Hearing Loss & Cognitive Decline:

Clinical Implications & Impact of Hearing Rehabilitation

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Cognitive Decline & Dementia

- The pace of population aging is increasing
- Dementia expected to triple worldwide by 2050
- Estimated **population attributable fraction (PAF)** = percentage reduction in new cases over a given time if that risk factor were eliminated
- Assuming causality, **global incidence of dementia could theoretically be decreased by 9% if hearing loss were eliminated**

Preventable & modifiable

Table 1. Potentially modifiable risk factors for dementia

	Relative risk for dementia (95% CI)	Prevalence	Communality	PAF	Weighted PAF*
Early life (age <18 years)					
Less education (none or primary school only)	1·6 (1·26–2·01)	40·0%	64·6%	19·1%	7·5%
Midlife (age 45–65 years)					
Hypertension	1·6 (1·16–2·24)	8·9%	57·3%	5·1%	2·0%
Obesity	1·6 (1·34–1·92)	3·4%	60·4%	2·0%	0·8%
Hearing loss	1·9 (1·38–2·73)	31·7%	46·1%	23·0%	9·1%
Later life (age >65 years)					
Smoking	1·6 (1·15–2·20)	27·4%	51·1%	13·9%	5·5%
Depression	1·9 (1·55–2·33)	13·2%	58·6%	10·1%	4·0%
Physical inactivity	1·4 (1·16–1·67)	17·7%	26·6%	6·5%	2·6%
Social isolation	1·6 (1·32–1·85)	11·0%	45·9%	5·9%	2·3%
Diabetes	1·5 (1·33–1·79)	6·4%	70·3%	3·2%	1·2%

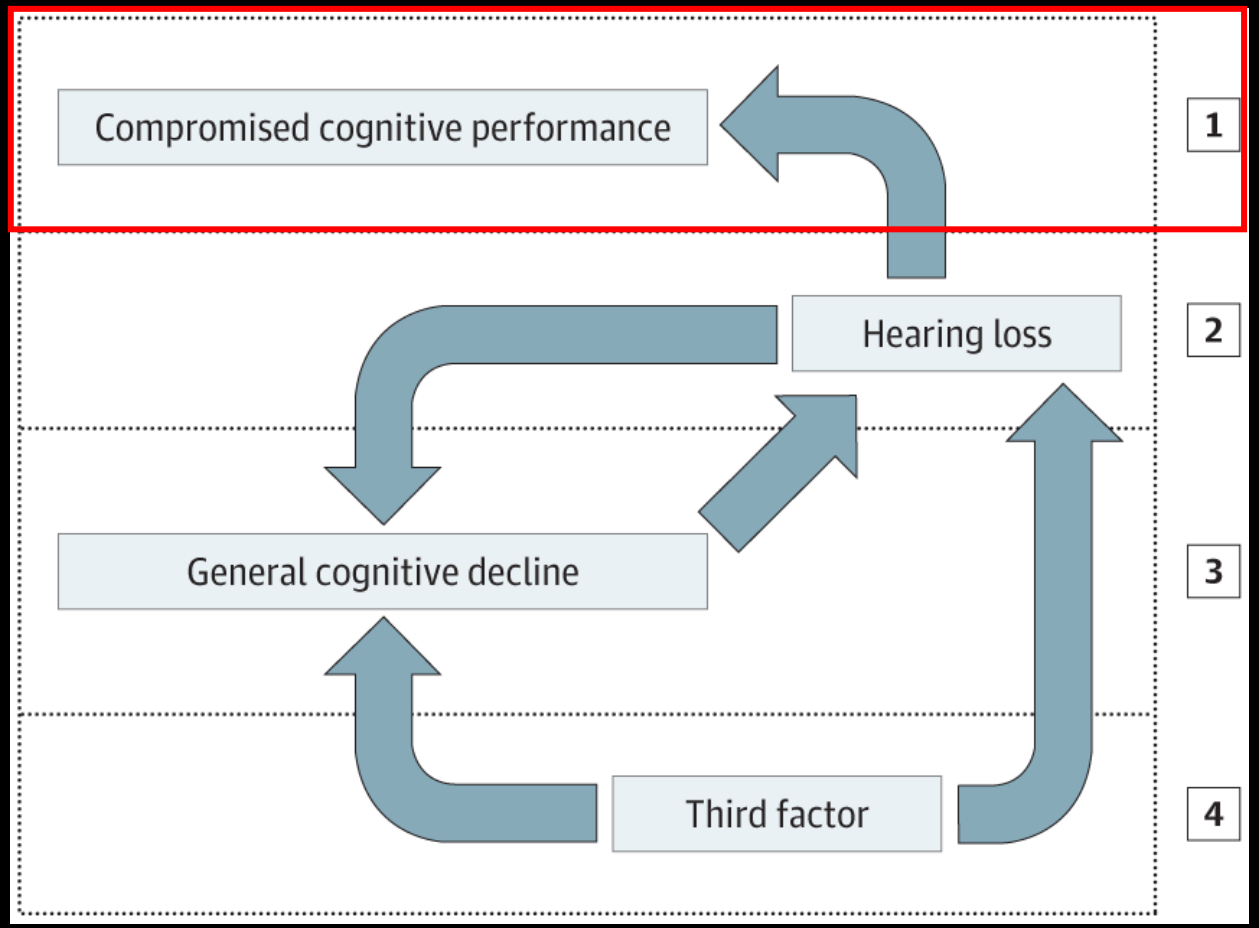
Data are relative risk (95% CI) or %. Total weighted PAF adjusted for communality=35·0%.
PAF=population attributable fraction.

Livingston et al., Lancet Commission on Dementia 2017, 2020

Moberly, Doerfer, & Harris, Laryngoscope, 2019

Information (Signal) Degradation Hypothesis:

Implies reversibility

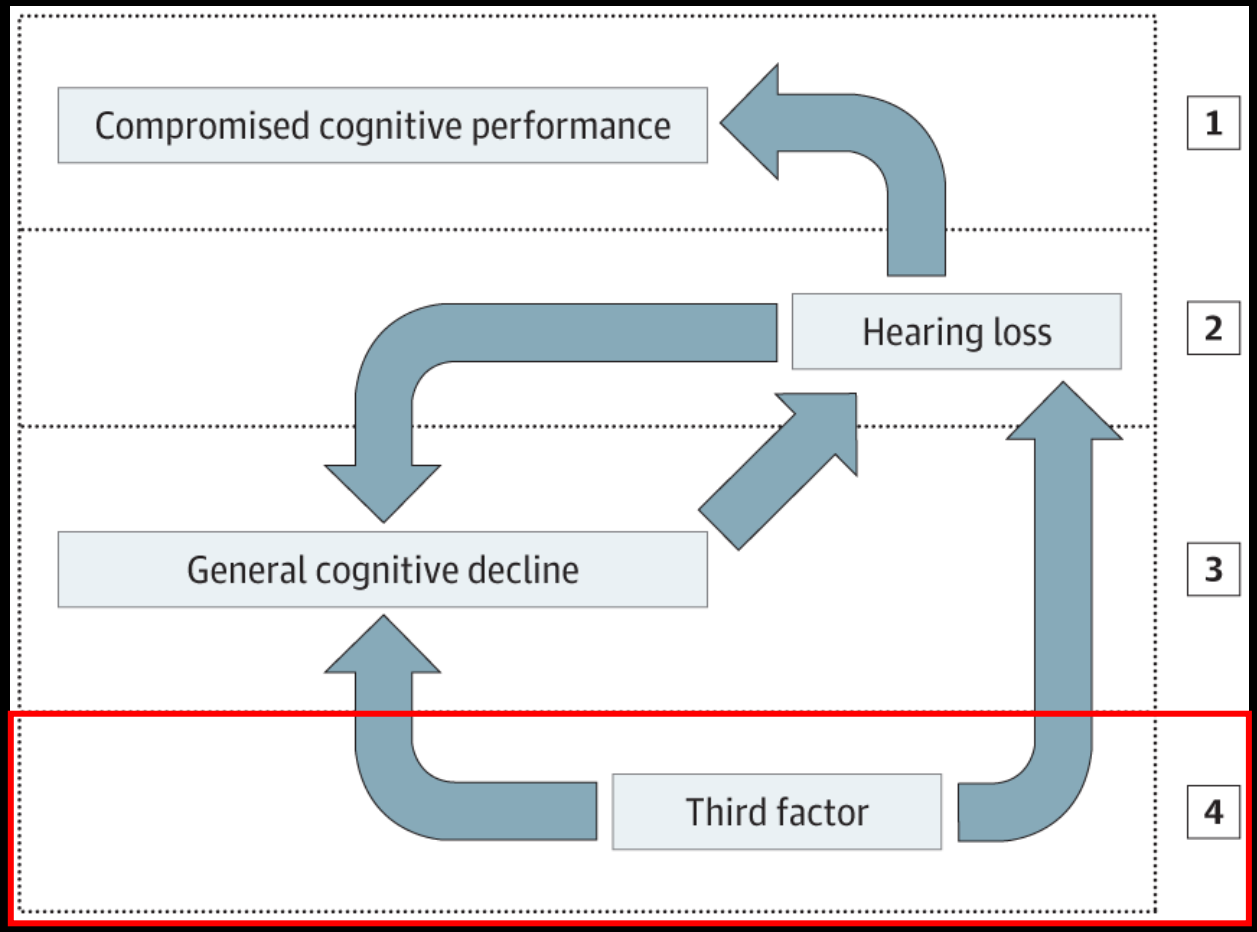


1. *Information degradation hypothesis*
2. *Sensory deprivation hypothesis*
3. *Cognitive load on perception hypothesis*
4. *Common cause hypothesis*

Moberly, Doerfer, & Harris, Laryngoscope, 2019

Common Cause Hypothesis:

Implies permanent cognitive decline



1. *Information degradation hypothesis*
2. *Sensory deprivation hypothesis*
3. *Cognitive load on perception hypothesis*
4. *Common cause hypothesis*

Hearing Loss & Cognitive Decline

Can functional neuroimaging tell us about mechanism & impact of cochlear implantation on brain function?

Ongoing study…

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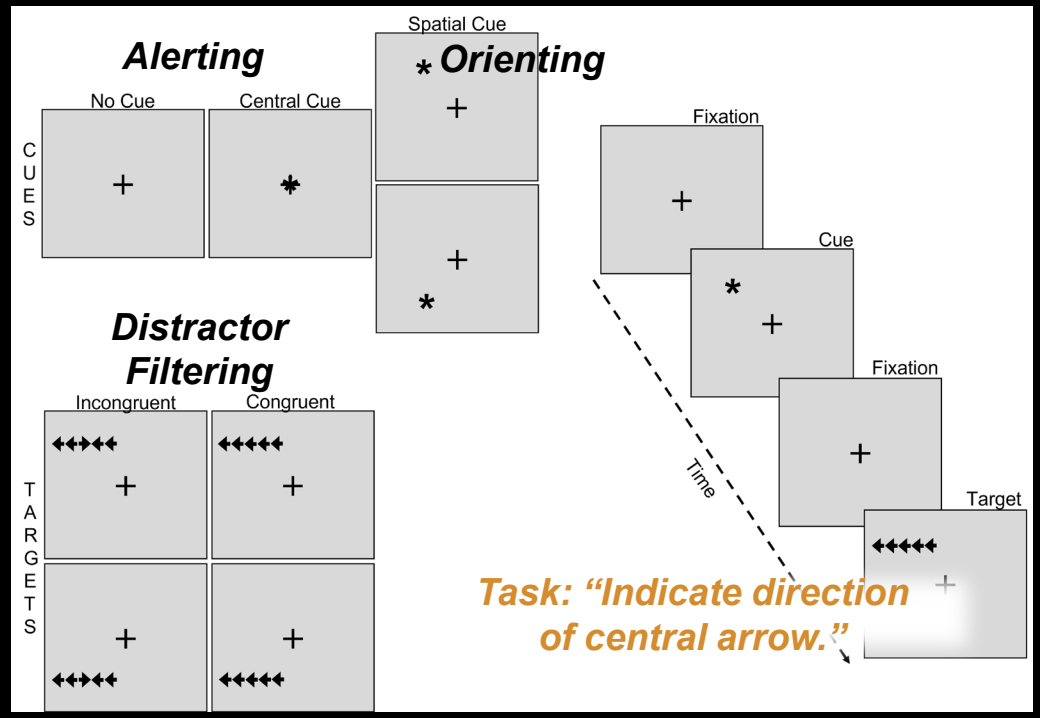
- Aim 1 – BEHAVIORAL measurement **nonauditory** attentional selection in older adults (72 years) (1) without hearing loss, (2) with hearing loss but without treatment, and (3) with hearing rehabilitation using a cochlear implant
- Aim 2 – FUNCTIONAL NEUROIMAGING (fMRI). Characterize changes in brain function and network dynamics associated with hearing loss & hearing rehabilitation
  - Measure Blood Oxygen Level Dependent (BOLD) signals during attentional tasks

- **Hypothesis:** disambiguation of auditory signals (use of CI) will relieve cognitive resources diverted away—demonstrating reversibility of cognitive deficits in support of the **Information Degradation Hypothesis**

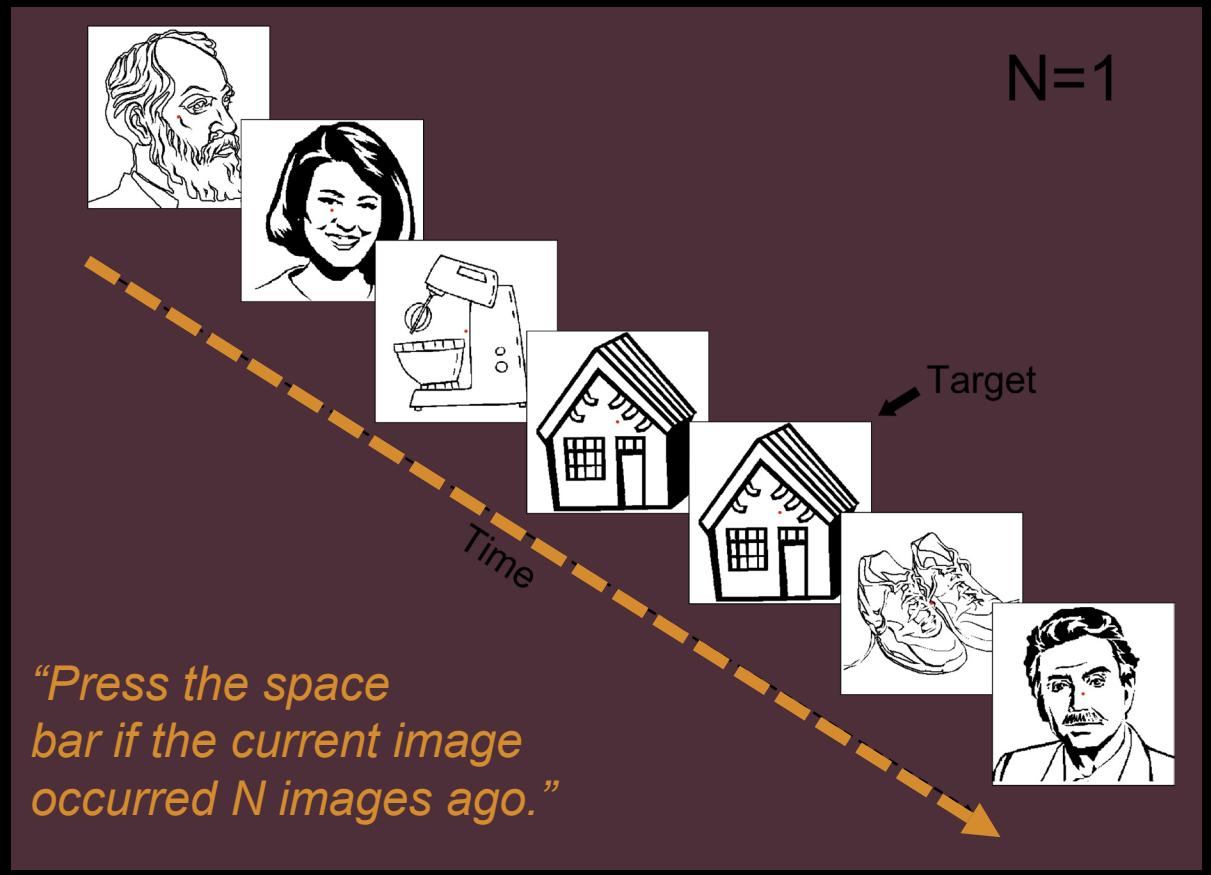
Construct of Attention

- –3-network model corresponding to 3 key attentional sub-processes *Posner & Petersen, 1990*
  - **Alerting**
  - **Orienting**
  - **Distractor filtering**
- **Attentional Network Test (ANT)**
  - Non-verbal/non-auditory assessment of these attentional control factors in the **visual domain**
  - Stable, robust, and reliable, & minimal practice effects *Fan et al., 2002; 2009*



Non-Verbal Working Memory

- **N-Back Task**
- Presentation of sequential images allowing memory load to be increased
- Participants perform 3 runs of the N-back task in which memory load is increased from N=1 to N=3



Behavioral Data (ANT)

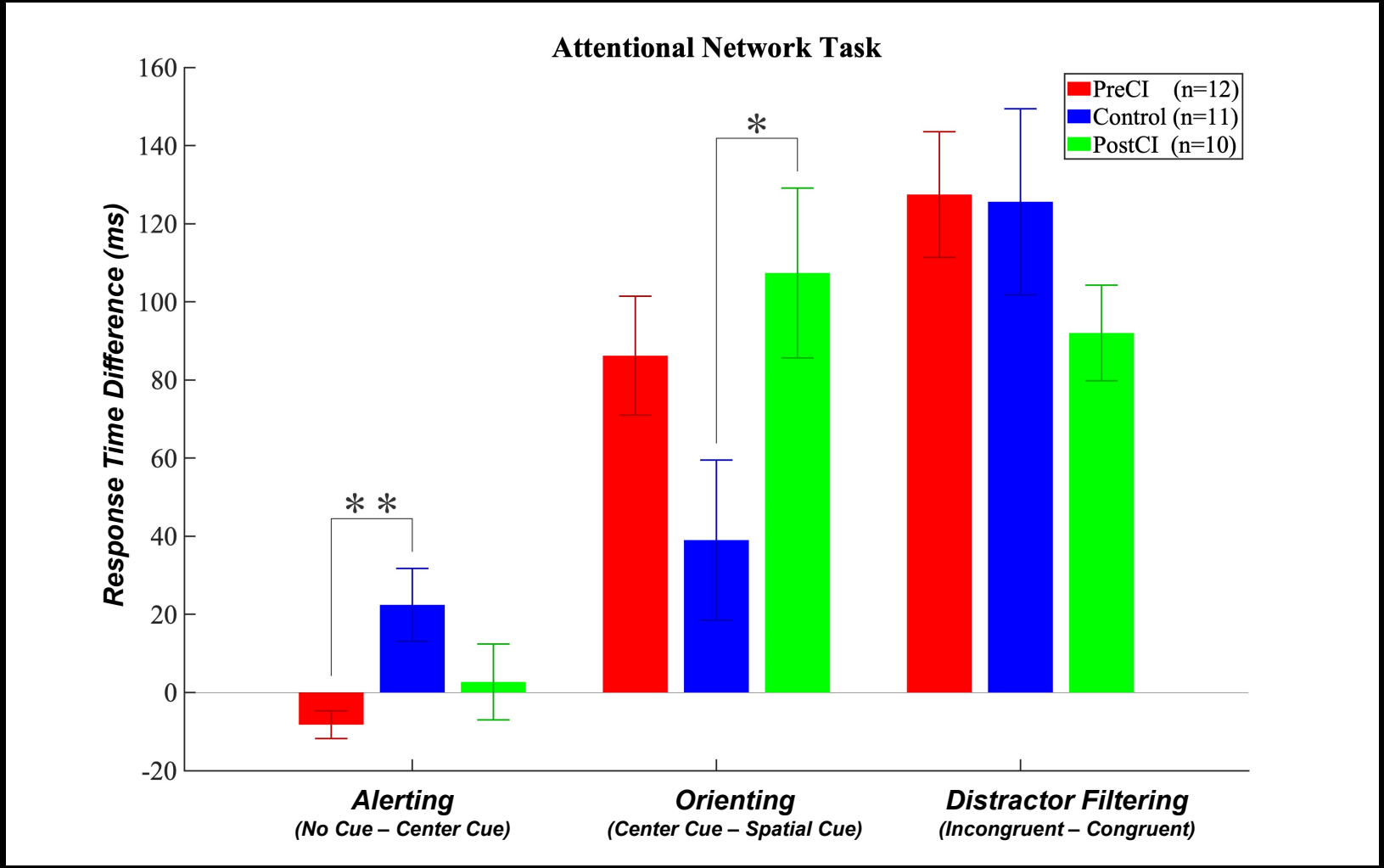
Between Groups

1. Normal Hearing (n = 11; mean age 69 years)
Approximately age-matched controls

2. Hearing Loss No CI (Pre-CI) (n = 12; mean age 73 years)
Adults (≥ 65 years) with **undertreated/untreated** post-lingually acquired sensorineural hearing loss who qualify for cochlear implants

3. Hearing Loss + CI (n = 10; mean age 73 years)
Adults (≥ 65 years) with post-lingual sensorineural hearing loss with a cochlear implant within 1-year of surgery (“learning phase”)

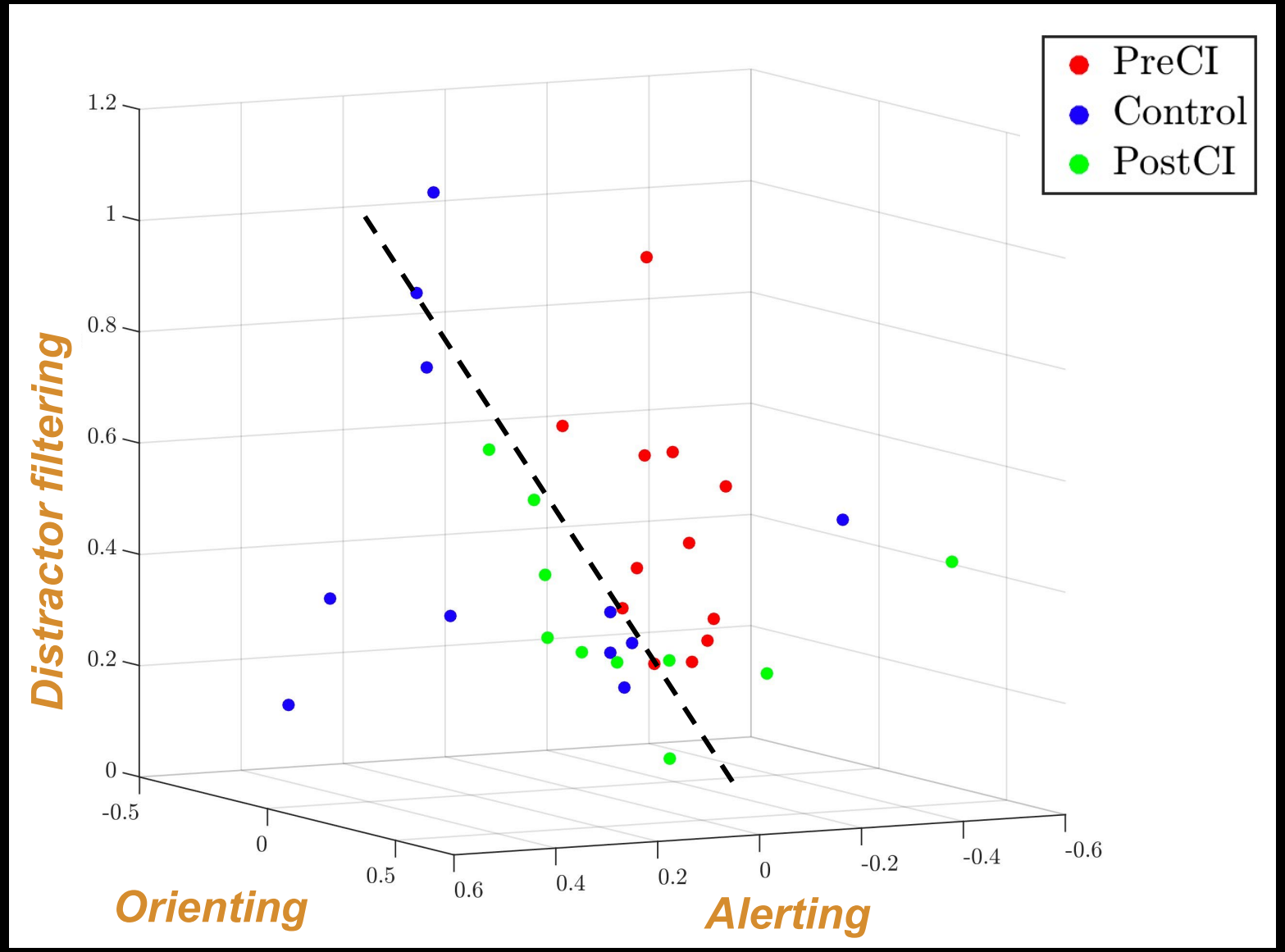
Attentional Network Test (ANT)



- Pattern of results different across three groups
- **Significant differences in alerting between Pre-CI & Control**

Post-CI & Controls engage attentional components *in concert* differently than Pre-CI

Attentional Network Test (ANT)



fMRI Data (Nback)

Between Groups

1. Normal Hearing
Approximately age-matched controls

2. Hearing Loss No CI (pre-CI)
Adults (≥ 65 years) with **undertreated/untreated** post-lingually acquired sensorineural hearing loss who qualify for cochlear implants

3. Hearing Loss + CI
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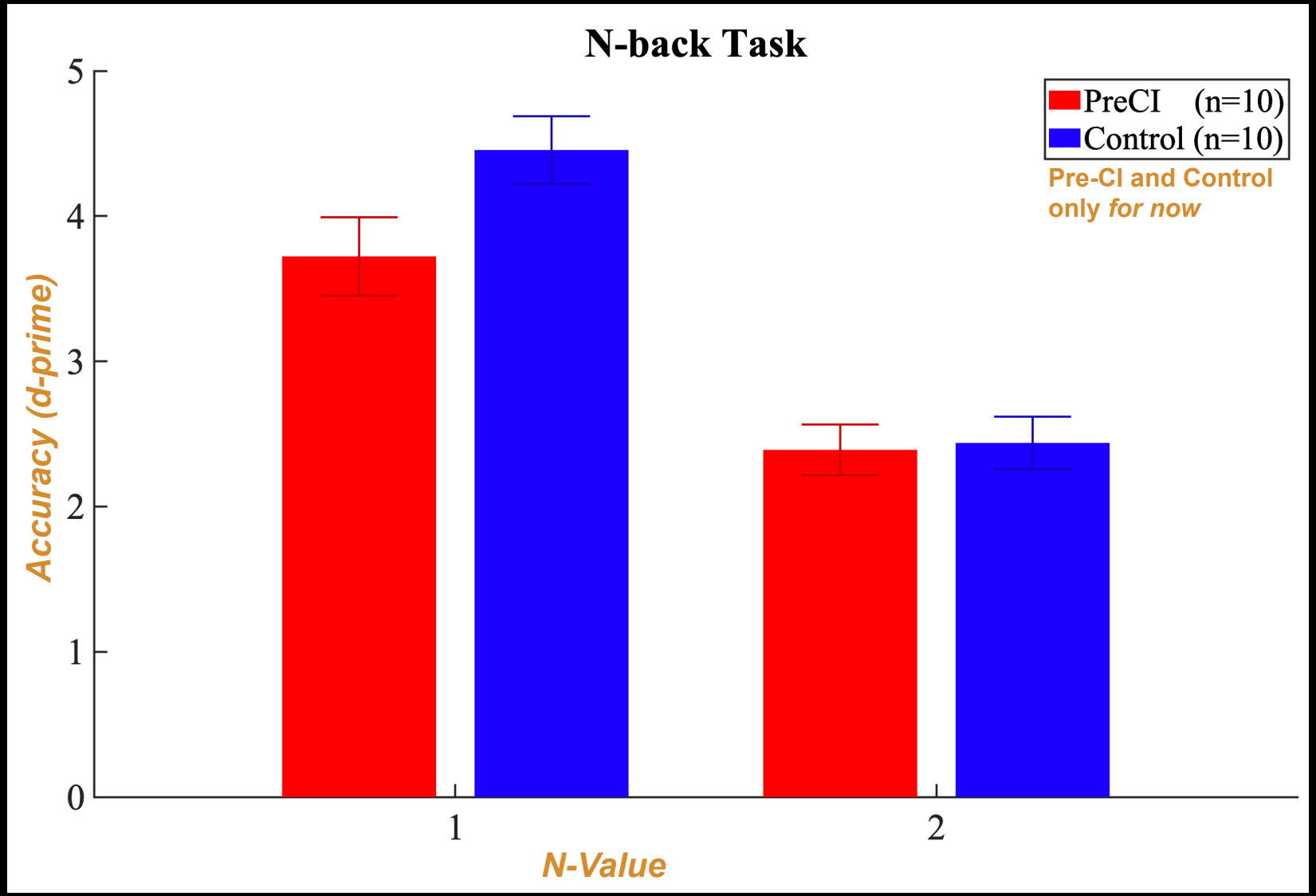
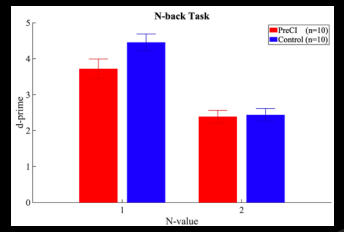
N-Back Behavioral Results

No significant differences between groups on N-back working memory task (collected in fMRI)…

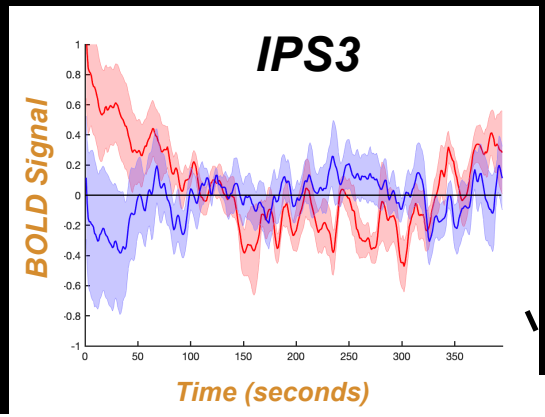


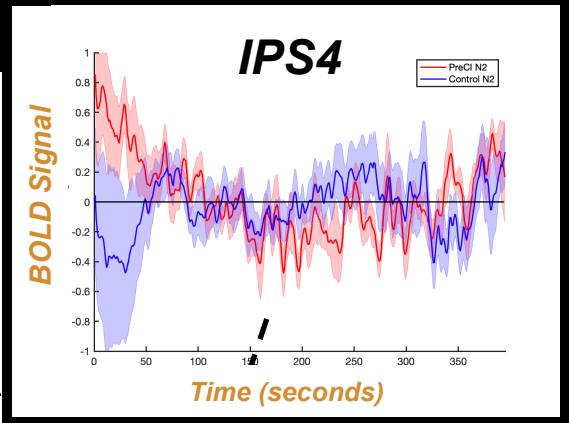


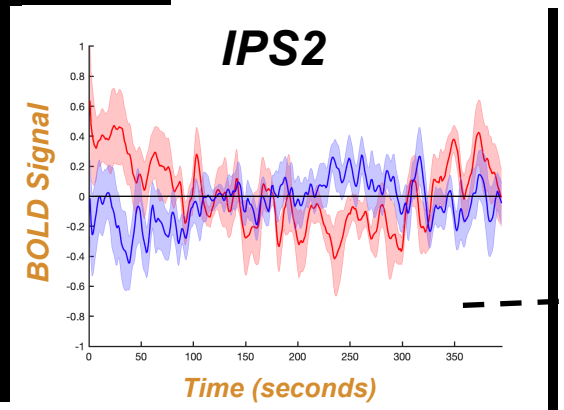
Control = Blue
Pre-CI = Red

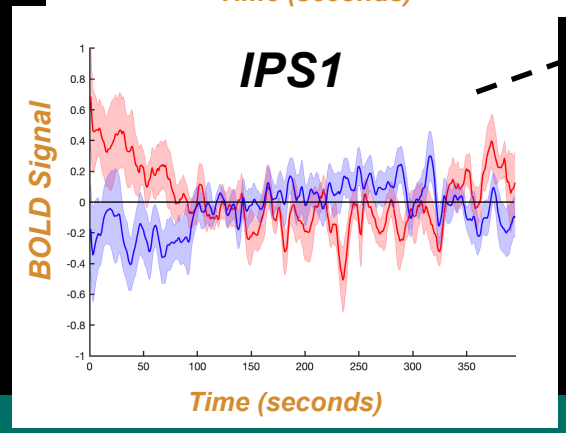
Intraparietal Sulcus (IPS)
Engaged in Working Memory & Attention
Significantly More Active
(contralateral hemisphere **BOLD signal** N2)
in Pre-CI group only

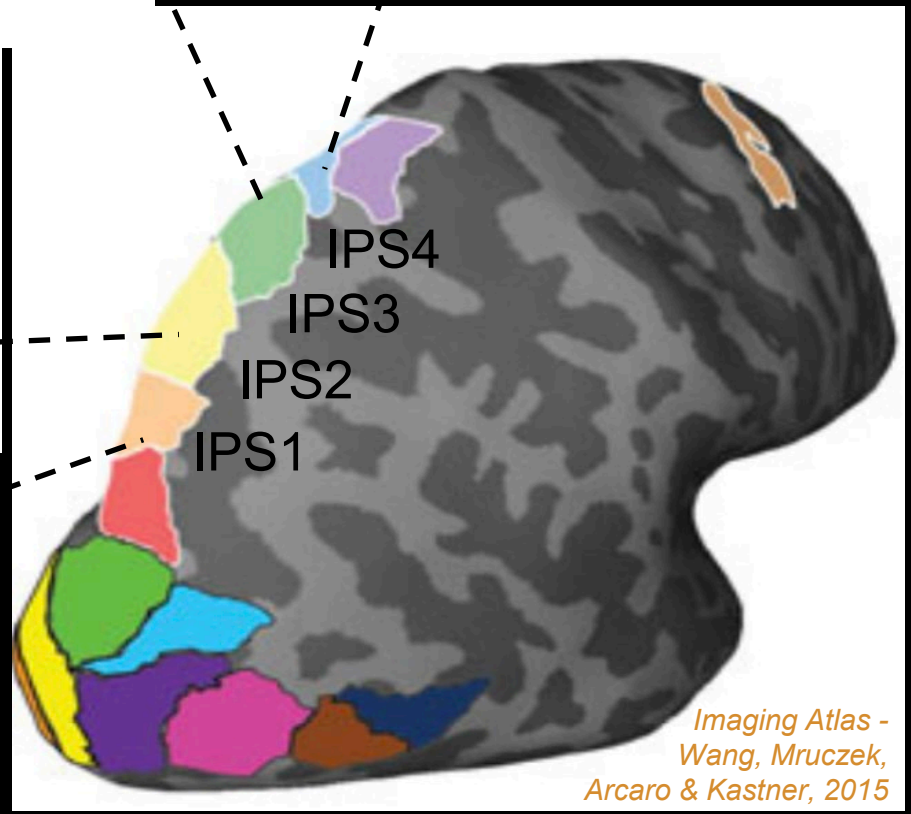
Pre-CI participants are recruiting greater amount of neural resources from IPS
Robust finding over 1.5 min







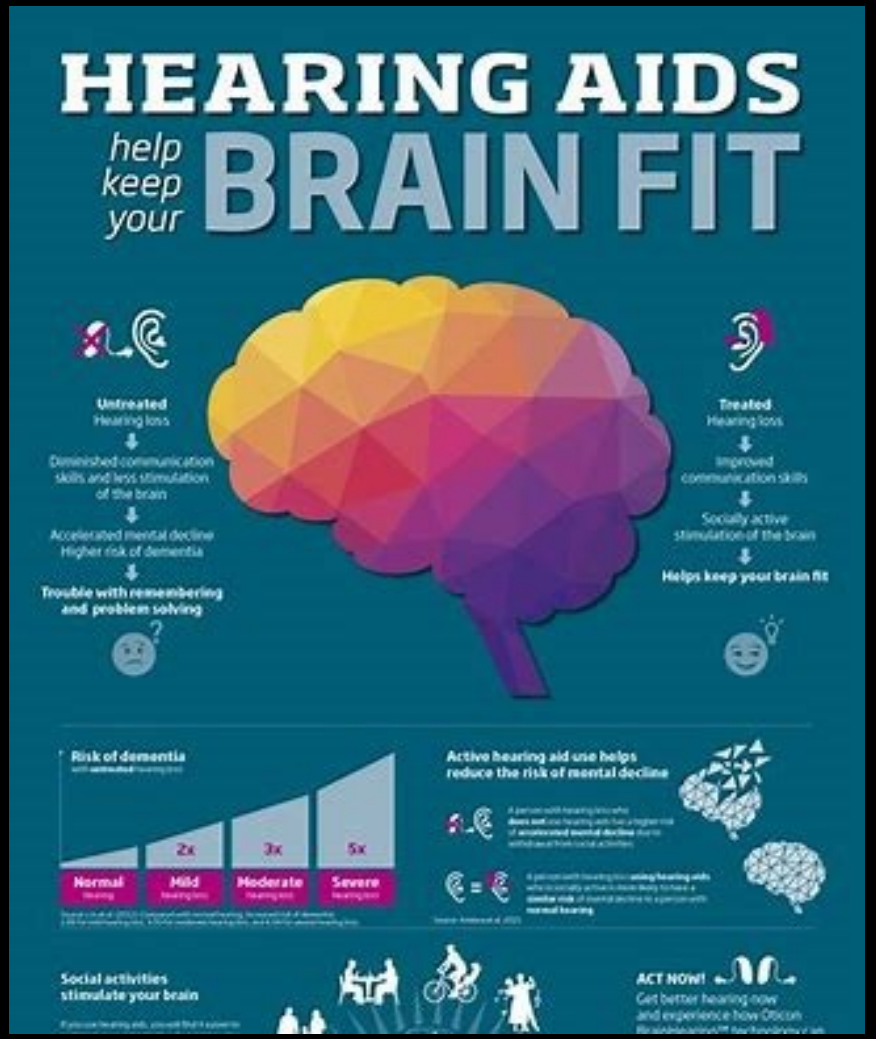




Imaging Atlas - Wang, Mruczek, Arcaro & Kastner, 2015

What to Tell Your Patients

- Both age-related hearing loss & cognitive decline are of increasing concern with the aging population
- Age-related hearing loss does appear to be independently associated with increased risk of cognitive decline
- The mechanism is not substantiated
- The role of hearing rehabilitation to reverse, slow, or prevent cognitive decline is unclear, but promising
- Attentional resources are utilized differently in those with hearing loss with and without hearing loss treatment.
- Absence of behavioral differences may be attributed to **compensatory mechanisms** within the parietal cortex (IPS)



Oticon – Hearing Aid Manufacturer

THANK YOU!

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