Altered Adaptation to Sound-Level Statistics in the Auditory Cortex of Older People

Björn Herrmann[1,*], Burkhard Maess[2], & Ingrid S. Johnsrude[1]

[1]The University of Western Ontario, London, ON, Canada

[2]Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany

** herrmann.b@gmail.com*

Introduction

- Optimal behavior requires that perceptual systems efficiently and adaptively process acoustic stimulation.
- Neurons supporting perceptual inferences are inherently limited in the range they have to respond to sensory inputs.
- One way to overcome this limitation is to dynamically adjust a neuron's response range (input-output function) to statistics of sound features in the environment.
- Such response-range adaptation has been observed in the auditory cortex of young nonhuman mammals. Whether the results generalize to people, particularly older people, is not known.
- We use magnetoencephalography to investigate whether aging affects neural adaptation to sound-level statistics in auditory cortex.

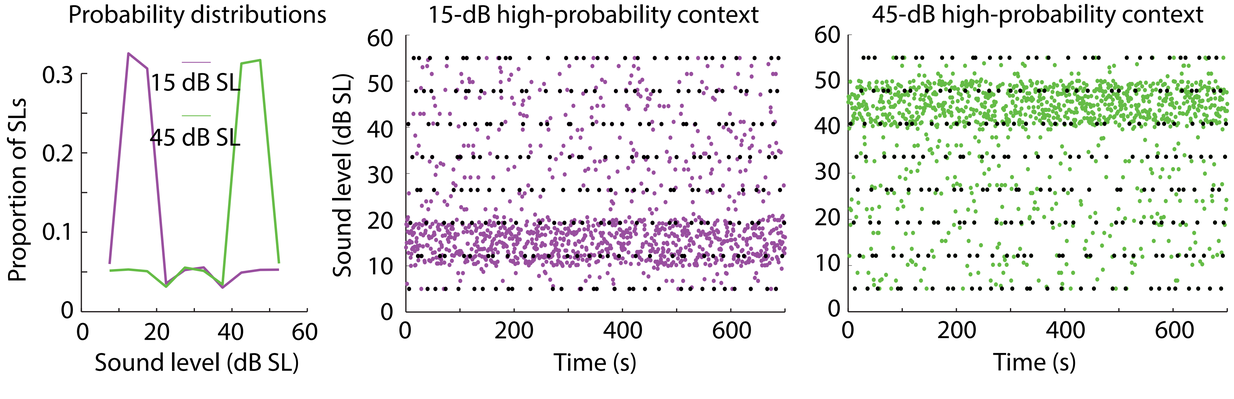
Discussion

- Responses (M100) were comparable between younger and older adults when neural populations were not adapted.
- Consistent with work in animals [1-3], both age groups show adaptation to sound-level statistics such that auditory cortex neurons are maximally sensitive to sound levels around and above the mode of a distribution.
- Adaptation to sound-level distributions is thought to avoid response saturation and to ensure sensitivity to a wide range of sound levels despite the limited response range of neurons [1].
- However, adaptation to the sound-level statistics was altered for older compared to younger adults. Response amplitude was sensitive to sound levels below the distribution's mode for older but not for younger individuals.
- The abnormal response enhancements are consistent with animal studies that report an age-related increase in response gain and a loss of inhibition along auditory pathways [4,5].
- The inability to fully adapt to the statistics in acoustic environments might contribute to the difficulty older people experience in filtering out irrelevant information.

References

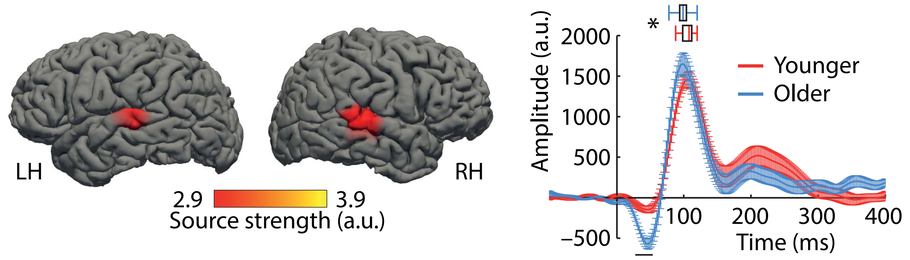
[1] Dean et al. (2005) Nat Neurosci; [2] Hildebrandt et al. (2011) J Neurosci; [3] Robinson et al. (2016) Nat Comm; [4] Hughes et al. (2010) Hearing Res; [5] Caspary et al. (2008) J Exp Biol.

Methods & Materials



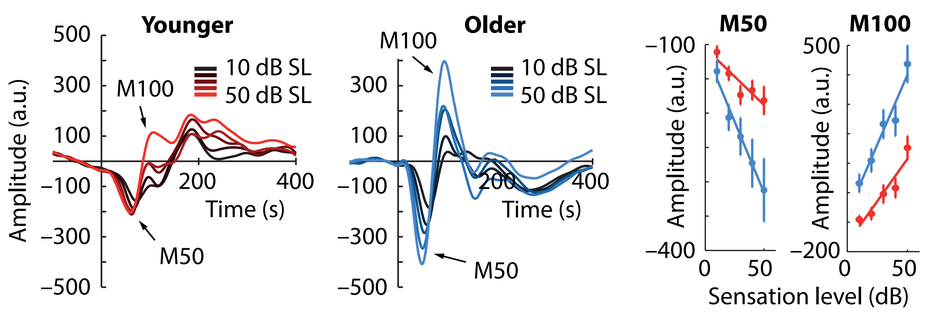
- N=19 younger adults (18–31 years); N=20 older adults (54–71 years)
- Sound stimulation while participants watched movie
- No-adaptation block: Tone presentation every 7 seconds; 55 dB SL
- Adaptation blocks (onset-to-onset interval of 0.5 s): Sound level distributions with different high-probability regions (15 dB SL; 45 dB SL; see Figure on the left)
- Sound levels of a subset of tones (black dots) and their precursors were identical in both block types; responses to these tones were analyzed
- MEG recordings; spatial filter for focus on auditory

No-adaptation block



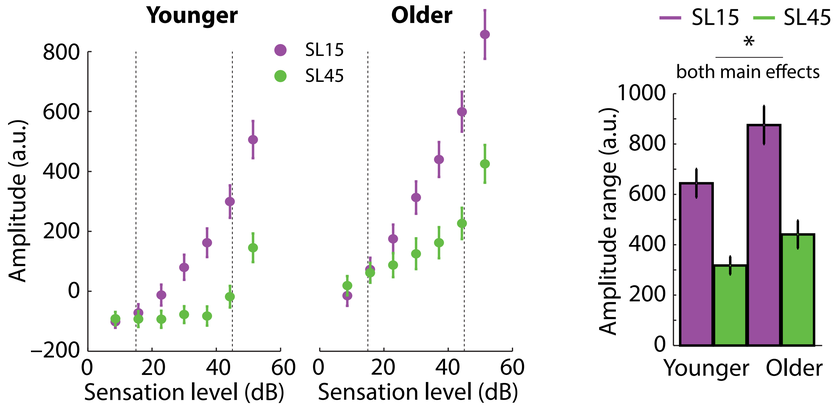
The sources underlying the spatial filter were localized in auditory cortex and superior temporal gyrus. Responses in the no-adaptation block were larger for older compared to younger for the M50 ($p<0.05$), but not the M100 response. The M100 latency was earlier in older compared to younger people ($p<0.05$).

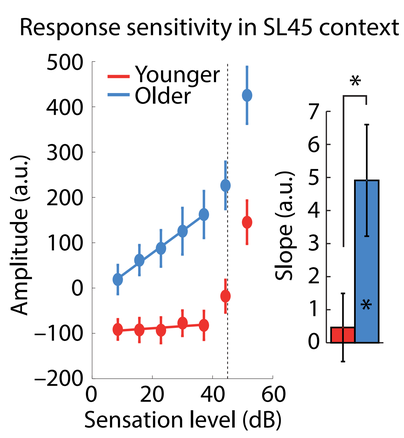
Neural sensitivity to sound level



M50 and M100 responses were sensitive to sound level in both age groups. M50 and M100 responses were larger in older compared to younger participants ($p<0.05$). M50 and M100 responses were more sensitive to sound level for older compared to younger people ($p<0.05$).

Neural sensitivity to sound-level distribitions





Top: Neural responses depended on the sound-level distribution: Responses were most sensitive to sound levels above the high-probability region. The response range was larger in older compared to younger people ($p<0.05$).

Left: Responses from the SL45 context for both age groups. Auditory cortex neurons in older, but not younger, adults remained sensitive to sound levels below a distribution's modal level. That is, slopes from linear fits (colored lines) differed between age groups ($p<0.05$).