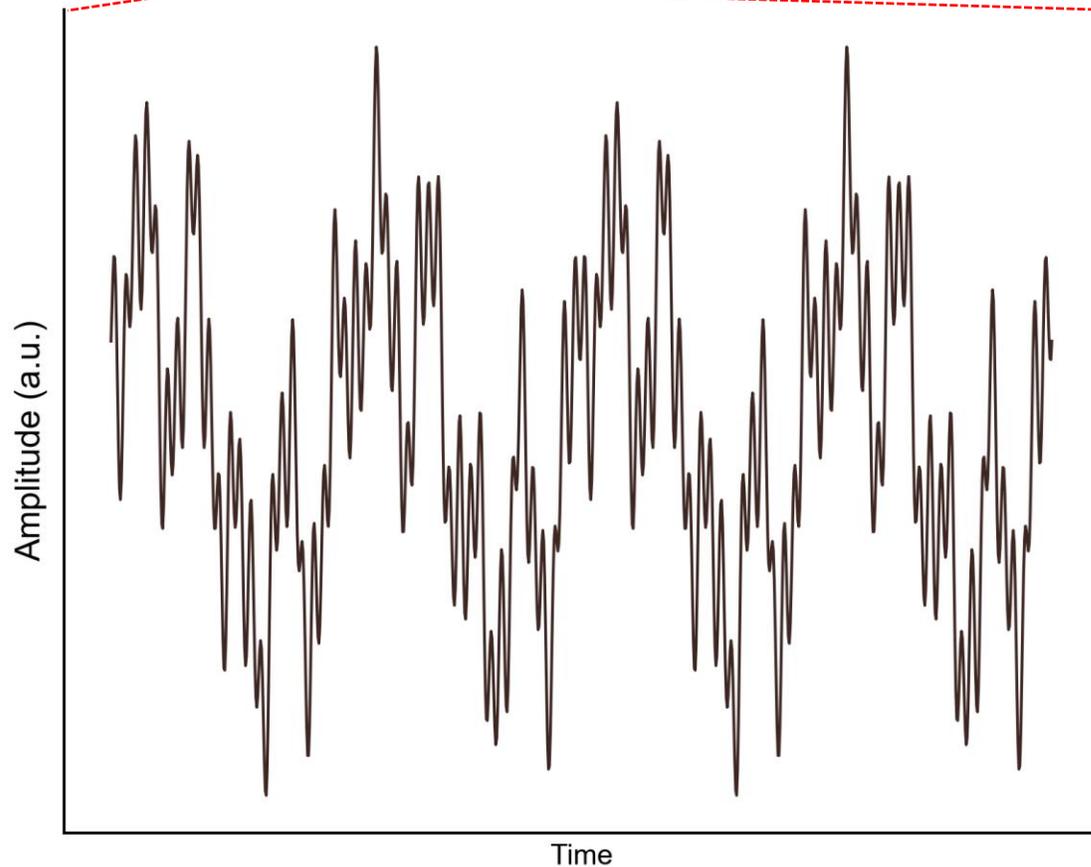
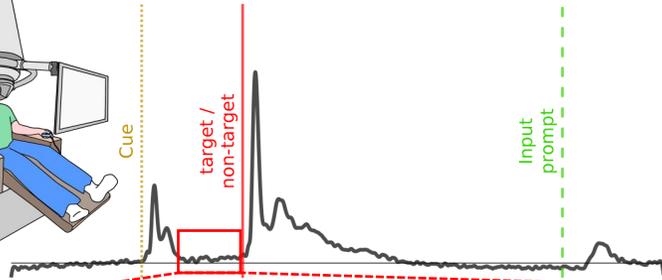
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In older, DAN drives the changes in the auditory cortex, with increased connectivity between the two regions.
4. What is changing in younger adults?



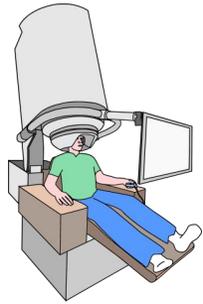
What is changing in younger adults?



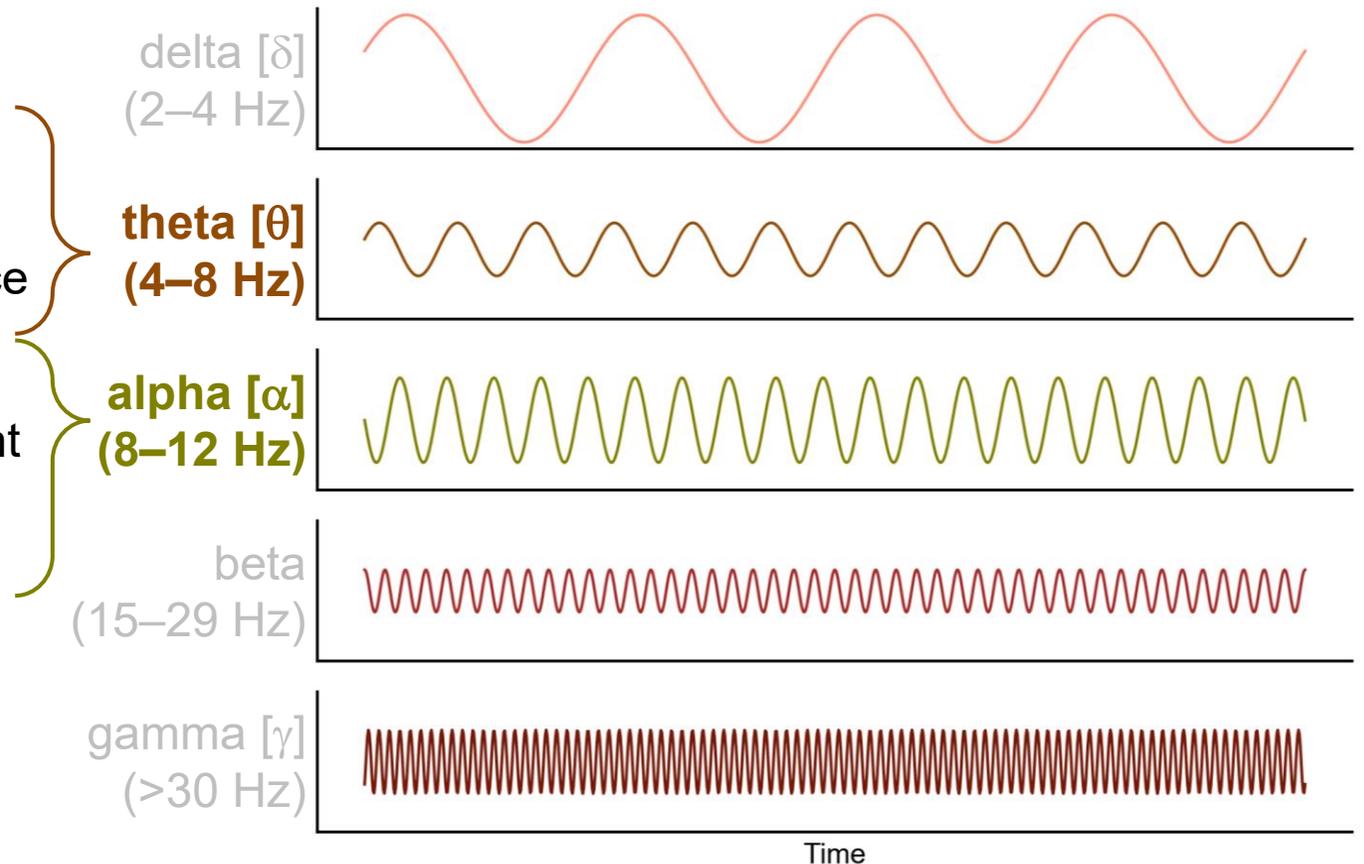
Decomposing brain waves into frequency bands:
Frequency decomposition



What is changing in younger adults?



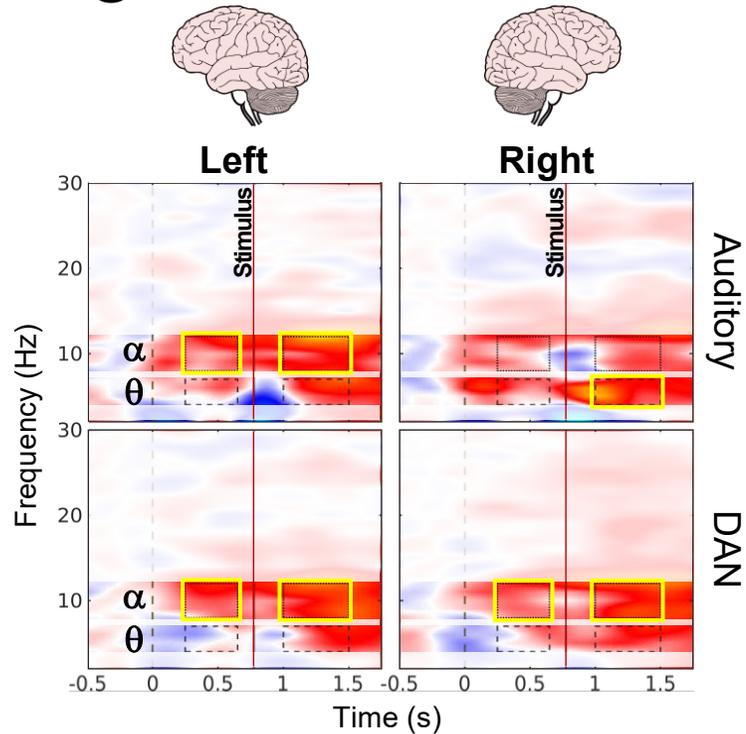
- cognitive control
- stimulus recognition
- memory maintenance
- attention
- inhibition of irrelevant stimuli
- memory protection



Are there frequency-specific changes related to the training?



younger adults

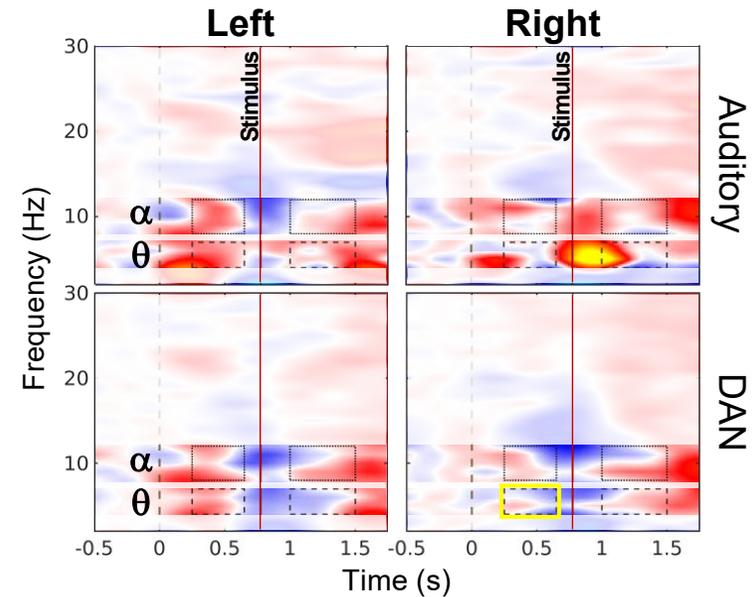
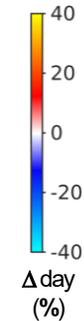


Younger:

- Broad increase in alpha activity pre- and post-stimulus in both auditory and DAN
- Increase in pre-stimulus alpha power predicted task performance



older adults

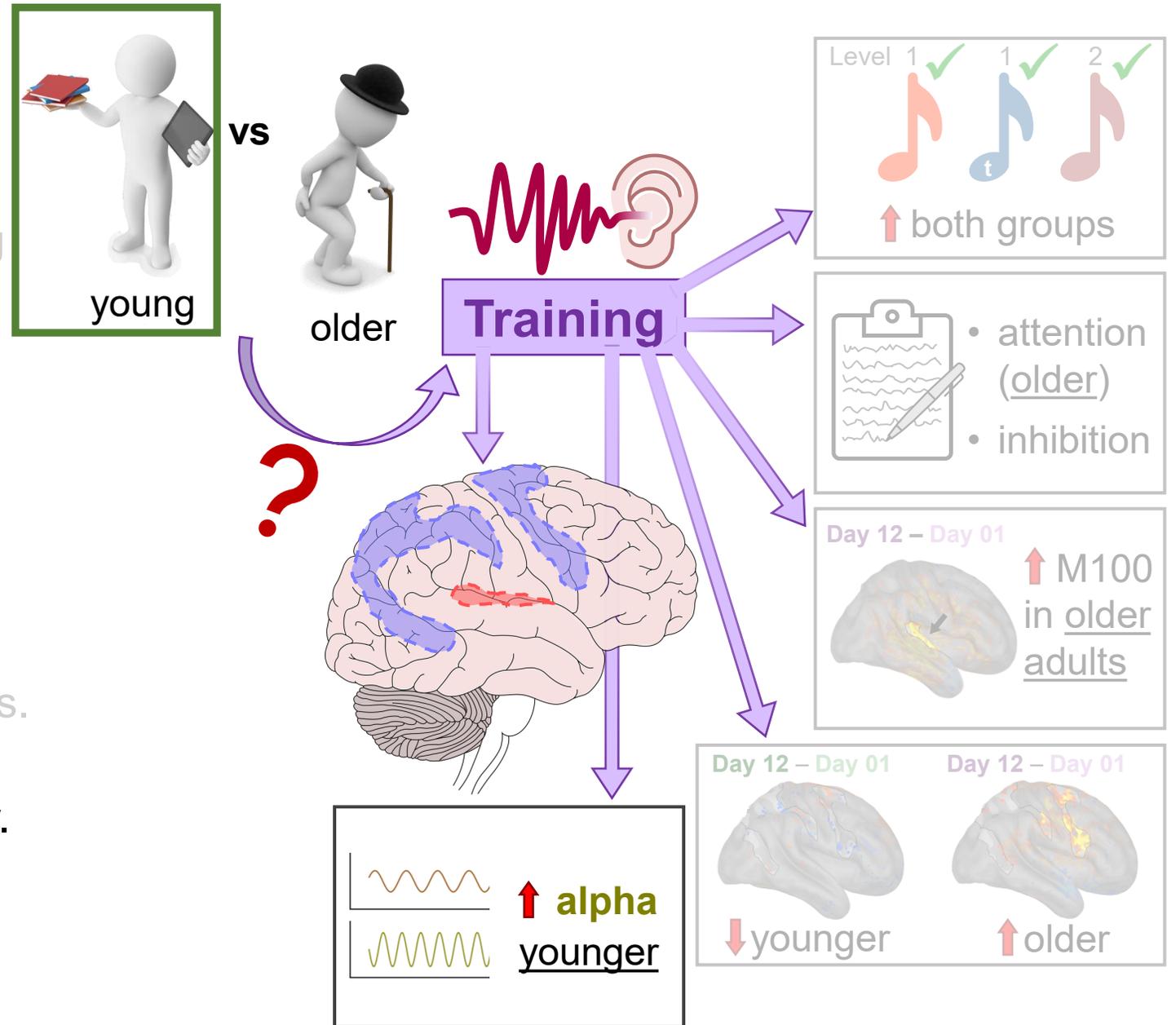


Older:

- No changes in alpha activity
- Reduction in pre-stimulus theta power

Summary

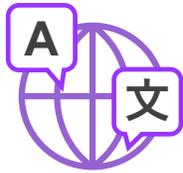
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4. Younger adults showed increased alpha power that related to behavior. No meaningful changes were observed in older adults.
5. What individual traits influence how the brain responds to training?



Which individual factors influence brain responses to training?



Education



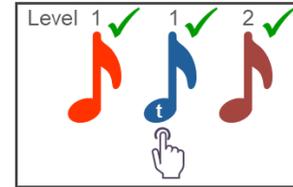
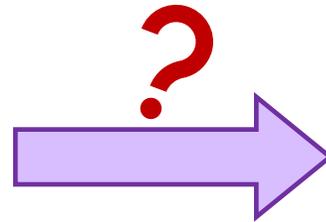
Languages



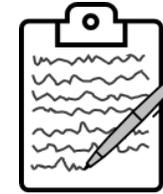
Music education



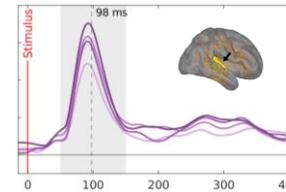
Hearing level



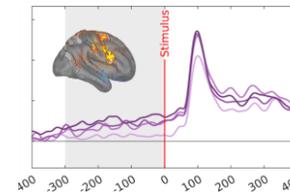
Task performance



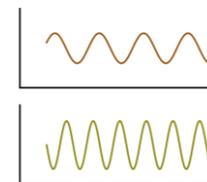
Cognitive results



Auditory M100 activation



DAN preM100 activation



Alpha and theta power

Which individual factors influence brain responses to training?

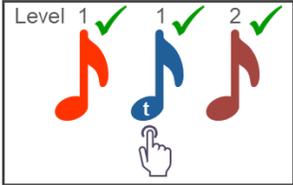
 Education

 Languages

 Music education

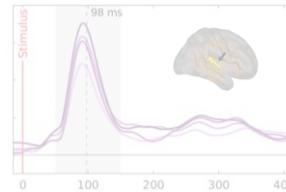
 **Hearing level**



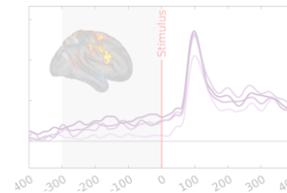
 Task performance



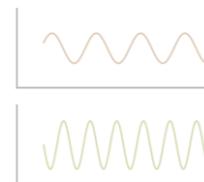
Cognitive results



Auditory M100 activation

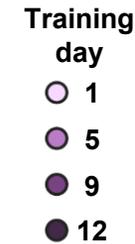
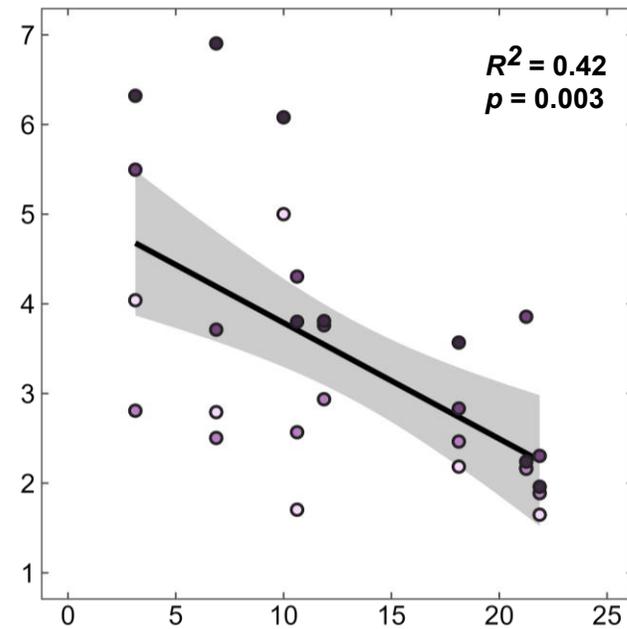
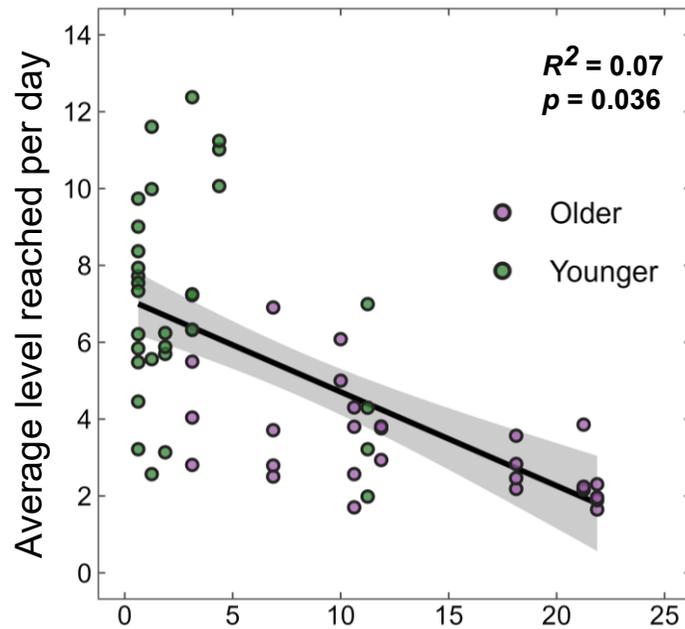


DAN preM100 activation



Alpha and theta power

Which individual factors influence brain responses to training?



Hearing ability

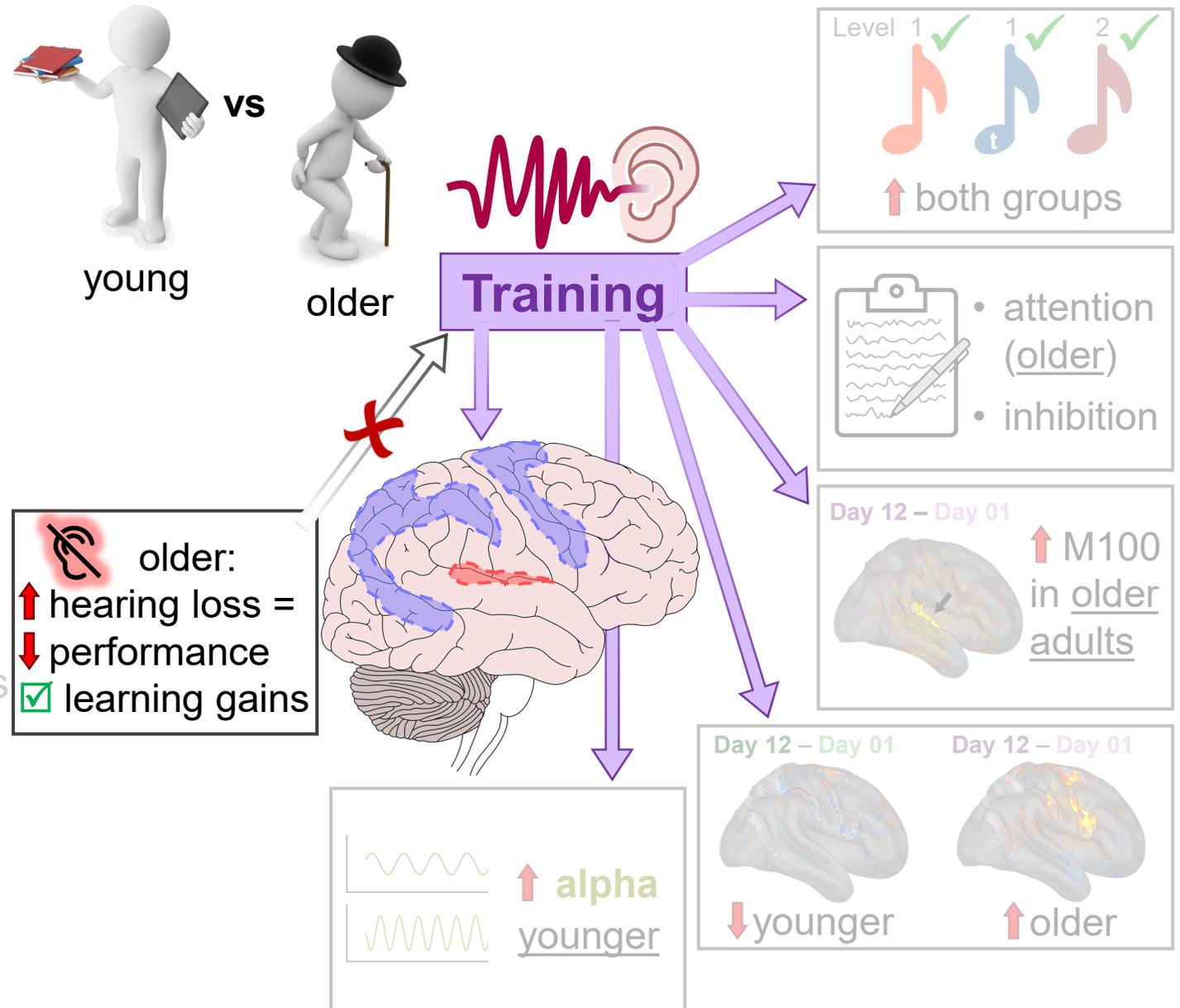
- Higher hearing loss, even though subclinical, resulted in lower task performance
- Learning gains were observed regardless of hearing ability

Standard Pure Tone Average (dBHL)

Worse hearing ability

Summary

1. Both groups improved in the training task and showed cognitive gains.
2. Auditory cortex shows increased activation with training only in older adults.
3. Decrease of activity in younger adults.
In older, DAN drives the changes in the auditory cortex, with increased connectivity between the two regions
4. Younger adults showed increased alpha power that related to behavior. No meaningful changes were observed in older adults.
5. Hearing ability predicts performance but doesn't impair learning



Main takeaways



Older adults

- Smaller performance gains, but greater cognitive benefits.
- Increased recruitment of attentional regions to support auditory processing.
 - Compensatory activity
 - Adaptability of aging brain
 - Auditory training may help with age-related deficits



Younger adults

- Reduced activity in auditory and attention areas.
- Changes in frequency-specific activity.
 - Lower use of brain resources
 - More efficient auditory and attentional processing

What is next?

- How long do these changes last?



12 days



- Can training help clinical populations?



healthy



hearing loss?

MCI?

Alzheimer's disease?

Taking care of your hearing is one way to take care of your brain!

Acknowledgements

Étienne de Villers-Sidani

Sylvain Baillet

Funding sources

EVS lab

Neurospeed Lab



McGill



**Fonds de recherche
Nature et
technologies**





¡Gracias!

Thank you!

Merci!

Dr. Ramos Sánchez

Comes a Zaida ti Standard Activation Do you like Impulse

UC DAVIS