

The effect of aging on auditory scene analysis – Evidence from a change detection paradigm

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Introduction

- Older listeners report increased difficulties with listening in crowded environments. These can be due to deterioration of the peripheral auditory system, or various deficits of cognitive and sustained-attention abilities.
- Current clinical tests focus on assessing hearing loss, but neglect the effect cognitive decline might have on listening.
- Because our auditory system is hypothesized to serve as an early warning system – continually monitoring our surroundings for important changes [1] – a change detection task [1] was selected to measure scene analysis abilities.

We aim to understand the effect of healthy aging on auditory scene analysis and how it relates to listeners' cognitive and audiometric profile. Using a change detection task, two aspects of scene analysis were investigated: sensitivity to predictable temporal patterns and distractibility.

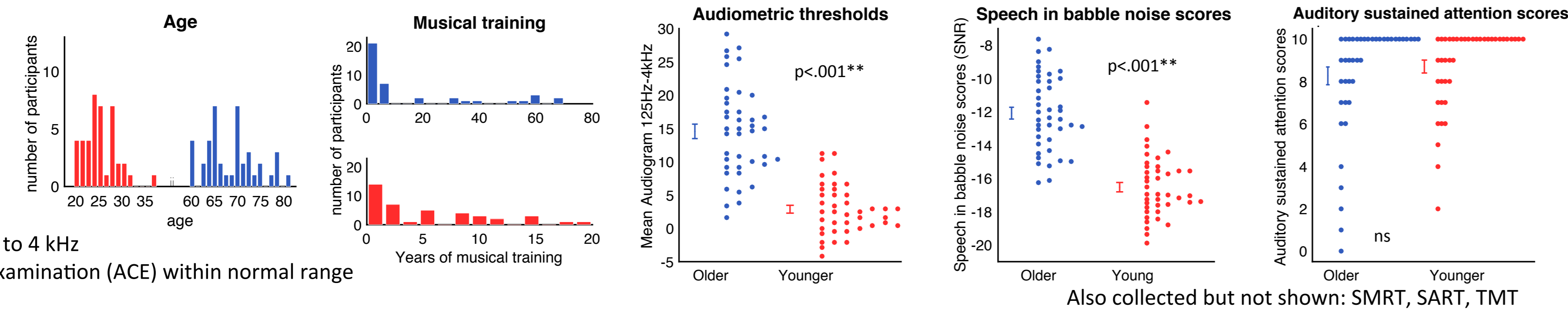
Effect of age on sensitivity to predictable temporal patterns

Participants

Young group (N=41)
Older group (N= 41)

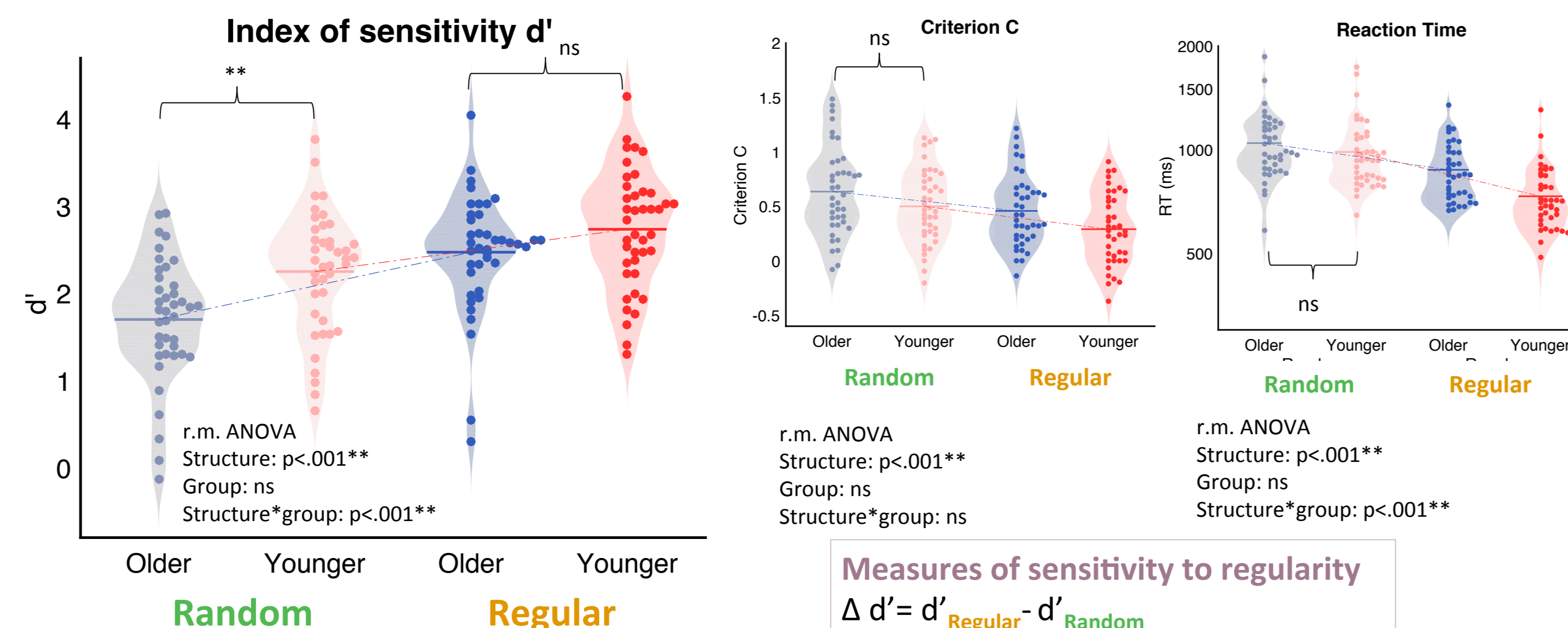
Inclusion Criteria

- Close to normal hearing up to 4 kHz
- Addenbrooke's Cognitive Examination (ACE) within normal range



Change detection task

- 'Artificial scenes' = 6 concurrent streams.
- Each stream = a sequence of tones with a unique frequency (range: 200-4000 Hz) and rate (range: 3-32 Hz). The streams are separated by at least 2 ERB to reduce energetic masking.
- A disappearance of one of the streams occurs on 50% of the trials.
- Random condition** characterised by **irregular** silent gap durations between tones.
- Regular condition** characterised by a **constant** silent gap duration (but different for each stream).
- Task instructions: press a button as soon as a change (disappearance) is heard.



Correlations of the older listeners' performance with profile measures

Profile measures	d' rand	RT rand	$\Delta d'$	ΔRT
Age	-	.315*	.430*	-
Musical training	.432*	-	-	-.385*
Audiometric thresholds	-	-	-	-
Speech in babble noise scores	-	-	-	-
Auditory sustained attention scores	.520**	-	-	-
SART (reaction time)	-	.427*	-	.363*
TMTa	-	.449*	-	-

- In the **regular condition**, d' scores were comparable for both age groups, suggesting that older and younger participants exhibited a similar sensitivity to regular patterns. However, younger participants were faster at detecting the changes.

- Measures of sensitivity to **regularity** correlated for d' with age and for RT with musical training and visual sustained attention performance (SART).

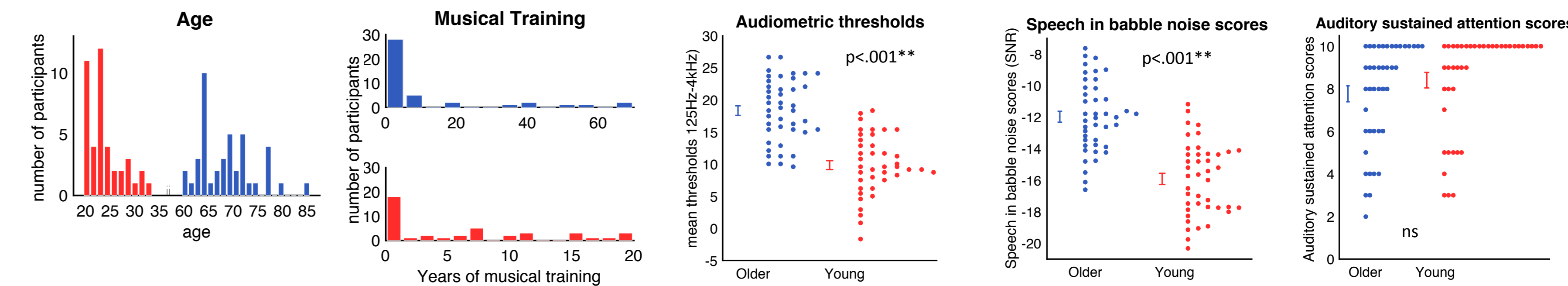
Main findings

- Change detection ability is degraded with age.
- However, sensitivity to regularity appears to be preserved with age. Older listeners compensate lower scene analysis abilities by relying to a larger extent on predictability cues.
- Change detection performance and sensitivity to regularity in the older group correlated with measures of auditory and visual sustained attention and musical training but not with measures of audibility or speech perception.

Effect of age on distraction

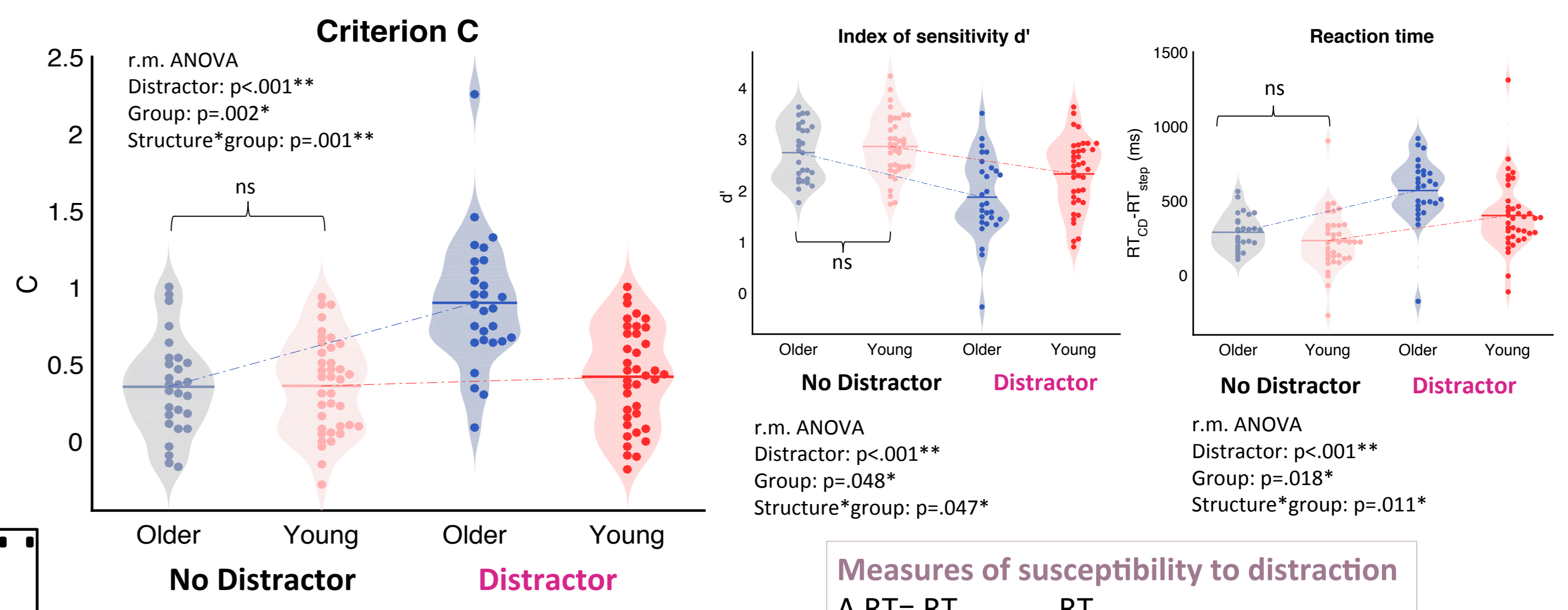
Participants

Young group (N= 42)
Older group (N= 42)

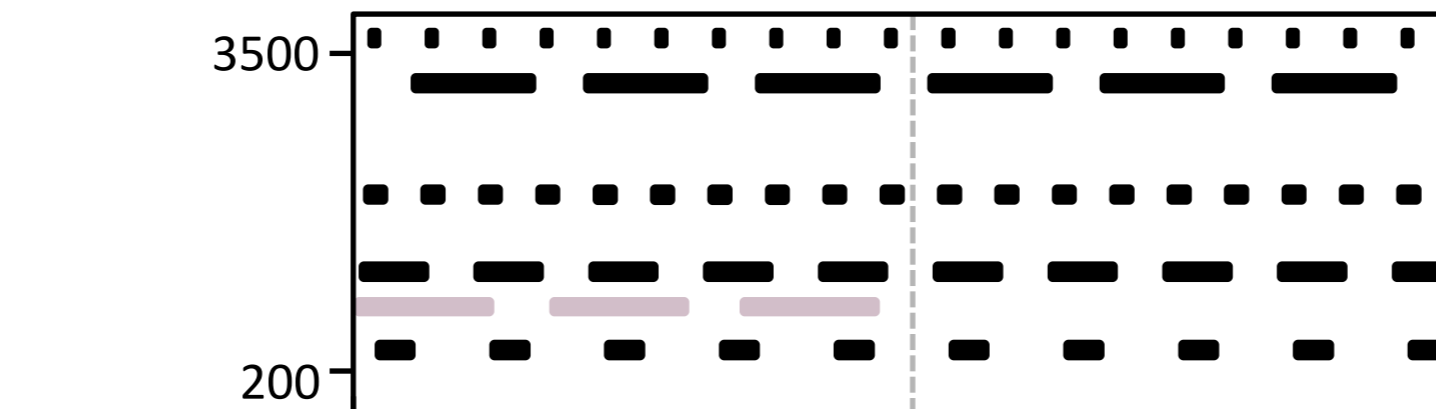


Change detection task

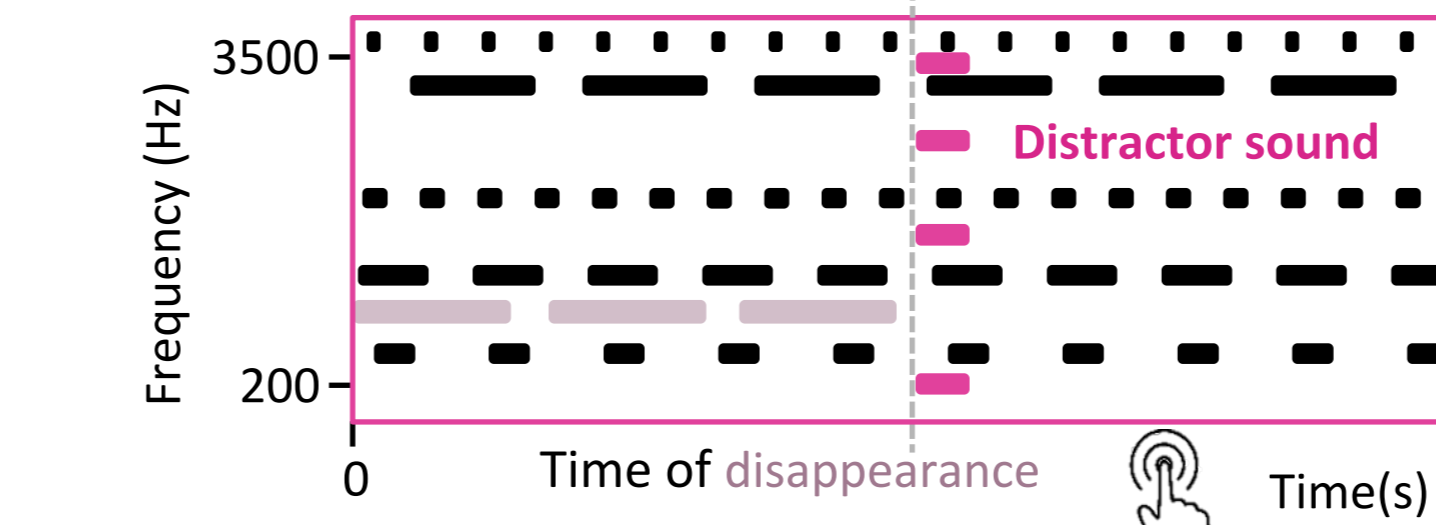
- Similar scenes to the **regular** ones previously presented
- Distractor** = 4 concurrent 100ms-long pure tones (frequency between 200-4000 Hz and amplitude modulated at 100Hz) presented at the time of change. Distractors were present on all trials and were not predictive of the change.
- Participants were instructed to ignore the distractor and focus on the change detection task.



No-distractor condition



Distractor condition



Correlations of the older listeners performance with profile measures

Profile measures	d' nd	RT nd	$\Delta d'$	ΔRT
Age	-	-	-	-
Musical training	.401*	-.330*	-	-
Audiometric thresholds	-.357*	-	-	-
Speech in babble noise scores	-	-	-	-
Auditory sustained attention scores	.454*	-	-	-.482*
Visual sustained attention	-.340* (timing)	-	-.504* (scores)	-

The **regular condition** was considered as a good baseline to measure susceptibility to distraction as similar performances were observed between young and older groups.

- The pattern of results in the **no distractor condition** replicated findings presented in the first experiment (d' and C).
- In the older group, change detection in the **no distractor condition** was associated with higher audibility, sustained attention (auditory and visual), and longer musical training.

- Introducing a **distractor** sound impaired performance for both groups but was associated with larger increase of C scores and RT for the older listeners.
- Measures of susceptibility to **distraction** correlated with measures of auditory and visual attention.

Main findings

- Introducing a distractor sound impaired performance for both groups.
- Reduced performance in older listeners was associated with increased criterion C and increased RT. Namely, the distractor had an **inhibitory effect** on performance.
- Measures of sustained attention, musical training, and measures of audibility were relevant measures to explain change detection performance and susceptibility to distraction.

Conclusion

- The ability to detect a change in complex scenes declines with age; but older listeners use compensatory mechanisms based on stimulus predictability to better perceive these complex scenes.
- The distraction results are consistent with accumulating evidence that the ability to ignore irrelevant information declines with age.
- Measures of sustained attention appear to be critical to better understand older listeners' listening difficulty in crowded environments.

References

- [1] Constantino, F.C., Pinggera, L., Paranamana, S., Kashino, M., Chait, M., 2012. Detection of Appearing and Disappearing Objects in Complex Acoustic Scenes. PLOS ONE 7, e46167.
 [2] Evans A.S., Preston A.S. (2011) Test of Everyday Attention. In: Kreutzer J.S., DeLuca J., Caplan B. (eds) Encyclopedia of Clinical Neuropsychology. Springer, New York, NY

SMRT: Spectro-Modulated Ripple Test
SART: Sustained Attention Response Task

TMT: Trail Making Test
TEA: Test of Everyday Attention

