Hearing Loss and Dementia: Public Health Implications for Older Adults

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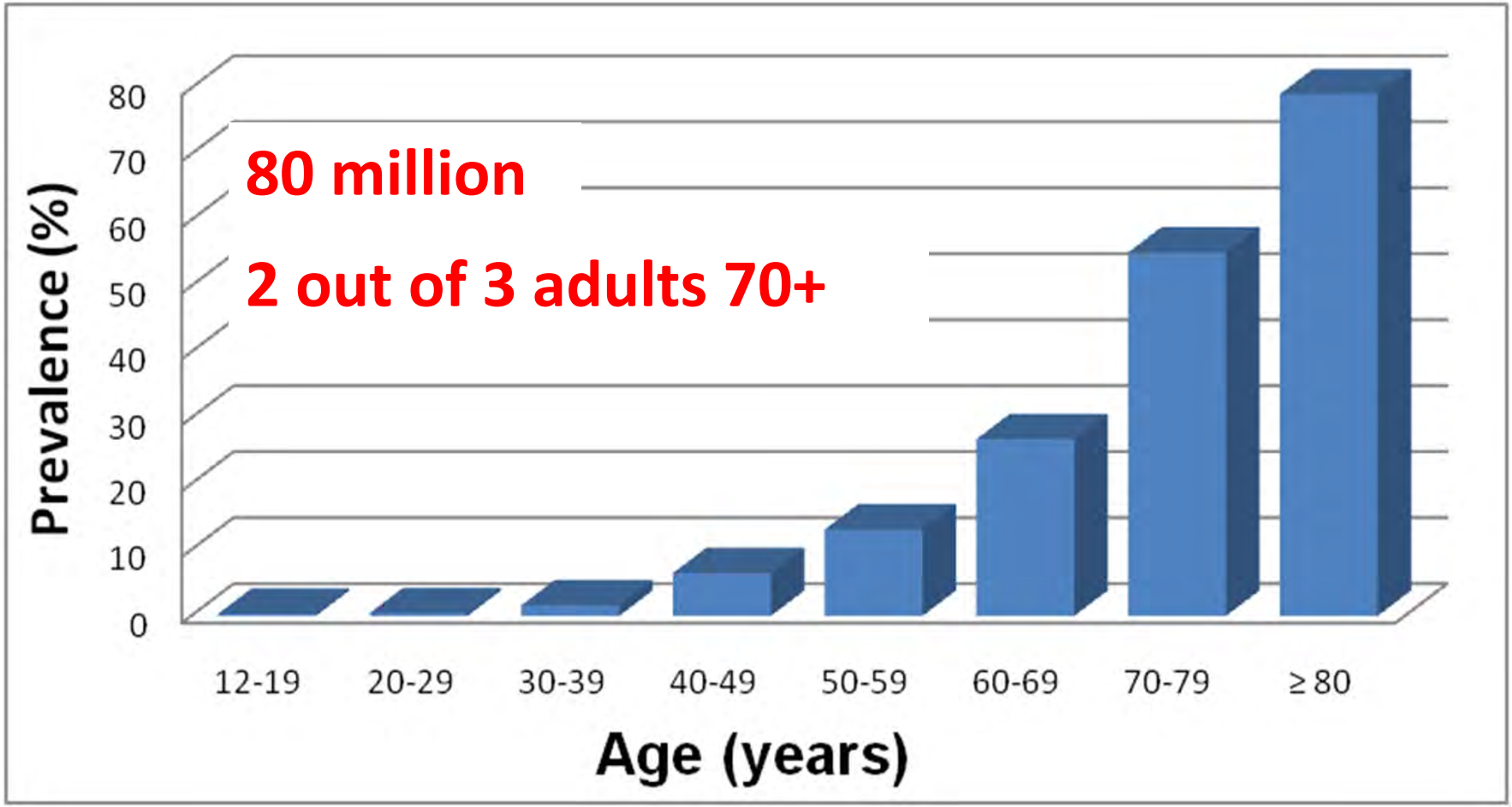
Prevalence of Hearing Loss by Age, United States, 2001-2008

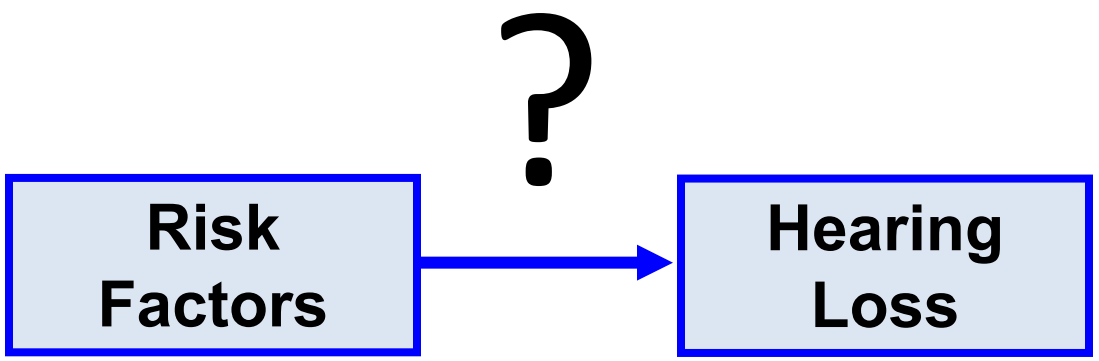


Hearing loss defined as a better-ear PTA of 0.5-4kHz tones > 25 dB

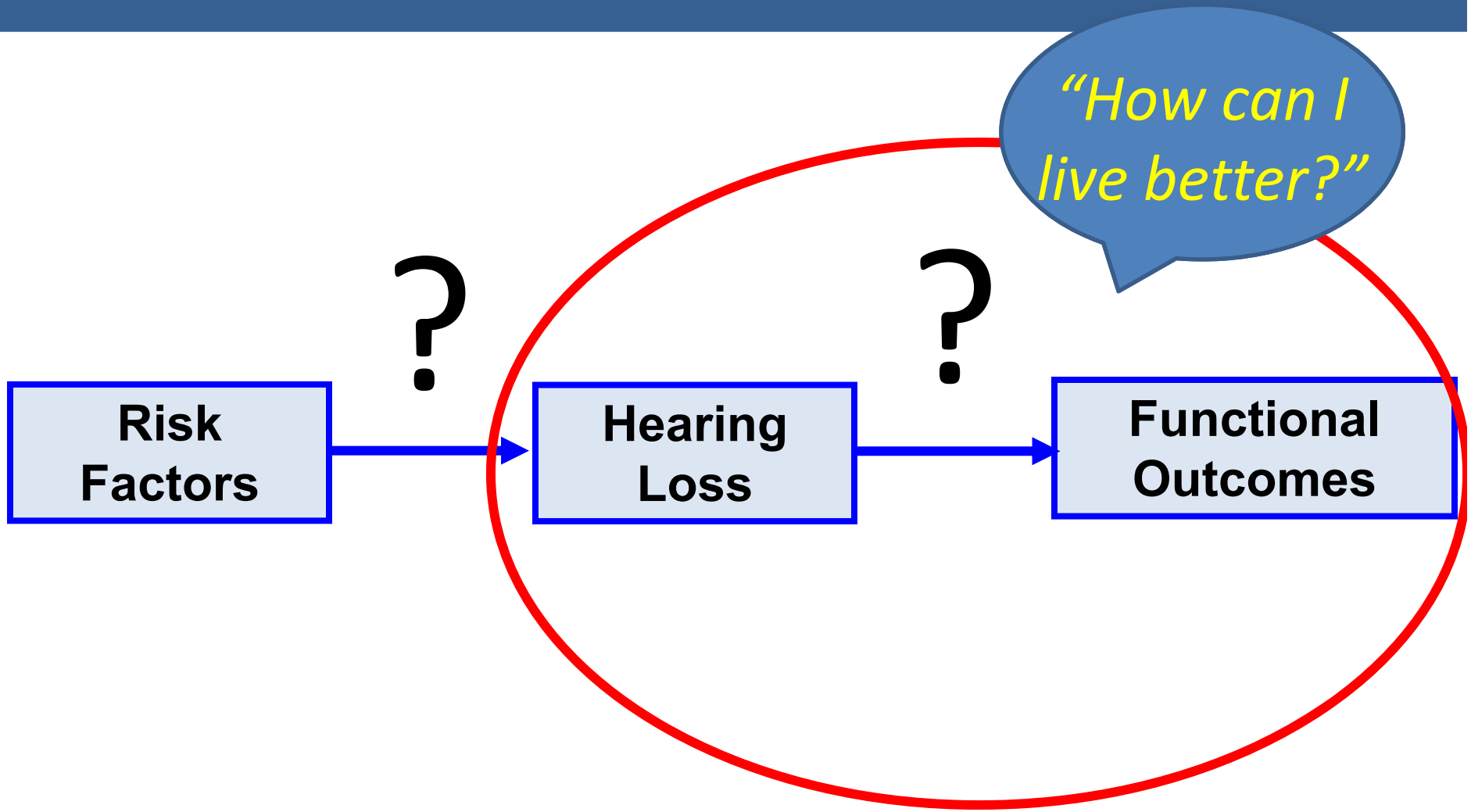
Lin et al., Arch Int Med. 2011

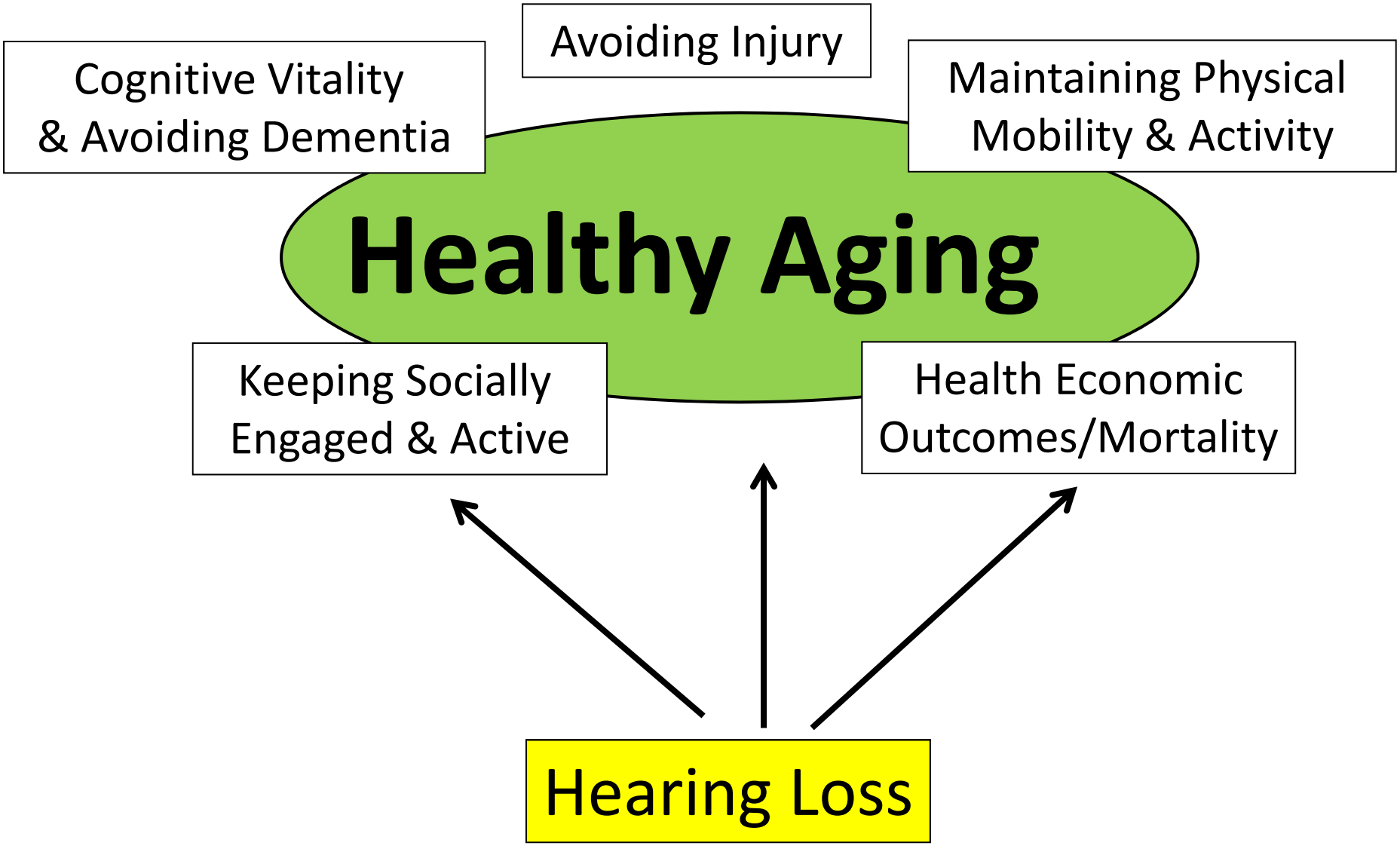
Hearing Loss & Function

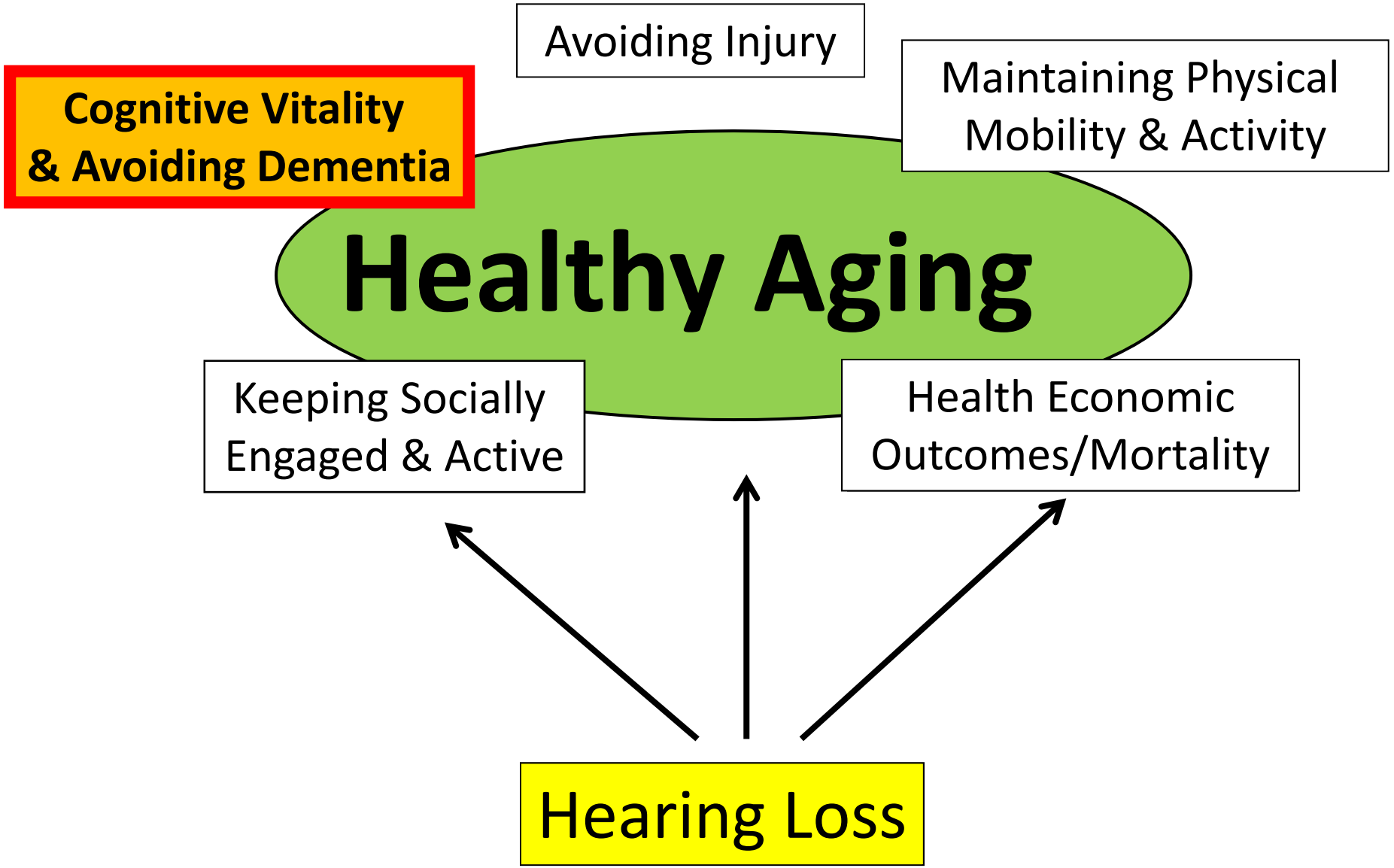
"How can I live better?"



Hearing Loss & Function




Avoiding Injury
Cognitive Vitality & Avoiding Dementia
Maintaining Physical Mobility & Activity
Healthy Aging
Keeping Socially Engaged & Active
Health Economic Outcomes/Mortality
Hearing Loss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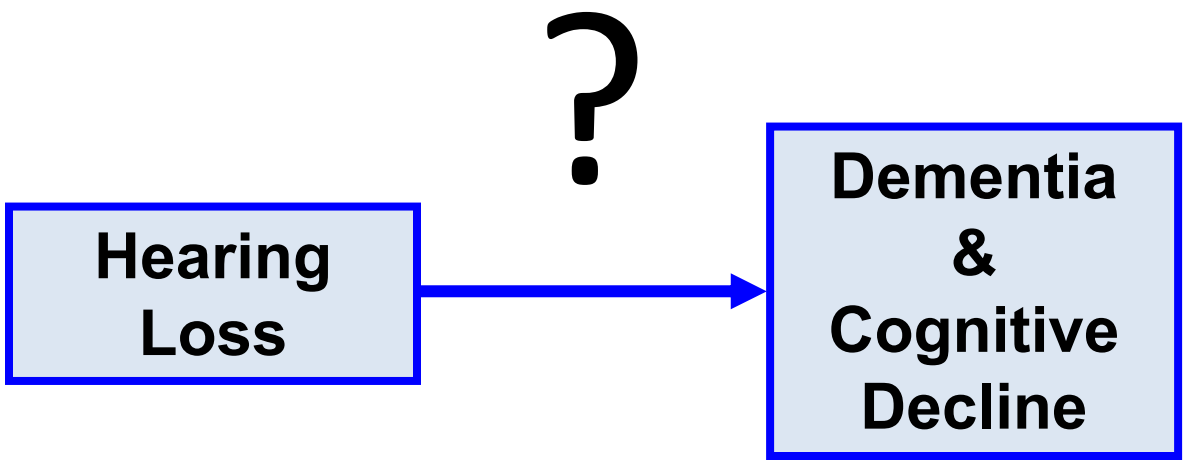
Hearing Loss & Cognition



Objectives

- Introduce important cognitive outcomes in geriatrics/gerontology dementia

- Present epidemiologic evidence for a relationship between hearing impairment and cognitive decline and dementia

What is cognitive function?

- Collection of mental processes controlled by the brain
- Includes attention, memory, language production and understanding, learning, reasoning, problem-solving and decision-making

Dementia

- Cognitive or behavioral (neuropsychiatric) symptoms that:

1. Interfere with the ability to function at work or at usual activities; and
2. Represent a decline from previous levels of functioning and performing; and
3. Are not explained by delirium or major psychiatric disorder

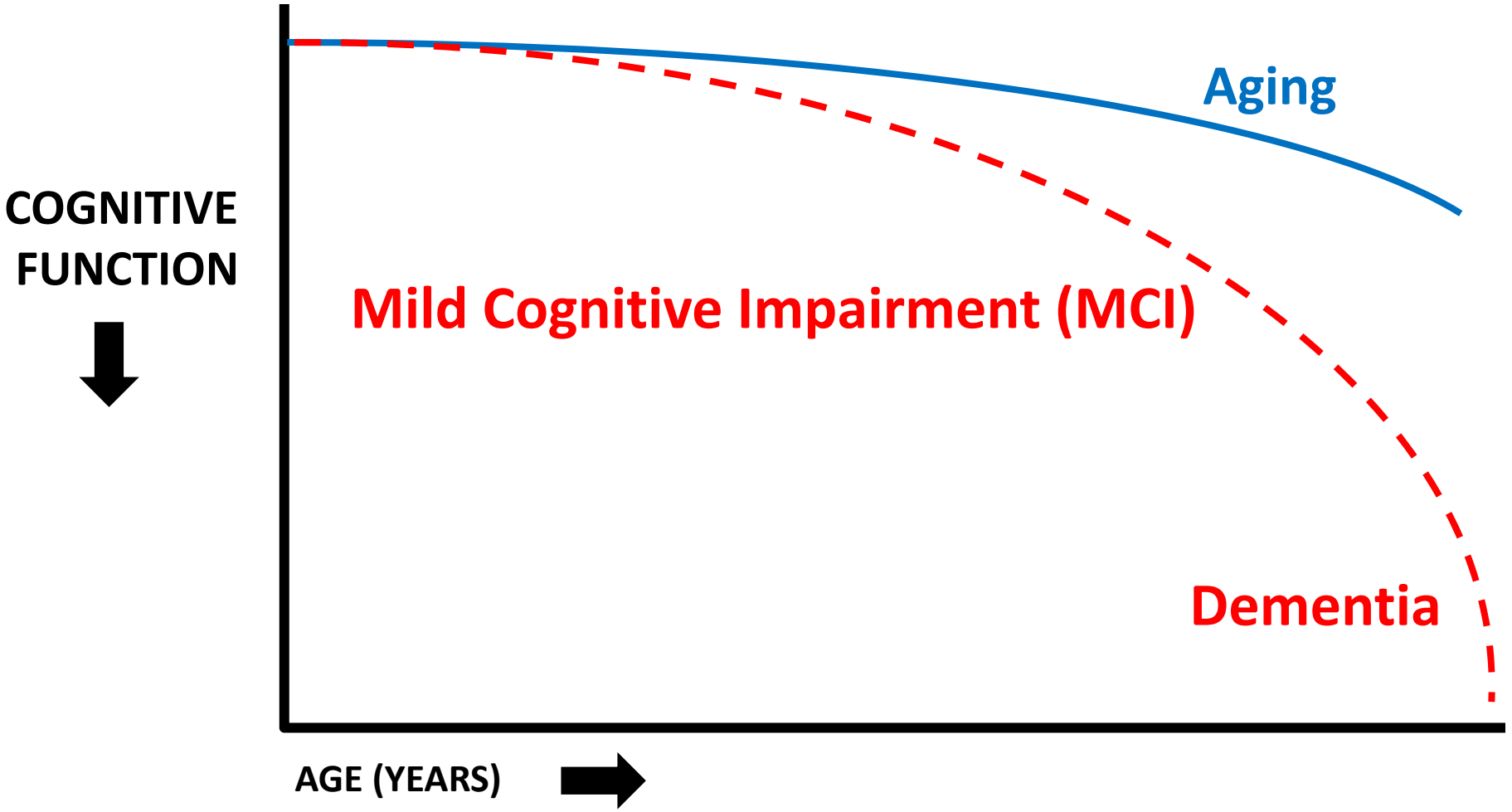
McKhann, et al. Alzheimer's & Dementia: The Journal of the Alzheimer's Association , Volume 7 , Issue 3 , 263 - 269

Dementia

- ≥ 2 domains of cognitive function
  - e.g., memory, language, executive function
- Significant interference in the ability to function at work or in usual daily activities
  - Differentiates dementia from MCI

McKhann, et al. Alzheimer's & Dementia: The Journal of the Alzheimer's Association , Volume 7 , Issue 3 , 263 - 269

The Continuum of Alzheimer's disease



Adapted from Sperling et al., Alzheimer's and Dementia (2011) 7:280-292.

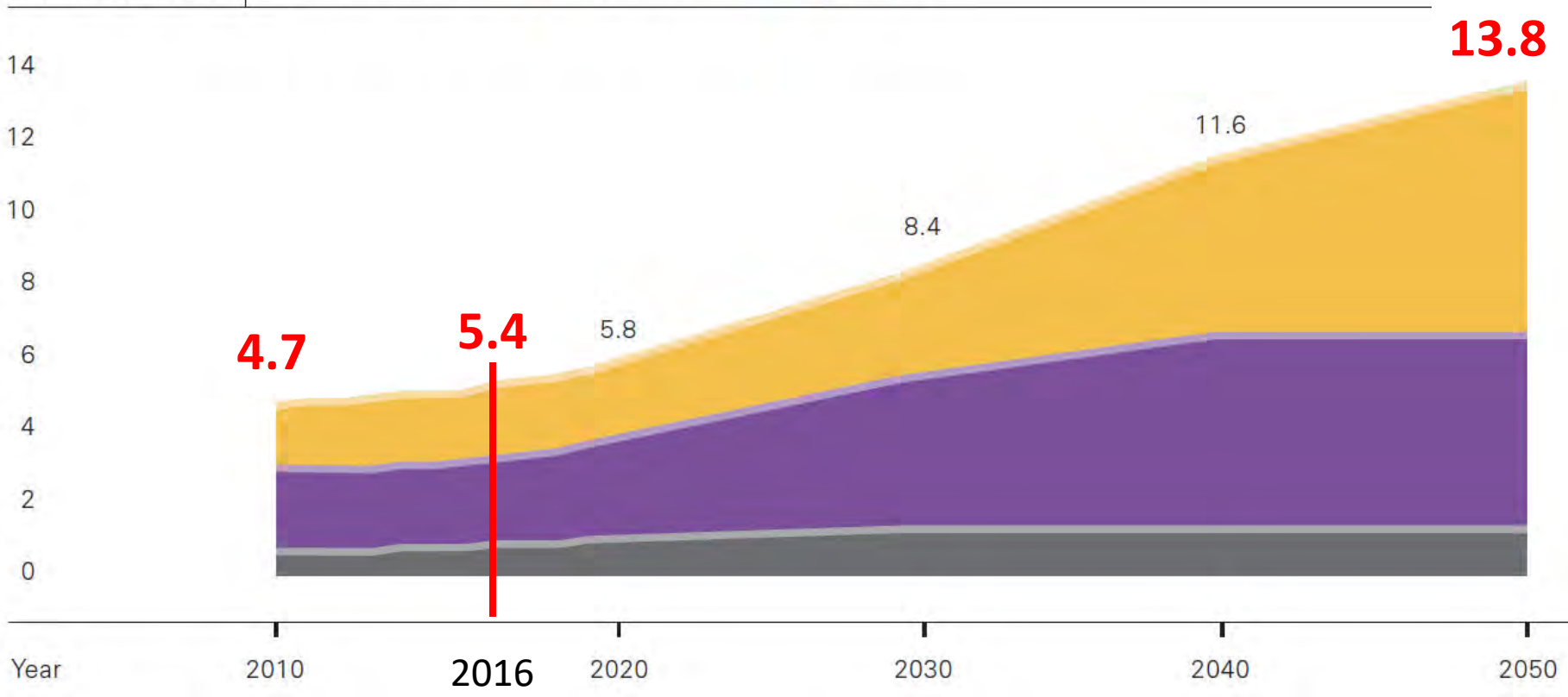
Alzheimer's disease

- Insidious onset
- Clear-cut worsening of cognition
- Initial/most prominent cognitive complaints:
  - Memory & learning (amnestic)
  - Non-amnestic (language, visuospatial, executive function)
- No evidence of other causes (e.g., cerebrovascular disease)

McKhann, et al. Alzheimer's & Dementia: The Journal of the Alzheimer's Association , Volume 7 , Issue 3 , 263 - 269

figure 5

Projected Number of People Age 65 and Older (Total and by Age Group) in the U.S. Population With Alzheimer's Disease, 2010 to 2050



Created from data from Hebert et al.[114], A11

https://www.alz.org/downloads/Facts_Figures_2014.pdf

Hebert & al. Neurology May 7, 2013 vol. 80 no. 19 1778-1783

Dementia Incidence Declining?

Temporal Trends in the Framingham Heart Study

Table 2. Temporal Trends in the Incidence of Dementia.*

Subtype	No. of Cases	Total No. of Observation Periods	5-Yr Hazard Ratio (95% CI)‡			P Value for Trend
			Epoch 2	Epoch 3	Epoch 4	
Overall dementia	371	9015	0.78 (0.59–1.04)	0.62 (0.47–0.83)	0.56 (0.41–0.77)	<0.001
Alzheimer's disease	264	9015	1.00 (0.70–1.43)	0.88 (0.62–1.25)	0.70 (0.48–1.03)	0.052
Vascular dementia	84	9014	0.89 (0.51–1.56)	0.46 (0.25–0.86)	0.45 (0.23–0.87)	0.004

late 1980's – early 90's | **late 90's – early 2000's** | **late 2000's – early 2010's**

Compared to late 1970's – early 80's

Global Burden of Dementia

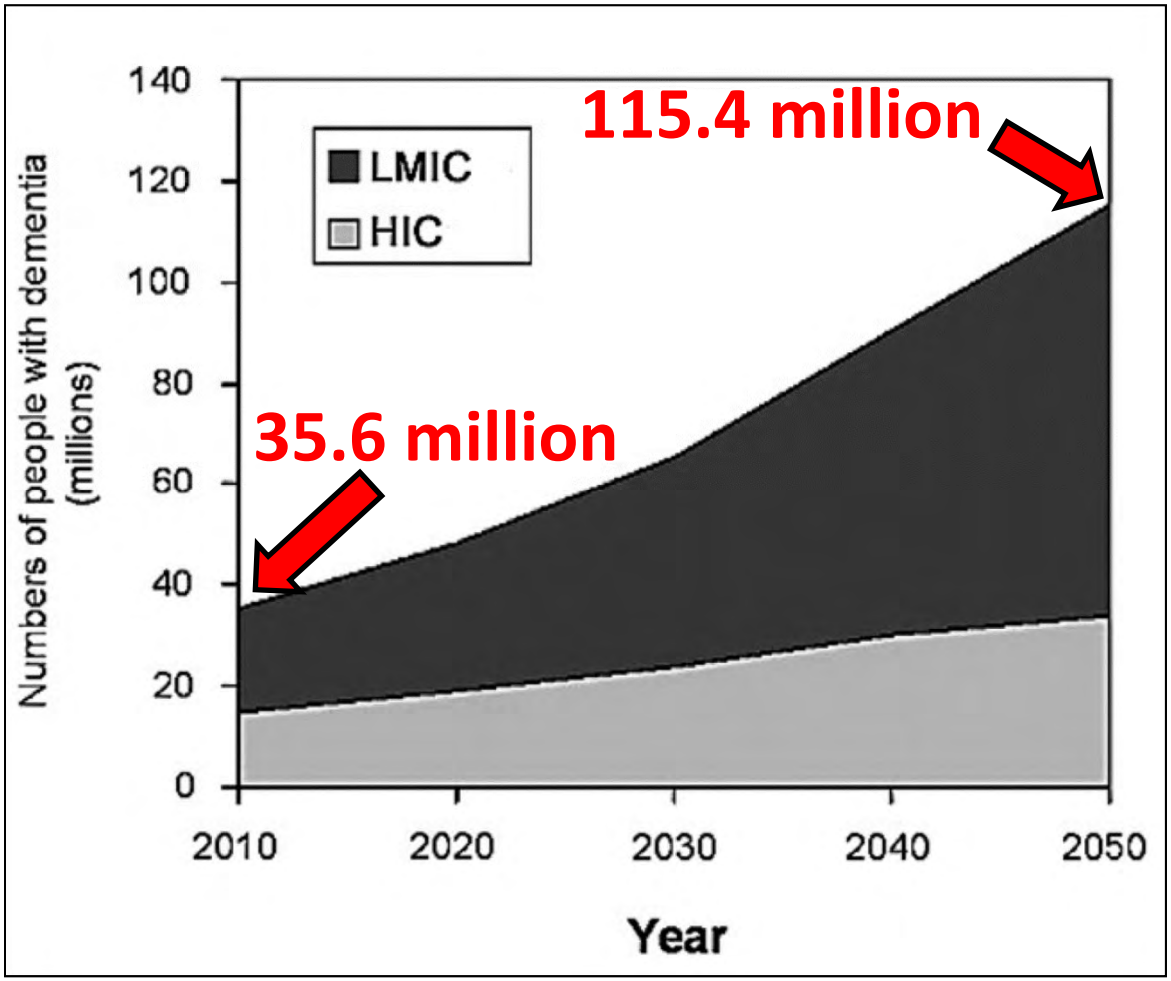


Fig. 2. The growth in numbers of people with dementia in high-income (HIC) and low- and middle-income countries (LMIC).

M. Prince et al. / Alzheimer's & Dementia 9 (2013) 63–75

The Cost of Dementia

Costs for Dementia Care Far Exceeding Other Diseases, Study Finds

By GINA KOLATA OCT. 26, 2015

Alicia Joseph, a home health aide with Partners in Care, helps Naomi Wallace, a dementia patient. Many of the costs of caring for dementia patients are not covered by Medicare. Sam Hodgson for The New York Times

Conclusion: Health care expenditures among persons with dementia were substantially larger than those for other diseases, and many of the expenses were uncovered (uninsured). This places a large financial burden on families, and these burdens are particularly pronounced among the demographic groups that are least prepared for financial risk.

Annals of Internal Medicine ORIGINAL RESEARCH

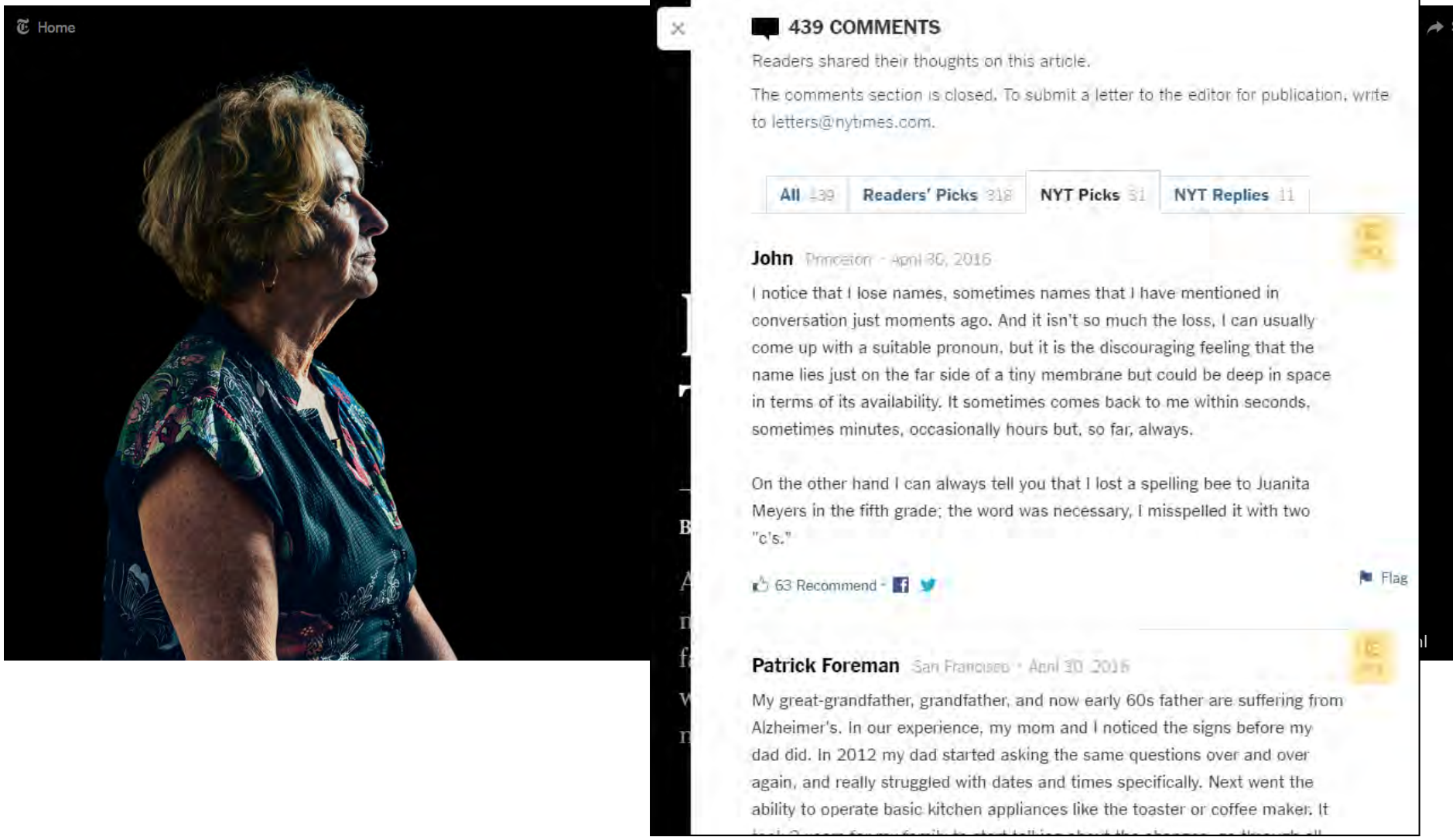
The Burden of Health Care Costs for Patients With Dementia in the Last 5 Years of Life

Amy S. Kelley, MD, MSHS; Kathleen McGarry, PhD; Rebecca Gorges, MA; and Jonathan S. Skinner, PhD

Ann Intern Med. Published online 27 October 2015 doi:10.7326/M15-0381

http://www.nytimes.com/2015/10/27/health/costs-for-dementia-care-far-exceeding-other-diseases-study-finds.html?_r=1

The Cost of Dementia



Treatments for Alzheimer's disease

Drug name	Brand name	Approved For	FDA Approved
1. donepezil	Aricept	All stages	1996
2. galantamine	Razadyne	Mild to moderate	2001
3. memantine	Namenda	Moderate to severe	2003
4. rivastigmine	Exelon	All stages	2000
5. donepezil and memantine	Namzaric	Moderate to severe	2014

http://www.alz.org/research/science/alzheimers_disease_treatments.asp

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Slow progression of symptoms, but only for a limited time

http://www.alz.org/research/science/alzheimers_disease_treatments.asp

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4.			2000
5. donepezil & memantine			2014

Prevention!!!

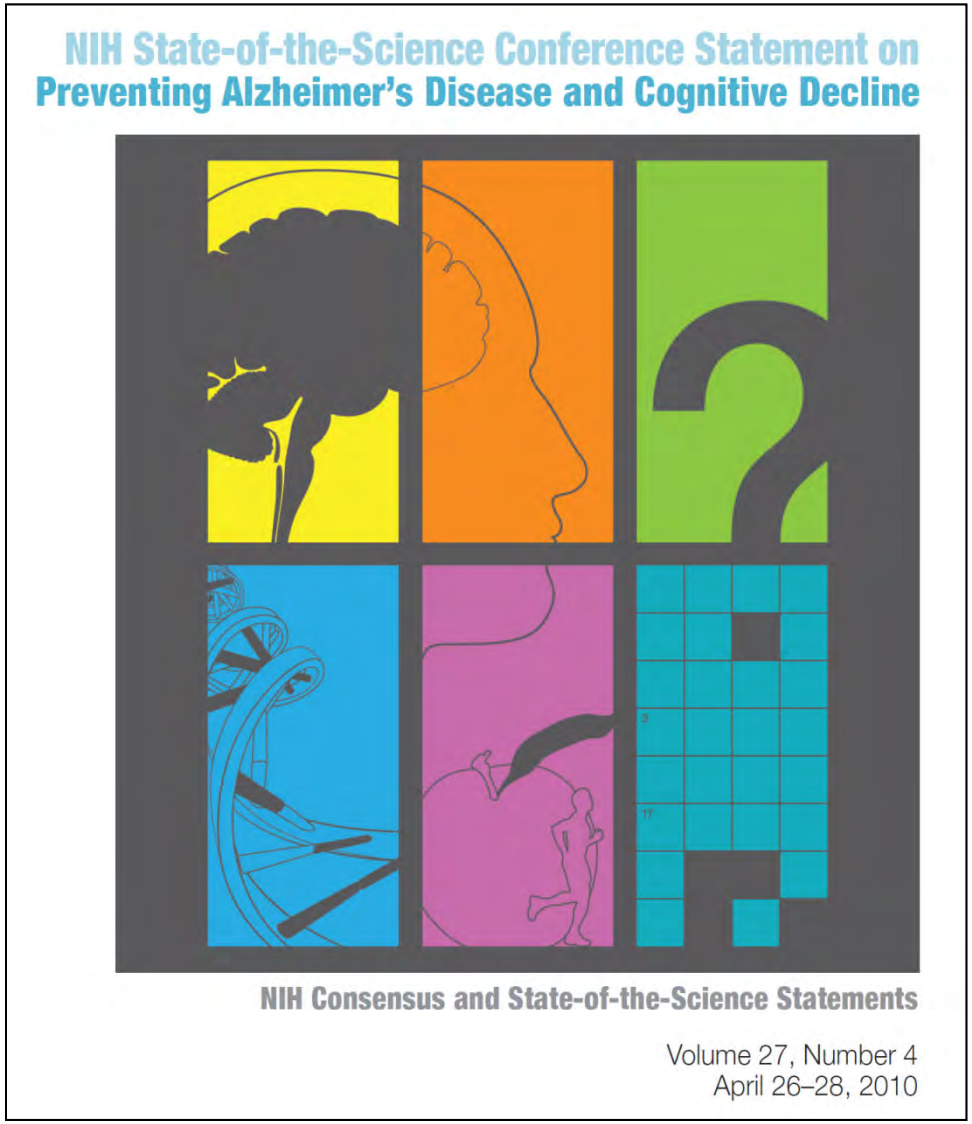
Identification of modifiable risk factors urgently needed

Slow progression ym s, bu ly for a limited time

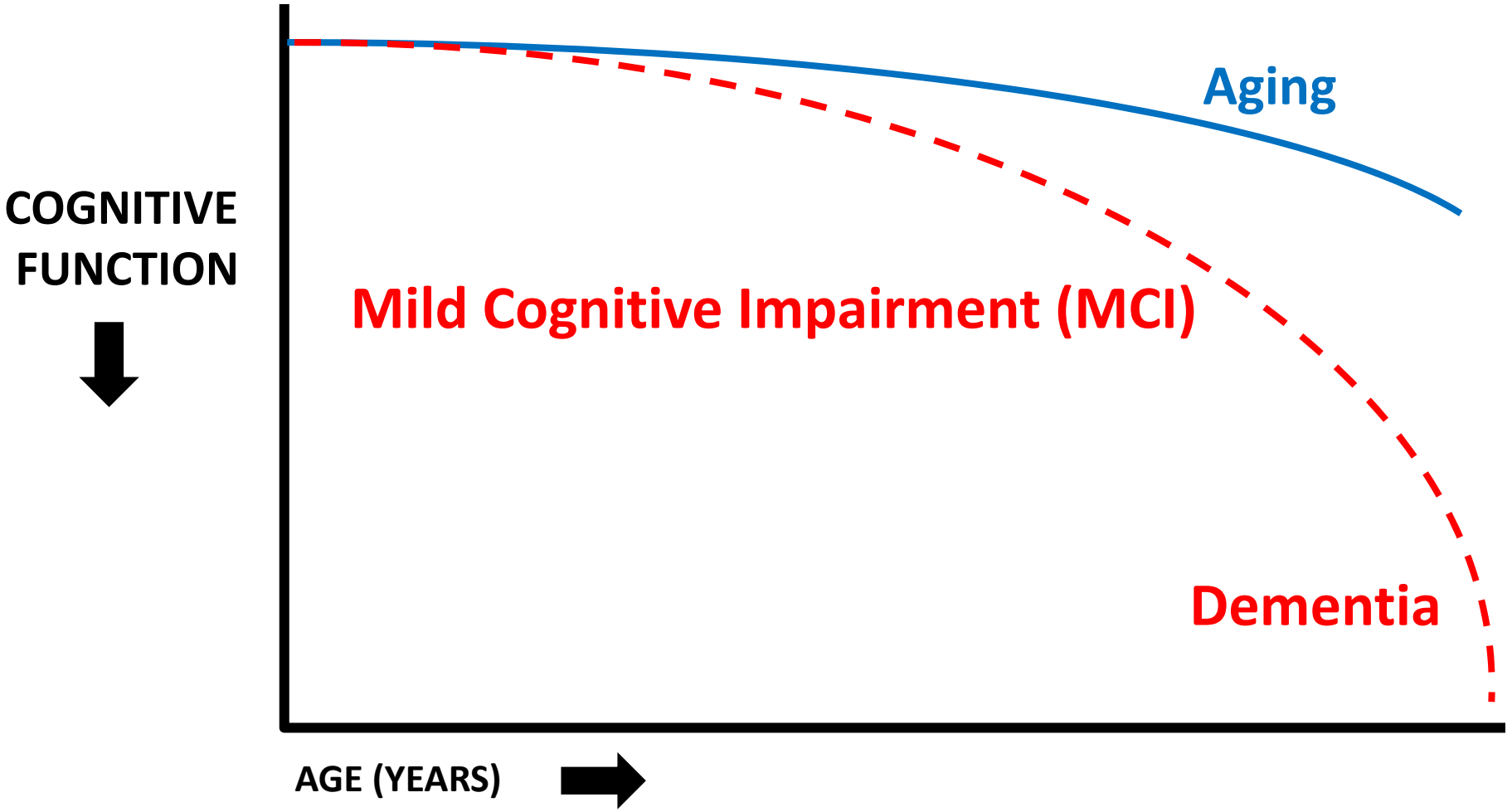
http://w w.alz.org/research/science/alzheimers_disease_treatments.asp

State of Prevention

"Currently, firm conclusions cannot be drawn about the association of any modifiable risk factor with cognitive decline"



The Continuum of Alzheimer's disease



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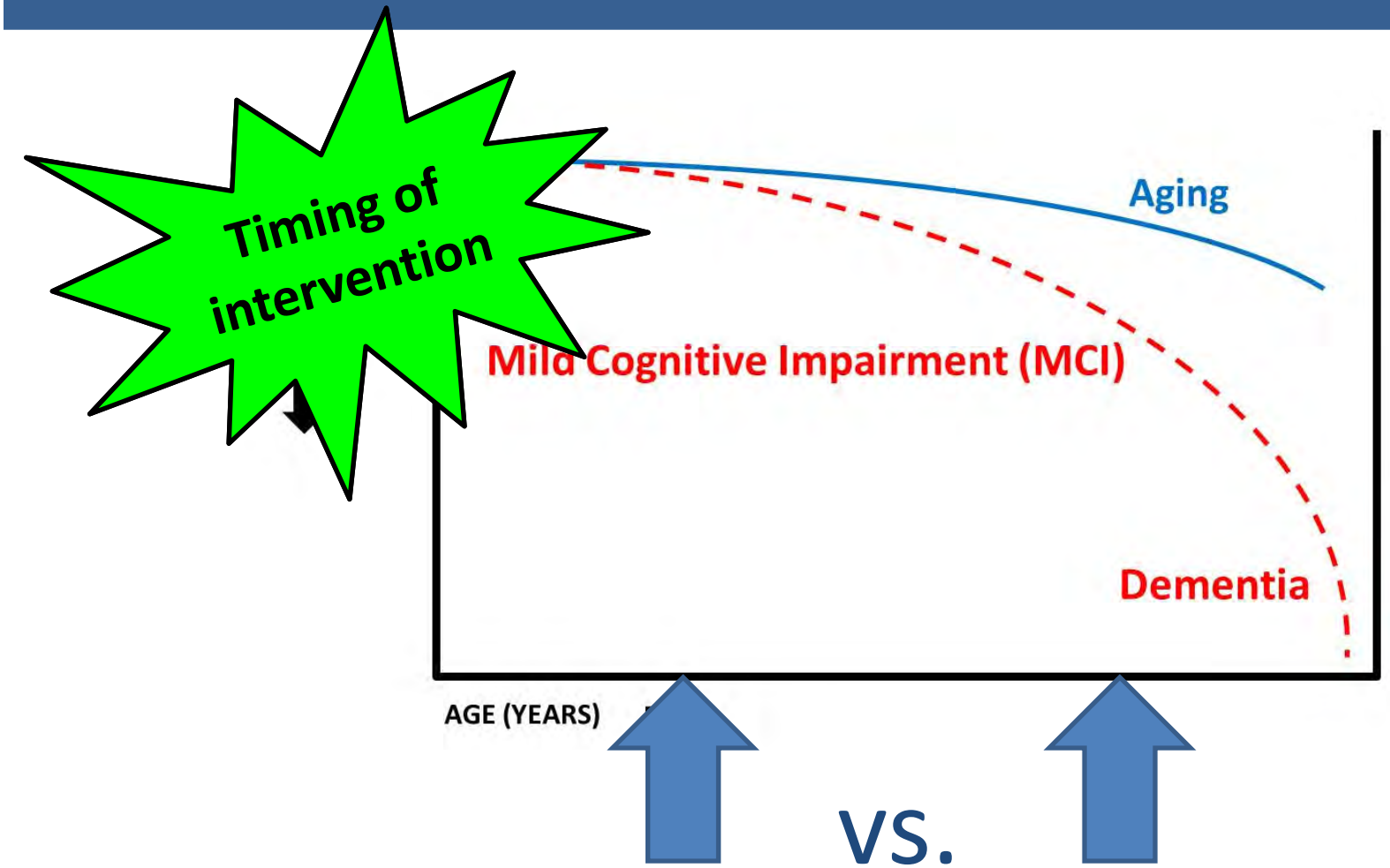
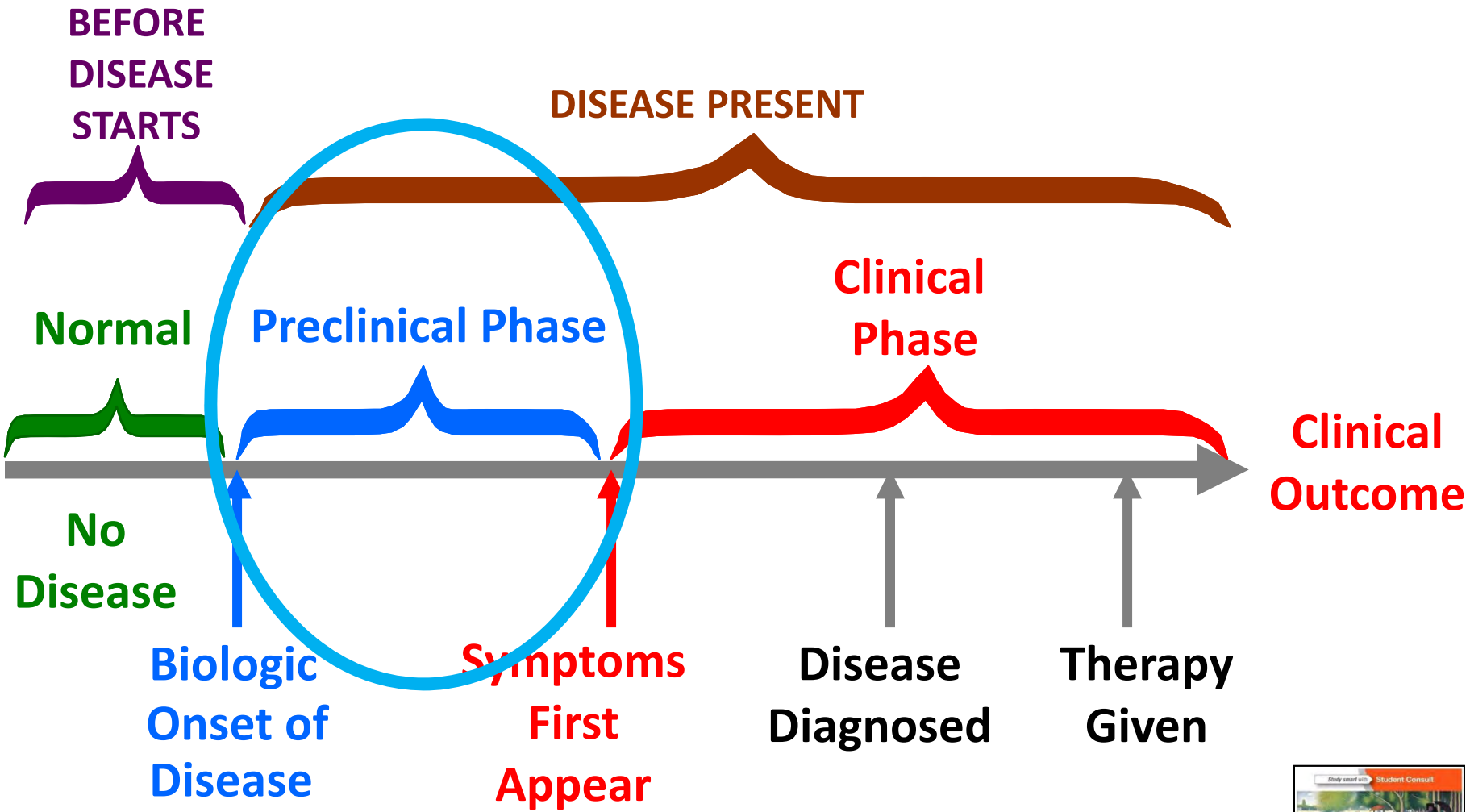
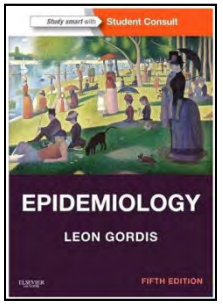
The Continuum of Alzheimer's disease



Does the effect of a factor differ by point on the continuum?

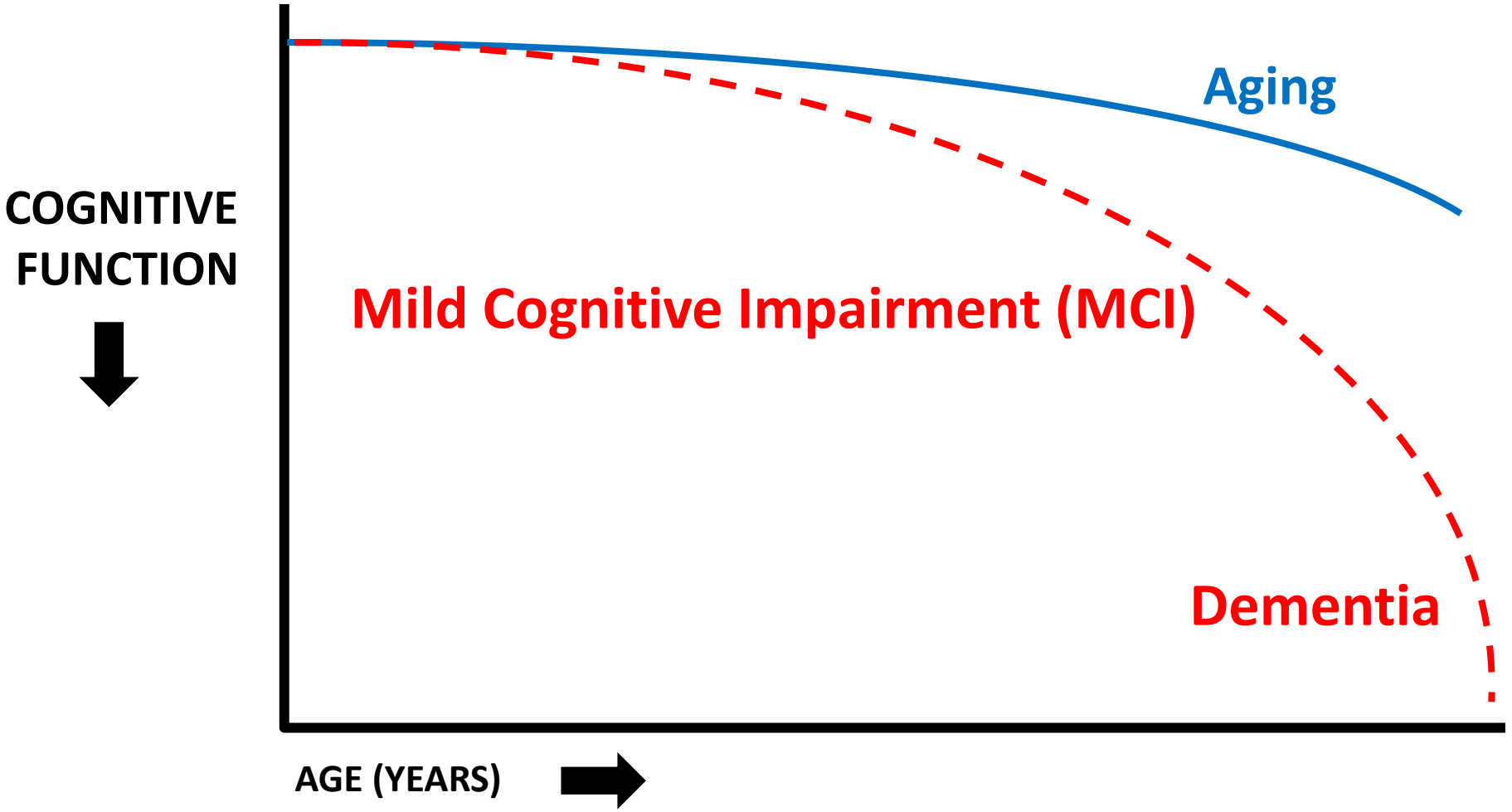
Adapted from Sperling et al., Alzheimer's and Dementia (2011) 7:280-292.





Gordis.Epidemiology.5th ed.

The Continuum of Alzheimer's disease



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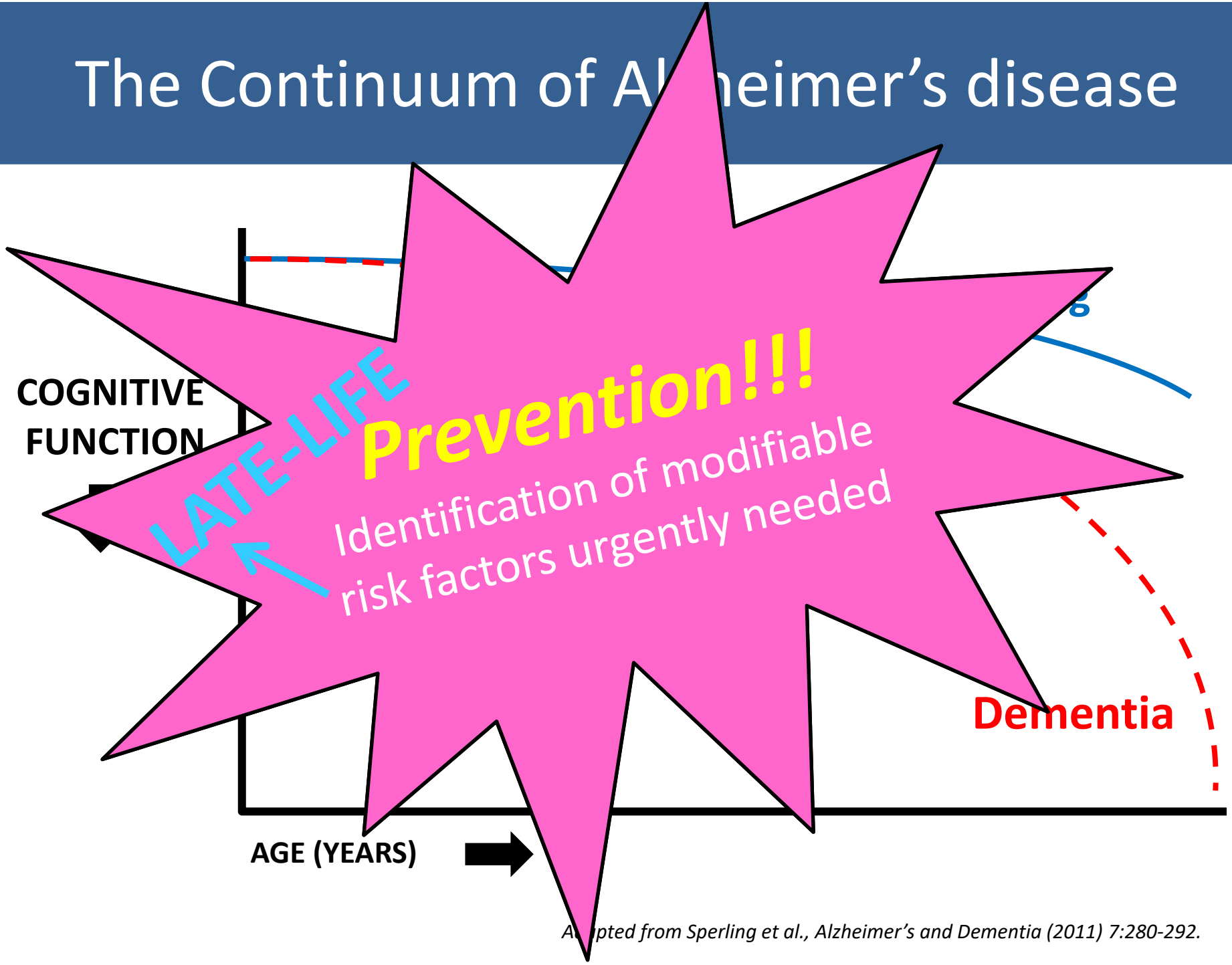

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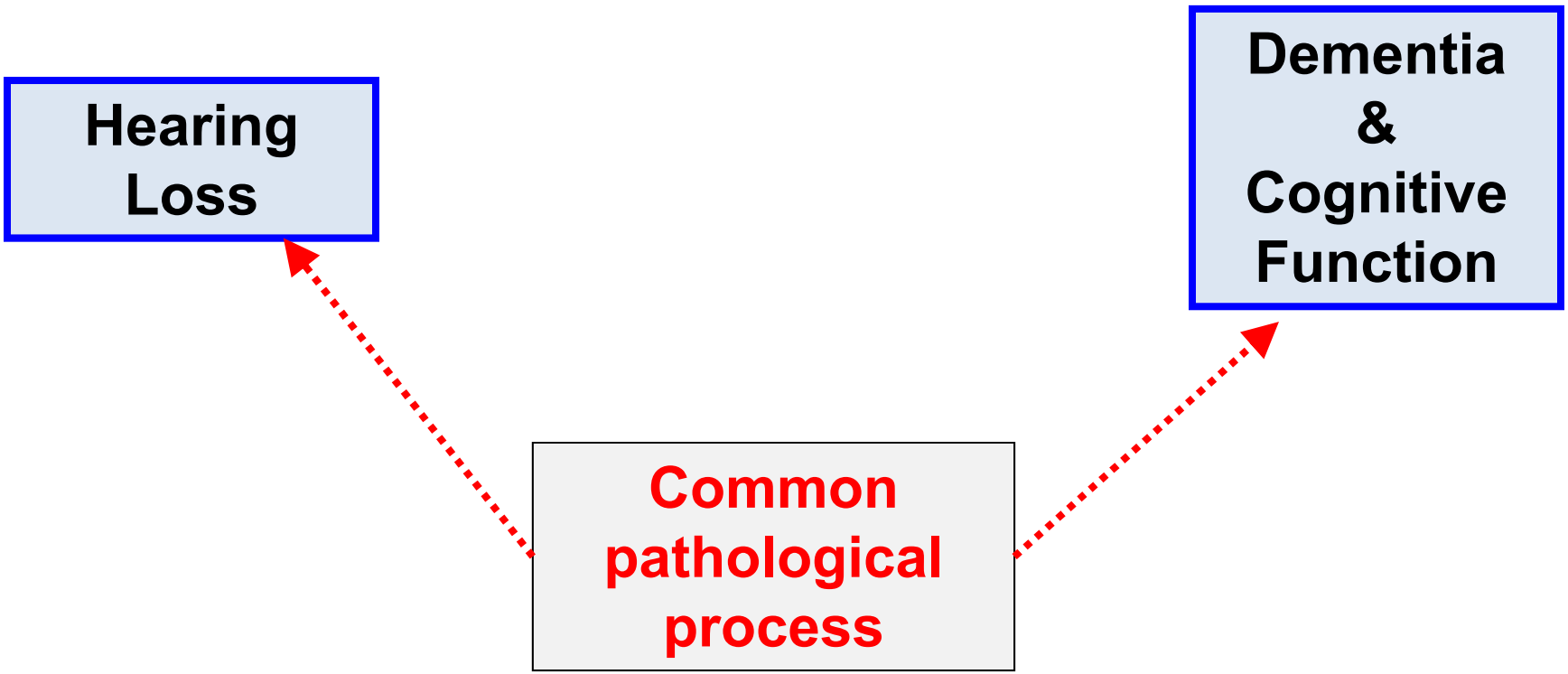
Hearing Loss & Cognition



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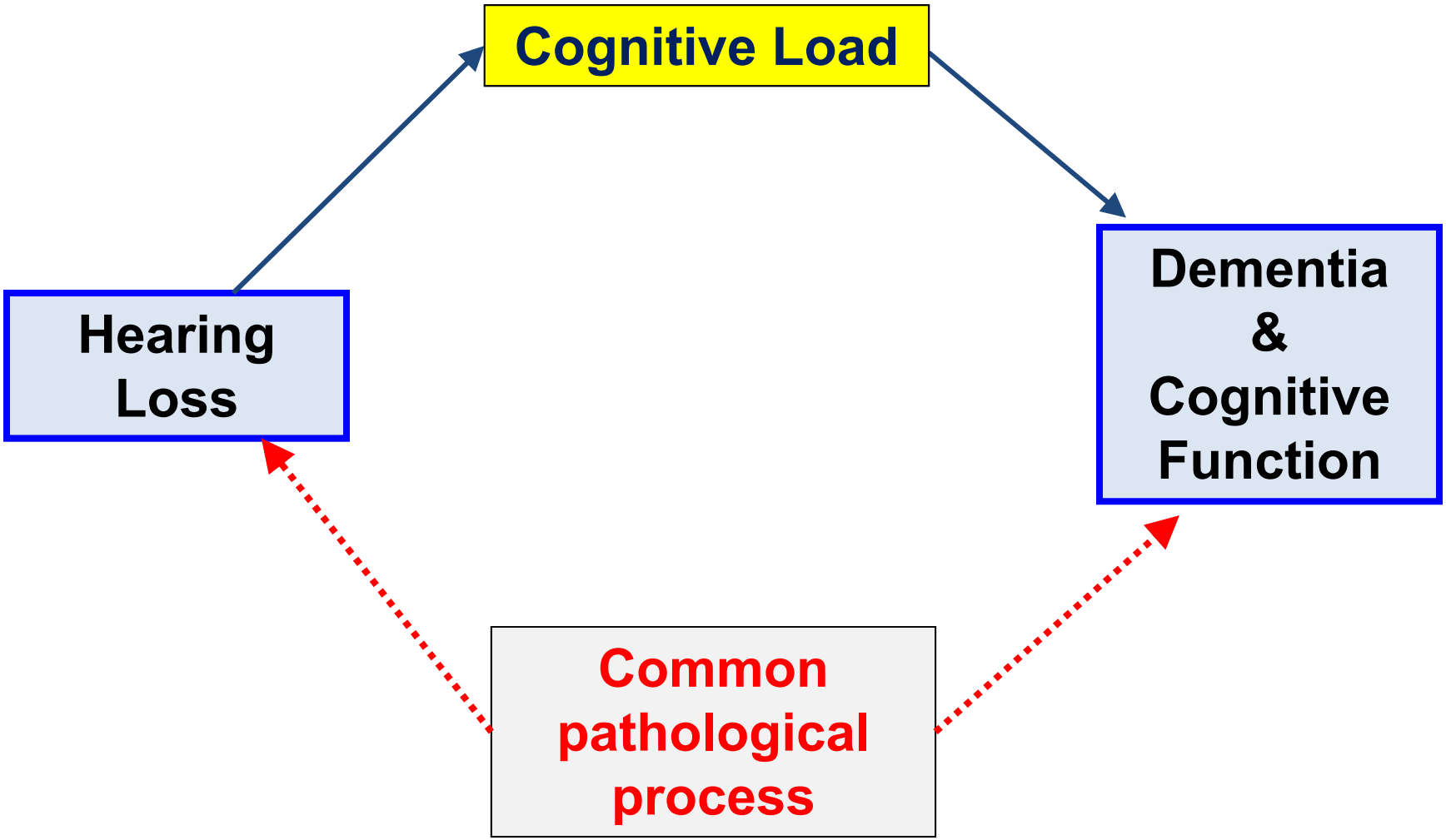
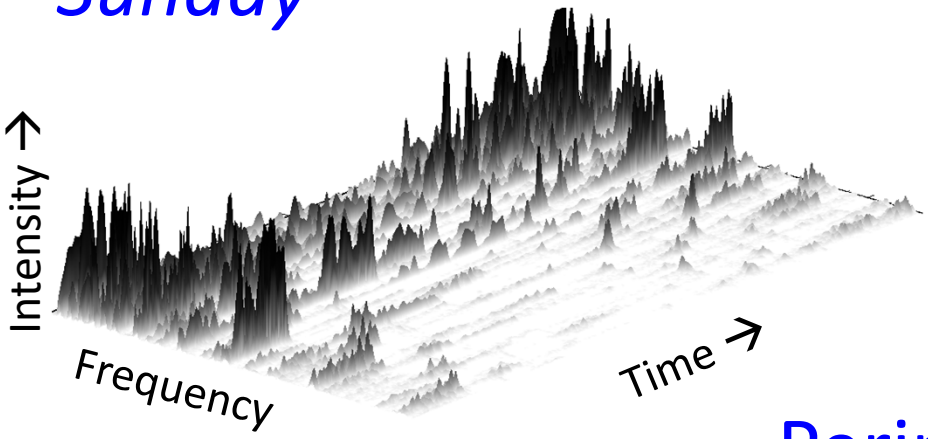
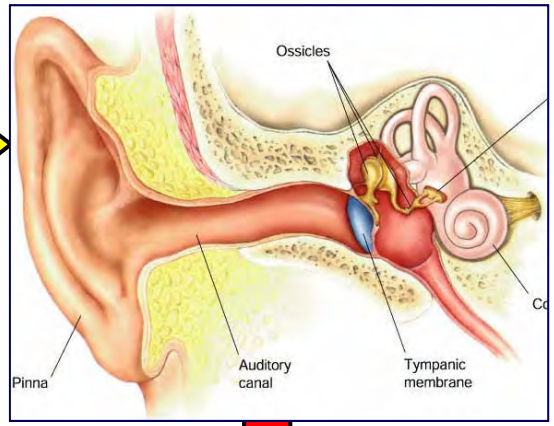


"Sunday"

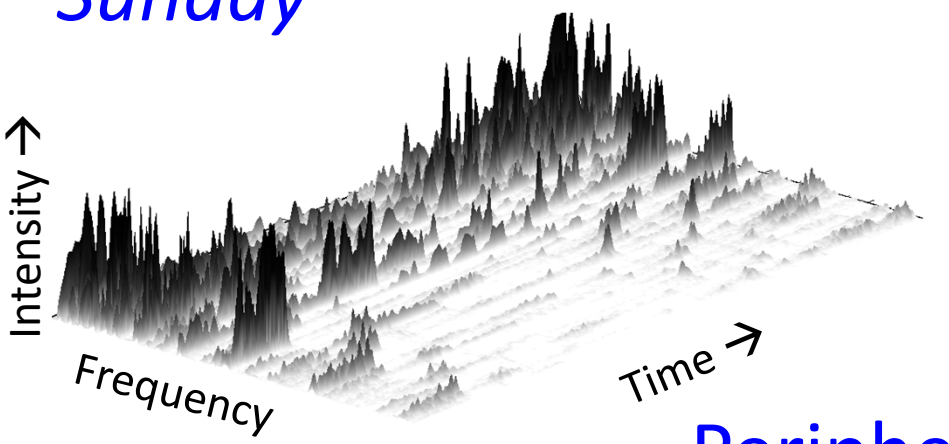


Peripheral transduction

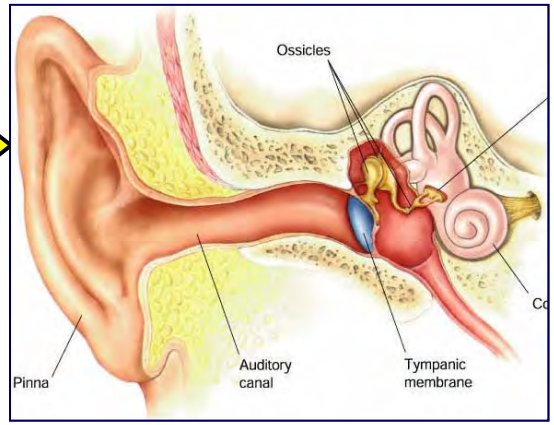


Central processing

"Sunday"



Peripheral transduction



Hearing Loss & Cochlear impairment

↓

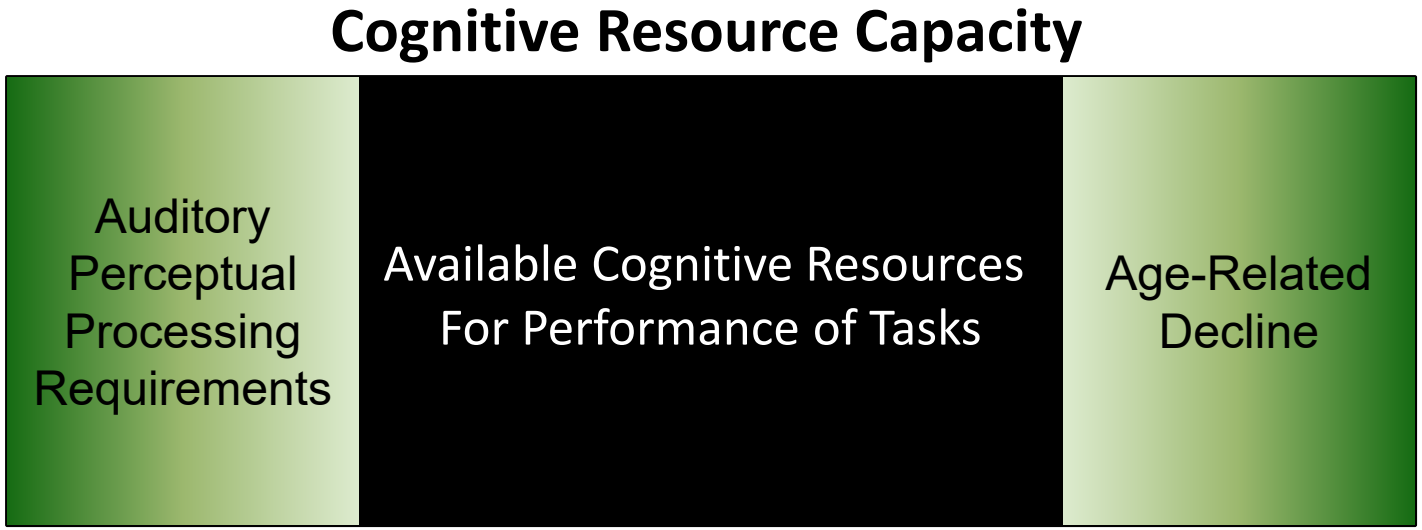
Decreased hearing sensitivity & poor frequency resolution

↓

"***Effortful listening***"

Hearing Loss & Cognitive Load

Kahneman model of shared attention and resource capacity (D. Kahneman, Attention & Effort,1973)



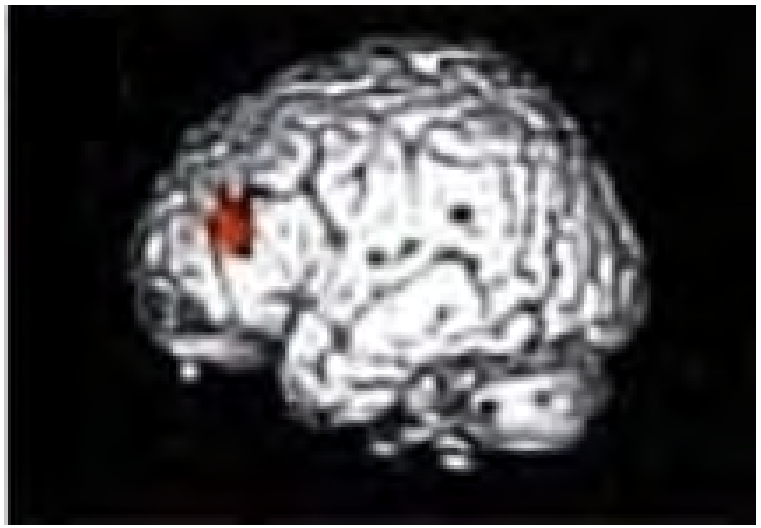
Hearing Loss & the Brain

Poorer hearing is associated with:

A. Reduced language-driven activity in primary auditory pathways

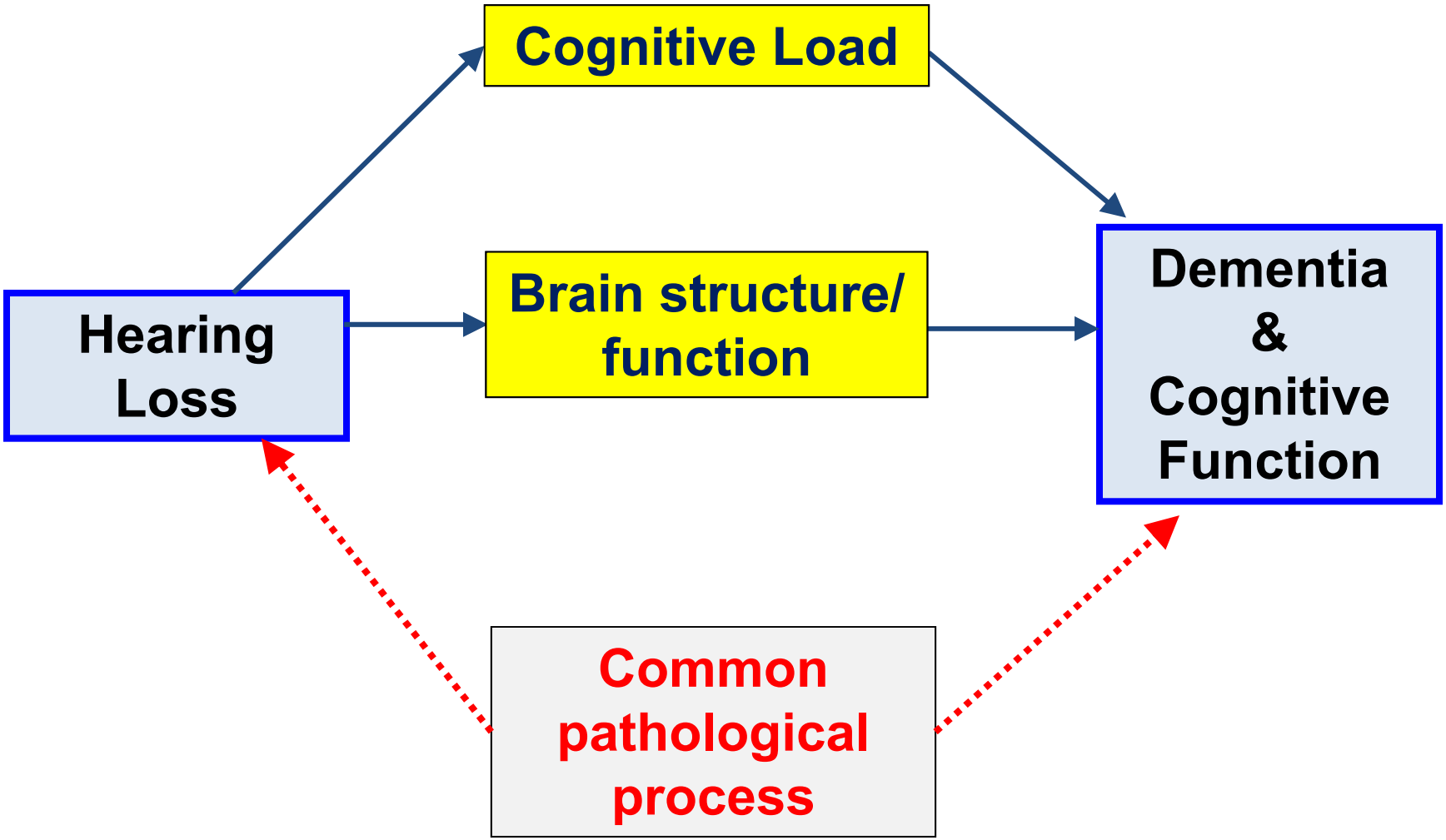
B. Increased compensatory language-driven activity in pre-frontal cortical areas

Peelle et al, J. Neurosci, 2011



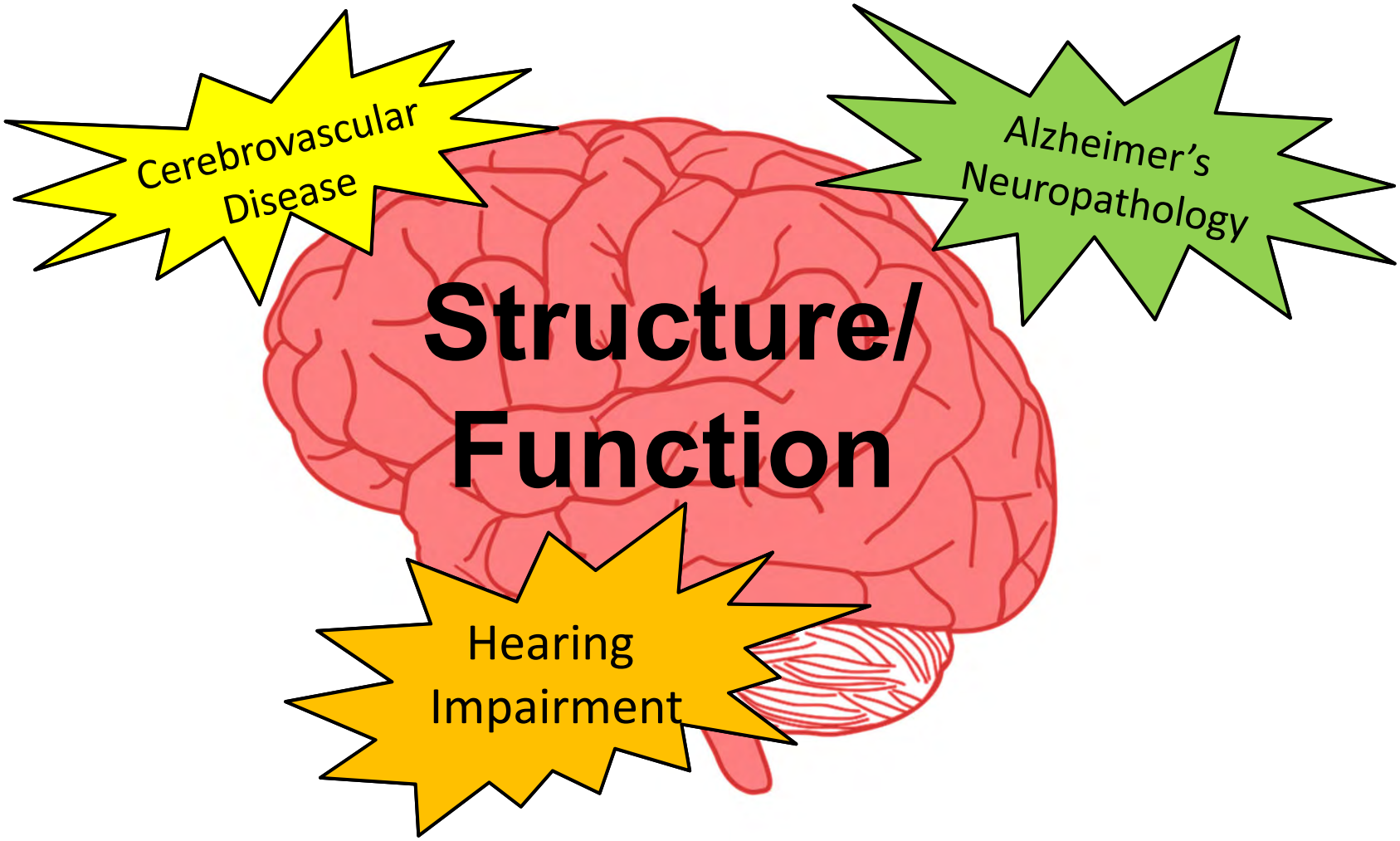
Grossman et al, Brain Lang, 2002

Hearing Loss & Cognition



Double Hit Theoretical Model

Hearing Loss & Brain Structure/Function



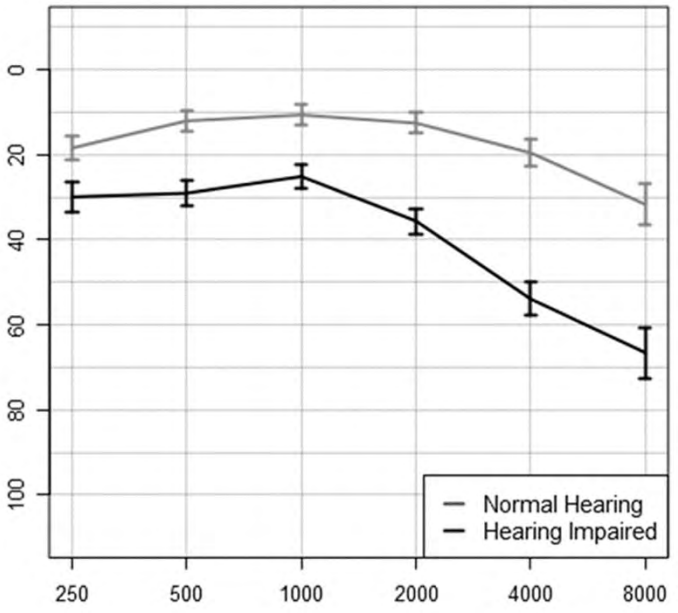
F. Lin & M. Albert, Aging & Mental Health, 2014

Hearing Loss & Incident Dementia

Dementia incidence in 1889 adults followed for 9 years in HealthABC

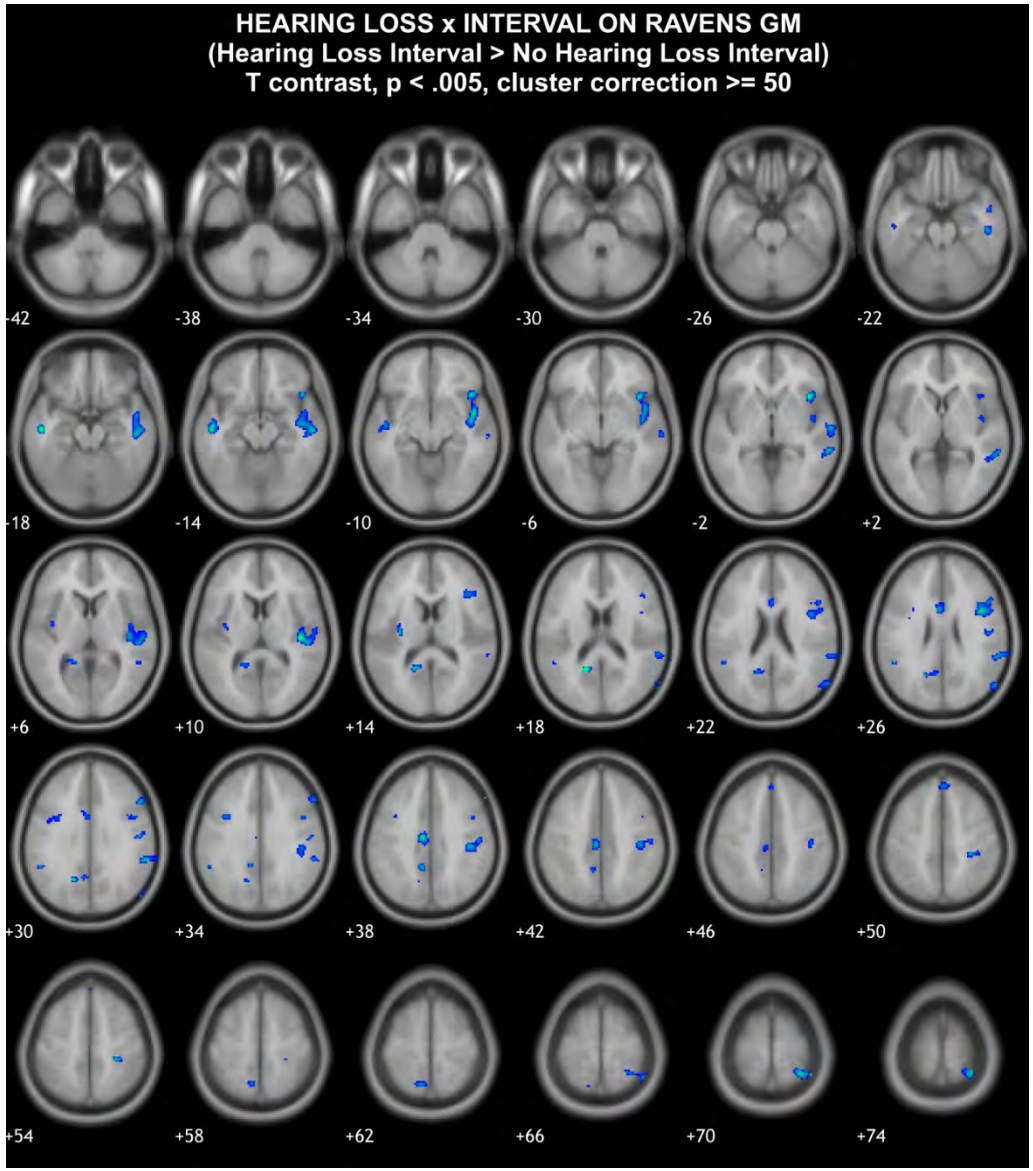
- **Hypothesis**: Hearing loss is associated with accelerated atrophy in the superior, middle, and inferior temporal gyri

- 126 participants (56-86 yrs) in the neuroimaging substudy of the BLSA
  - Mean follow-up duration of 6.4 years
  - 1.5T MRI performed annually



Lin et al. Neuroimage 2014

Hearing Loss & Accelerated Brain Volume Decline



Voxel-Based Analyses

Difference in mean gray matter volume change in those with HL vs. NH

Faster decline in brain volume in HL vs. NH

Lin et al. Neuroimage 2014

Estimated Annual Rates of Change in Brain Volume (cm^3/year), Baltimore Longitudinal Study on Aging (BLSA)

	Normal Hearing mean (SE)	Hearing Loss, mean (SE)	Difference mean (SE)
	N=75	N=51	
Global measures			
Whole brain	-7.21 (0.27)**	-8.33 (0.36)**	**-1.13 (0.45) + p = .015**
vCSF	1.30 (0.10)**	1.28 (0.14)**	-0.020 (0.18)
White matter	-4.14 (0.31)**	-4.99 (0.39)**	**-0.85 (0.39) + p = .031**
Gray matter	-2.63 (0.22)**	-3.38 (0.28)**	**-0.76 (0.36) + p = .036**
Lobar measures			
Gray matter			
Frontal	-0.96 (0.11)**	-1.11 (0.14)**	-0.16 (0.14)
Temporal	-0.46 (0.096)**	-0.71 (0.12)**	**-0.25 (0.12) + p = .036**
Parietal	-0.71 (0.051)**	-0.74 (0.066)**	-0.044 (0.081)
Occipital	-0.54 (0.057)**	-0.50 (0.073)**	0.047(0.071)
Regional Volumes			
Superior temporal gyrus	-0.20 (0.023)**	-0.31 (0.030)**	**-0.11 (0.038) * p = .0046**
Middle temporal gyrus	-0.15 (0.033)**	-0.30 (0.042)**	**-0.15 (0.054) * p = .0065**
Inferior temporal gyrus	-0.048 (0.015)*	-0.12 (0.020)**	**-0.067 (0.025) * p = .0093**
Hippocampus	-0.019 (0.0051)**	-0.031 (0.0065)**	-0.012 (0.0062)

+ < .05; * < .01; ** <.001

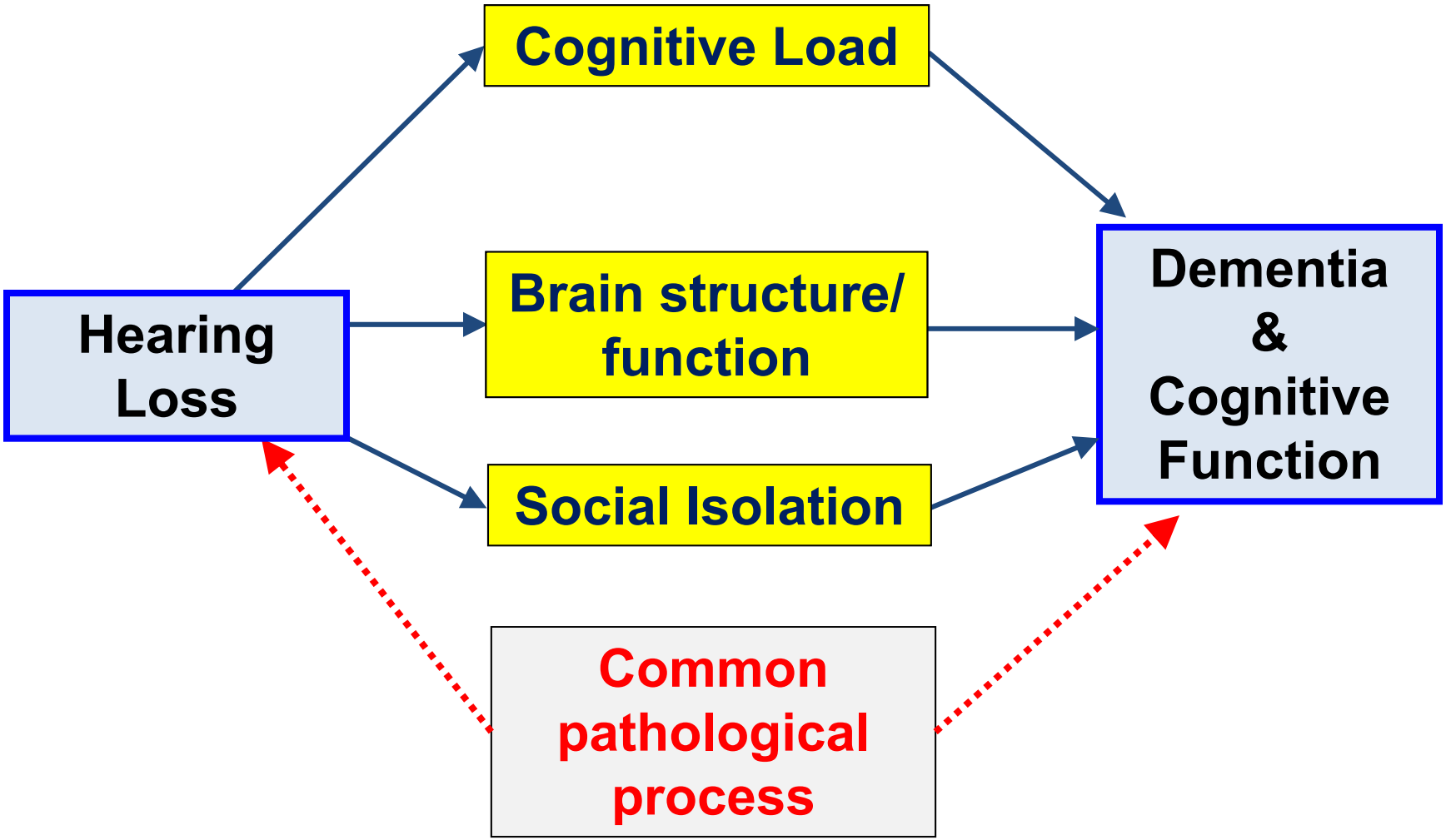
N=126 participants
aged 56-86 years
Annual MRI for up to 10 yrs
Mean follow-up = 6.4 years

Sound & speech

But also memory,
sensory integration

Lin et al., Neuroimage 2013

Hearing Loss & Cognition

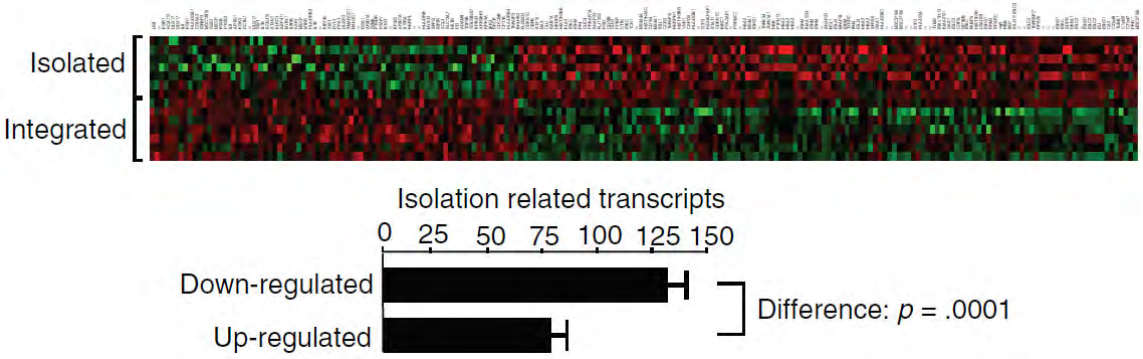


Social Isolation → Cognitive & Physical Functioning

Health Behavioral Pathways
- Smoking
- Adherence to medical tx
- Diet
- Exercise

Psychological Pathways
- Self-esteem
- Self-efficacy
- Coping
- Sense of well-being

Physiologic Pathways
- HPA axis response
- Immune system fxn
- Cardiovascular reactivity



Social isolation is associated with upregulation of pro-inflammatory genes & increased inflammation

Cole & Cacioppo, Genome Biology, 2007
Cole & Cacioppo, PNAS, 2011

Hearing Loss & Healthy Aging

Cross-sectional Datasets for Epidemiologic Analyses

- **NHANES**: *National Health and Nutritional Examination Survey*
  - Cross-sectional, representative sample of U.S. population

Hearing Loss & Healthy Aging

Longitudinal Datasets for Epidemiologic Analyses

- **ARIC**: *Atherosclerosis Risk in Communities*
  - Prospective, population-based study of 15,792 men and women from 4 US communities aged 45-64 years at baseline (1987-89)
- **BLSA**: *Baltimore Longitudinal Study on Aging*
  - Ongoing prospective study of older adults since 1958
- **Health ABC**: *Health, Aging, & Body Composition*
  - Prospective, population-based study of ~3000 adults 70 years and older

Cognitive Assessment

- Global cognitive function
  - Mini-Mental State Exam (Folstein 1975)
- Cognitive domains
  - Address different cognitive abilities
  - e.g.,
    - Memory
    - Executive Function
      - Cognitive abilities that control & regulate other abilities & behaviors
      - Goal-directed behavior, planning, initiating, inhibiting

Cognitive Assessment

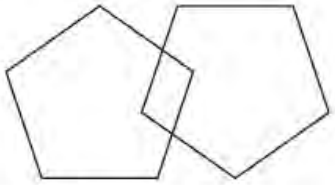
- Why study cognitive domains?
  - Hierarchy of decline across domains
    - Speed 30's
    - Vocabulary intact into 70's
  - Domain-specific decline associated with:
    - Transition to dementia
    - Disability
    - Mortality

Global Function: The Mini-Mental State Exam

The Mini-Mental State Exam

Patient_____ Examiner _____ Date_____

Maximum	Score	
		Orientation
5	( )	What is the (year) (season) (date) (day) (month)?
5	( )	Where are we (state) (country) (town) (hospital) (floor)?
		Registration
3	( )	Name 3 objects: 1 second to say each. Then ask the patient all 3 after you have said them. Give 1 point for each correct answer. Then repeat them until he/she learns all 3. Count trials and record. Trials _____
		Attention and Calculation
5	( )	Serial 7's. 1 point for each correct answer. Stop after 5 answers. Alternatively spell "world" backward.
		Recall
3	( )	Ask for the 3 objects repeated above. Give 1 point for each correct answer.
		Language
2	( )	Name a pencil and watch.
1	( )	Repeat the following "No ifs, ands, or buts"
3	( )	Follow a 3-stage command: "Take a paper in your hand, fold it in half, and put it on the floor."
1	( )	Read and obey the following: CLOSE YOUR EYES
1	( )	Write a sentence.
1	( )	Copy the design shown.

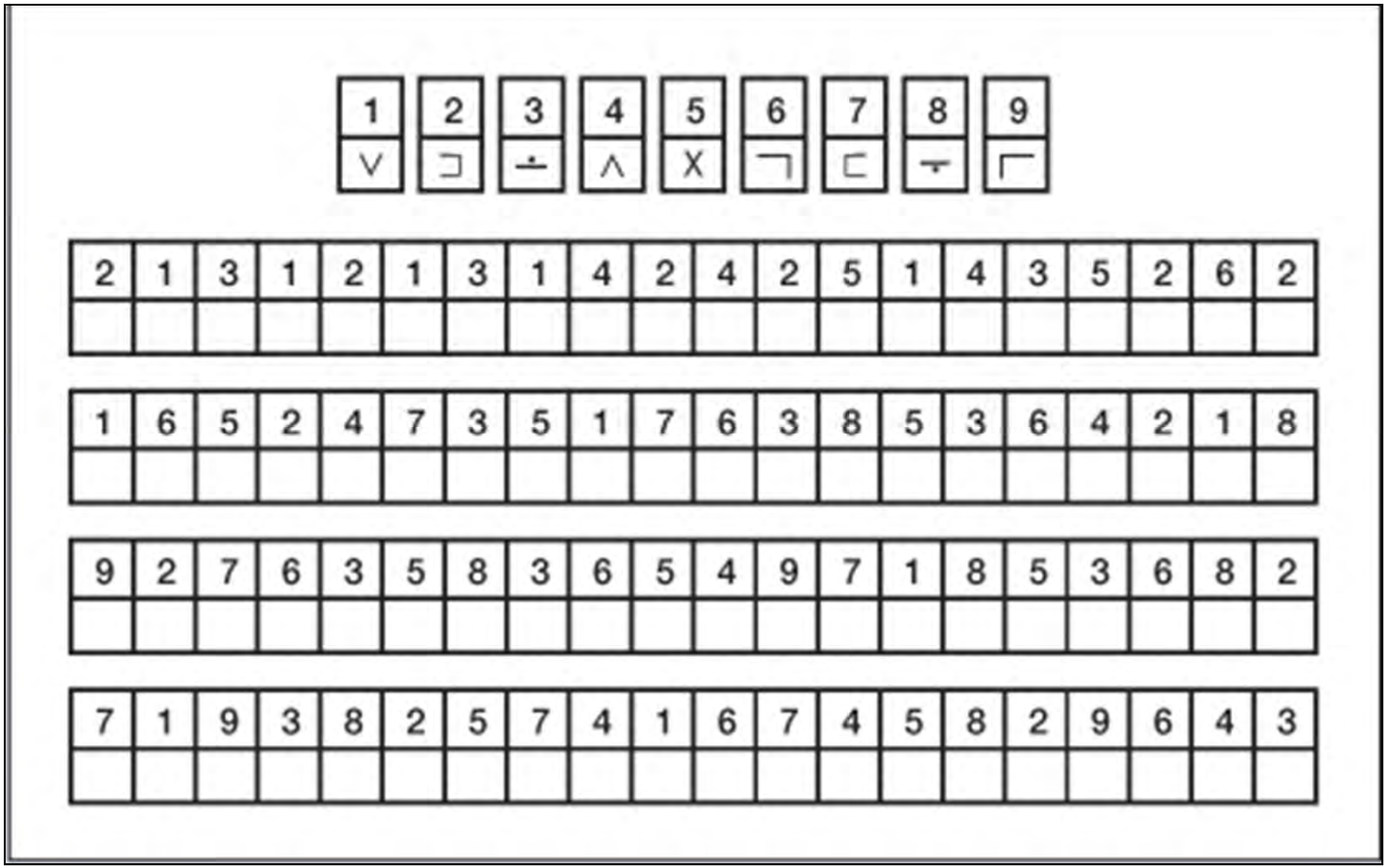


_____ Total Score

ASSESS level of consciousness along a continuum _____

Alert Drowsy Stupor Coma

Executive Function:
Digit Symbol Substitution Test (DSST)



Executive Function: Stroop Mixed

Look at the list below and say the COLOR not the word.

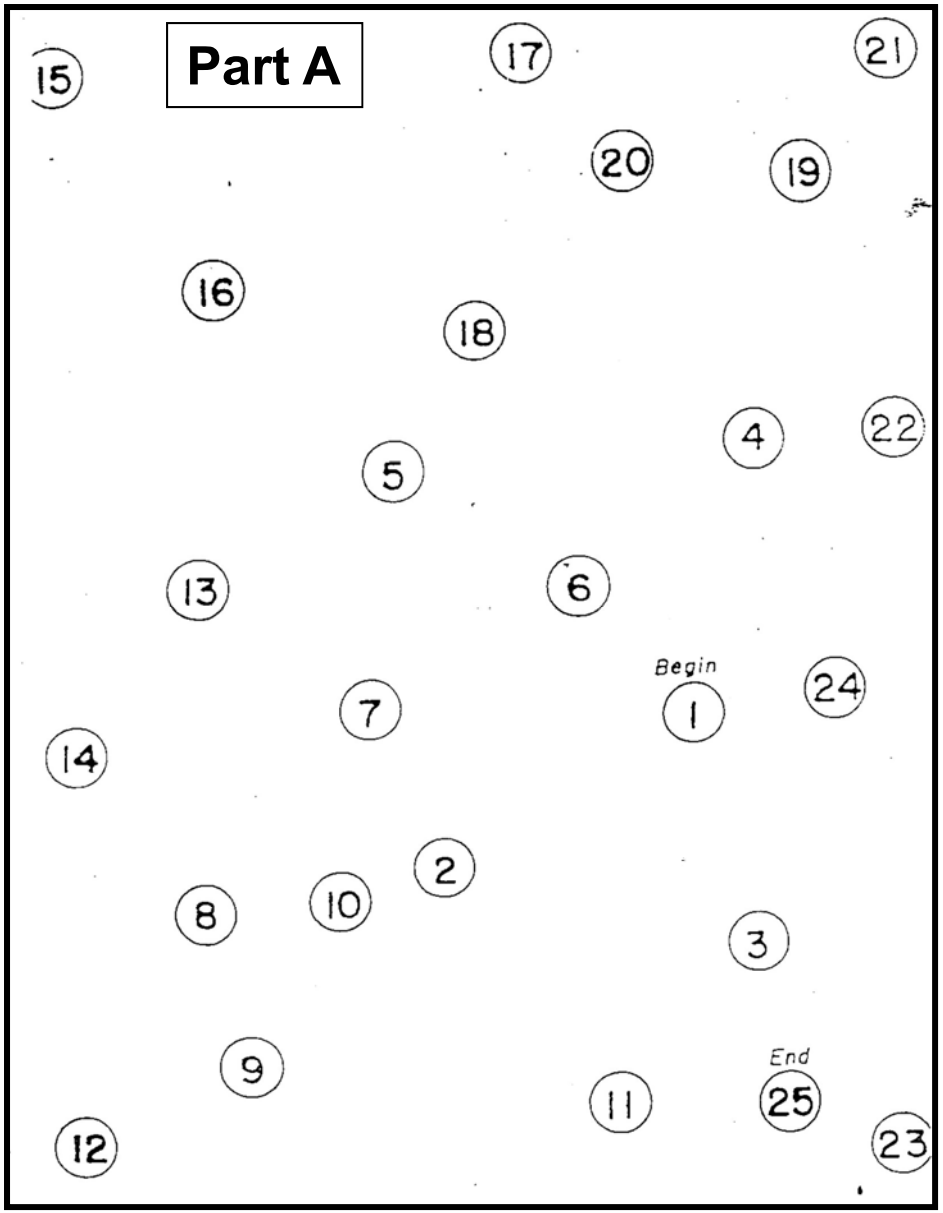
YELLOW	BLUE	ORANGE
BLACK	RED	GREEN
PURPLE	YELLOW	RED
ORANGE	GREEN	BLACK
BLUE	RED	PURPLE
GREEN	BLUE	ORANGE

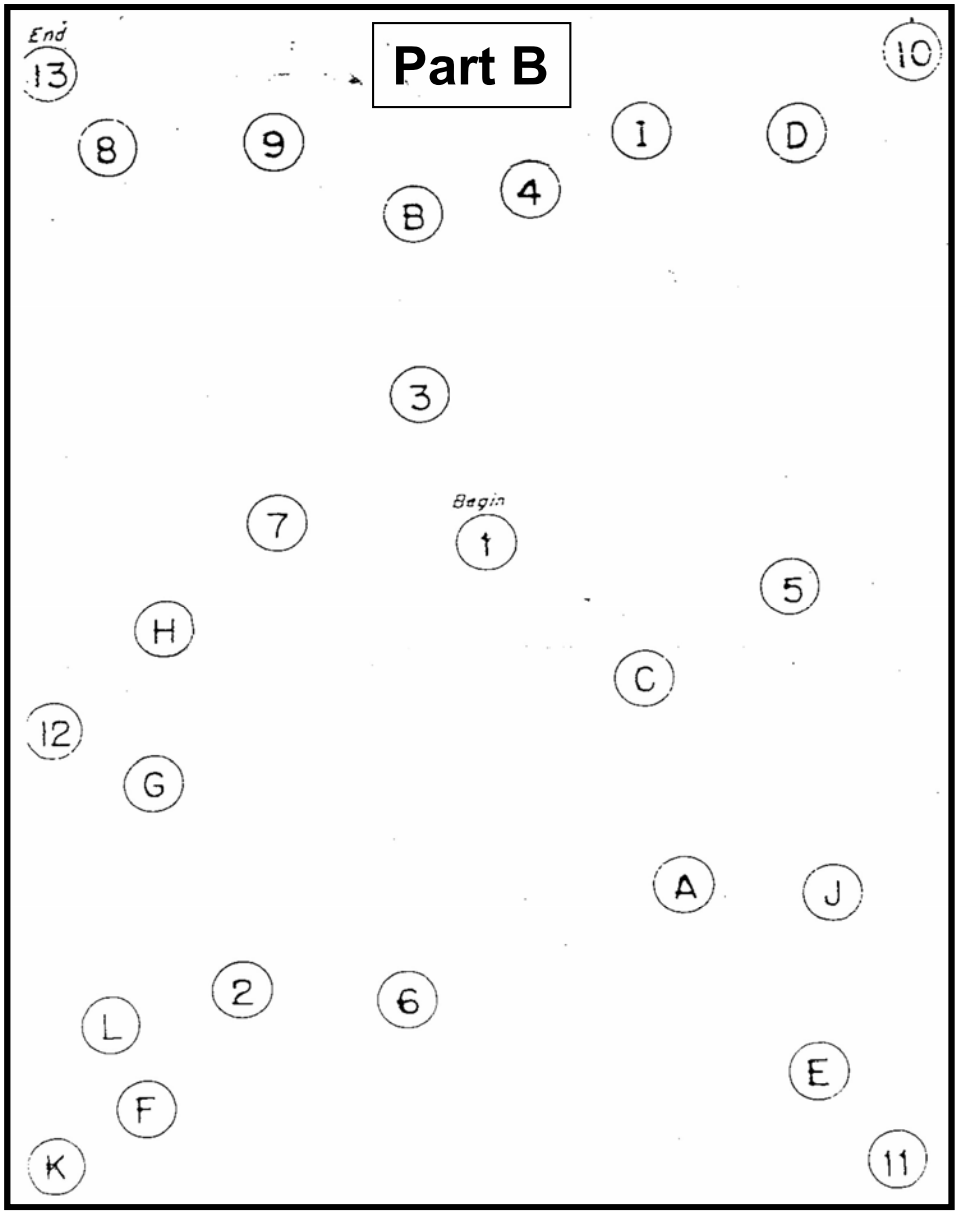
Left – Right Conflict

Your right brain tries to say the color but
Your left brain insists on reading the word.

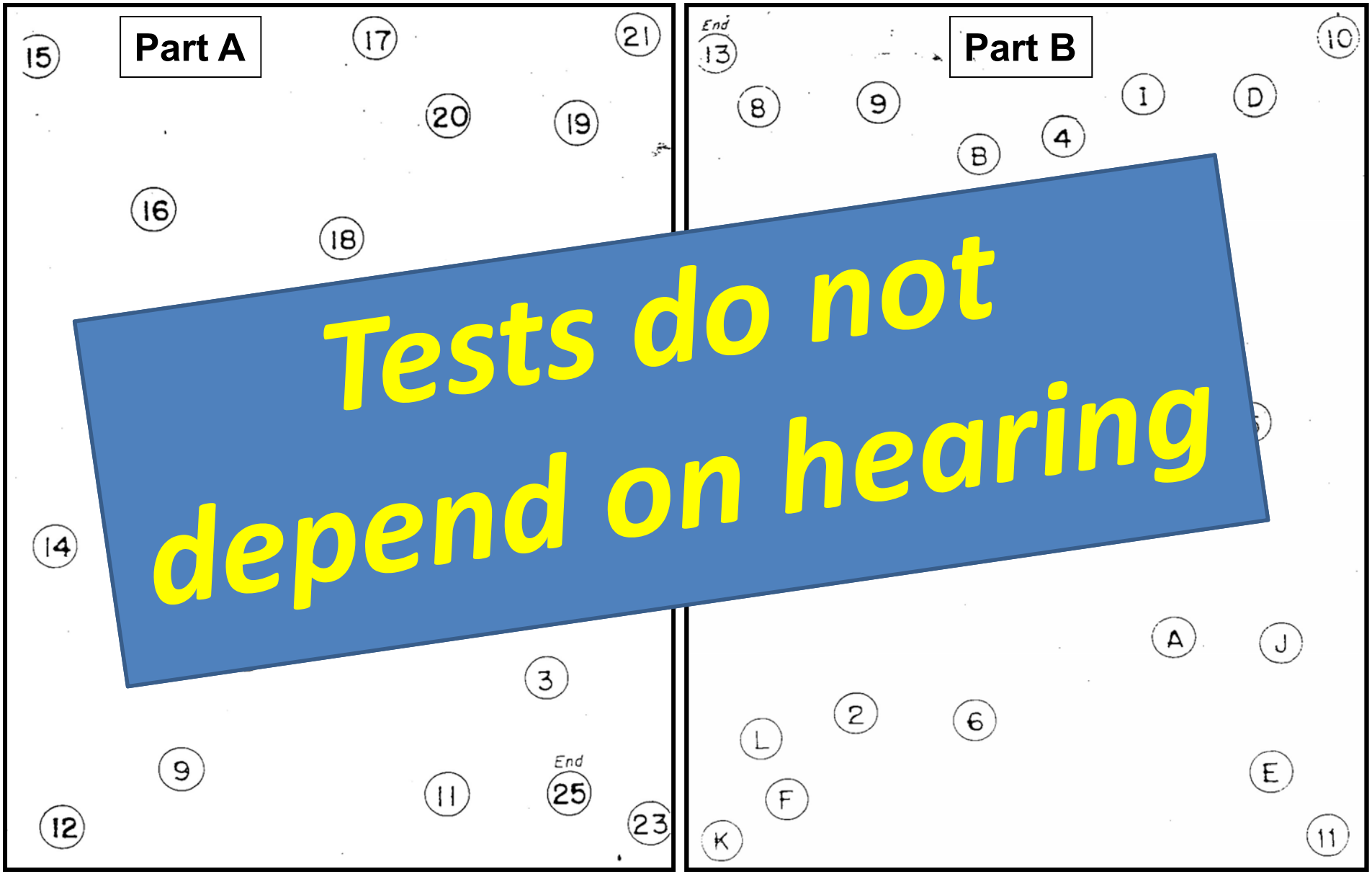
http://cdn.lifeinthefastlane.com/wp-content/uploads/2015/06/stroop-effect.jpg

Executive Function: Trail Making Tests





Executive Function: Trail Making Tests



Hearing Loss and Cognition

Cross-Sectional Studies

NHANES

N = 605 adults 60-69 years

Lin, J. Geront. Med. Sci., 2011

	Age (per year) β[a] (95% CI)	*P*	Hearing loss (per 25 dB) β[b] (95% CI)	*P*	Δ Age (years) equivalent to 25 dB of hearing loss
Digit Symbol Substitution Test	-0.55 (-0.92 – -0.18)	<.01	-3.86 (-7.15 – -0.56)	.02	7.0

BLSA

N = 347 adults >60 years

Lin et al., Neuropsych., 2011

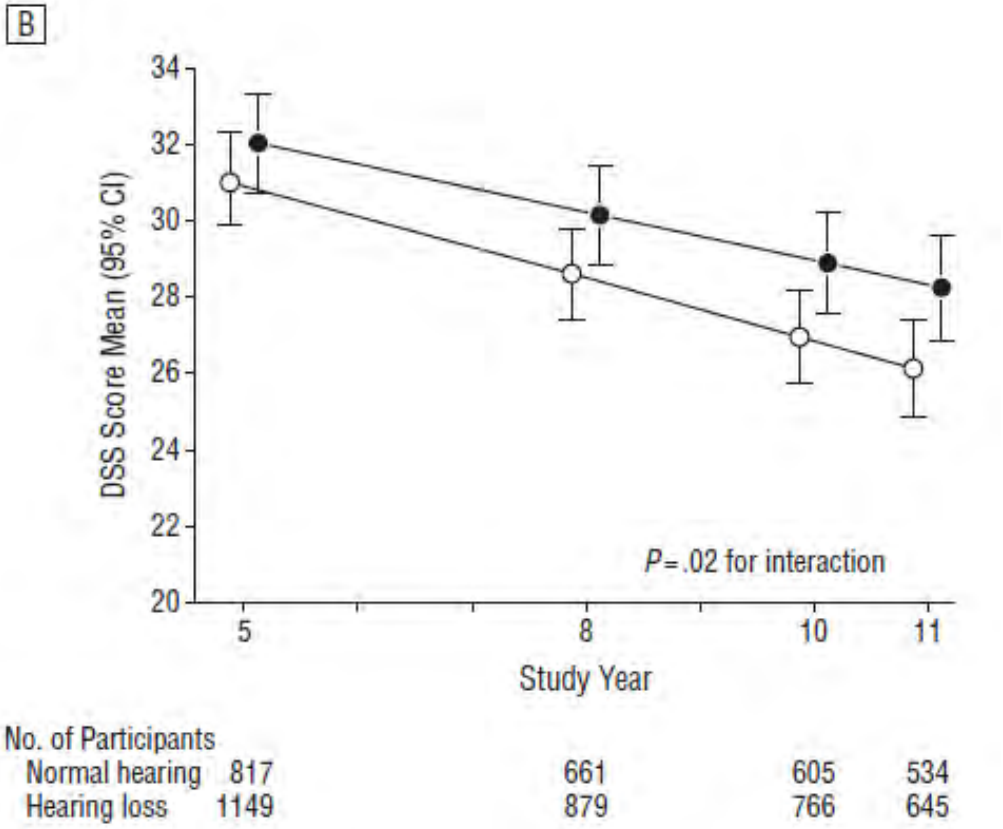
Stroop Mixed	-0.33 (-0.48 – -0.18)	<.001	-2.27 (-4.14 – -0.40)	.02	6.8
Trail Making B	-0.00011 (-0.00018 – -0.000044)	.001	-.00074 ($-0.0015 – 2.74 \times 10^{-6}$)	.05	6.7

Models adjusted for age, sex, race, education, diabetes, smoking, hypertension

Hearing Loss & Cognitive Decline

HealthABC

Adjusted DSS scores by years of follow-up and hearing loss status in 1,966 adults > 70 years followed for 6 years

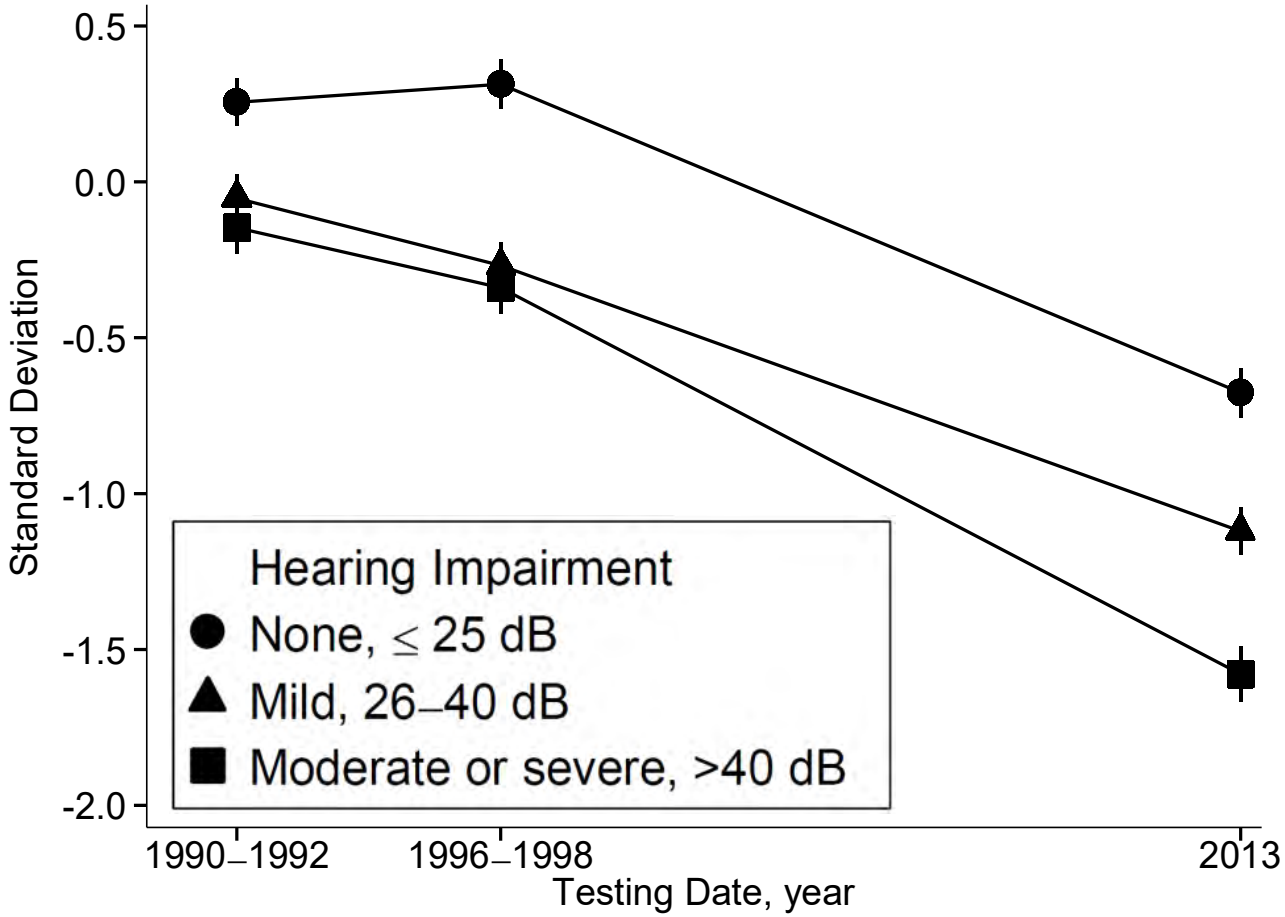


32% faster rate of cognitive decline in DSS scores in hearing loss vs. normal hearing

Adjusted for age, sex, race, education, study site, smoking status, hypertension, diabetes, and stroke history

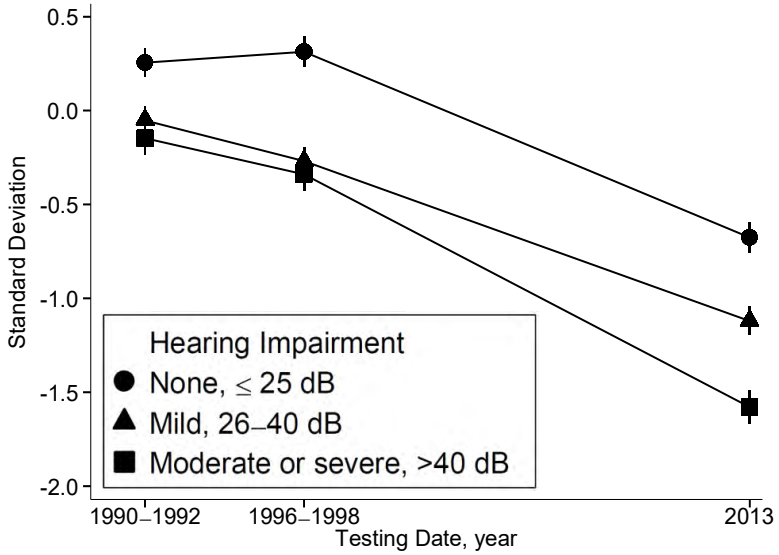
Lin et al. JAMA Int Med. 2013

Hearing Loss & Memory Decline
ARIC, 1990-2013



* Adjusted for age, age^2, sex, education, smoking status, diabetes, hypertension, and Wide Range Achievement Test (WRAT)

Change in MEMORY,* 1990-2013

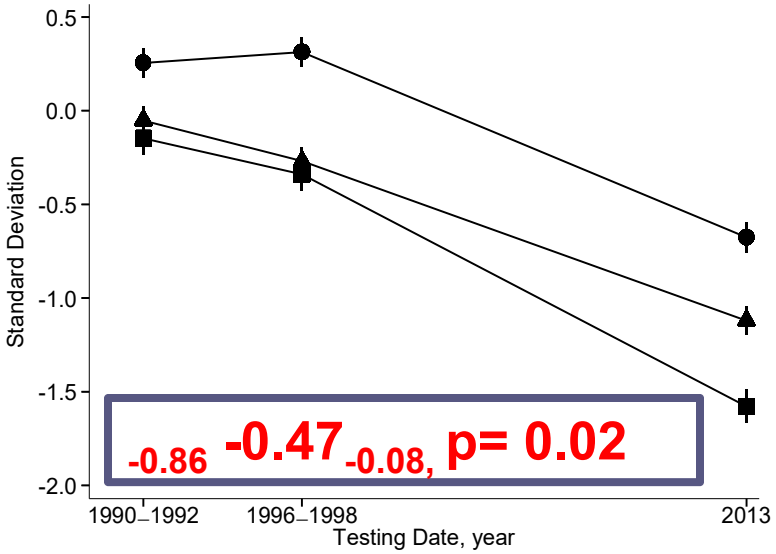


* Adjusted for age, age^2, sex, education, smoking status, diabetes, hypertension, and Wide Range Achievement Test (WRAT)

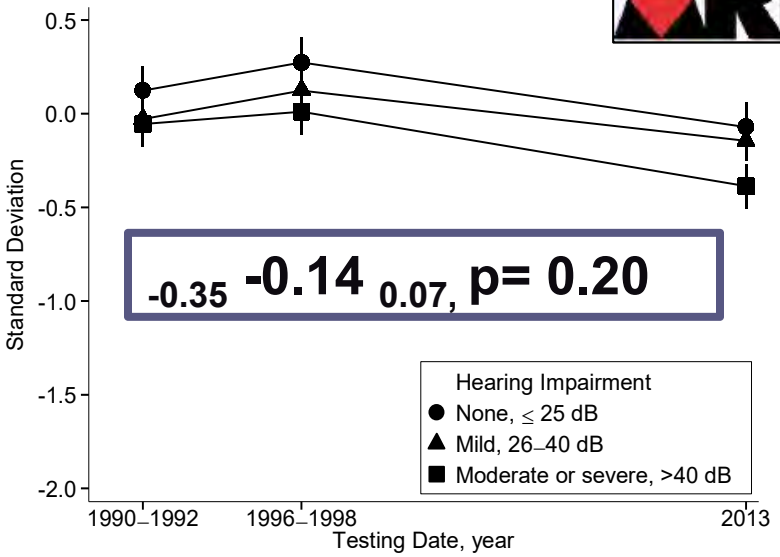
Rates of 20-Year Change* in MEMORY, ARIC

Hearing status:	Estimate 95% CI	P-value
Moderate/severe	-1.66 -1.35 -1.05	<0.0001
Mild	-1.24 -1.02 -0.80	<0.0001
None	-1.13 -0.88 -0.64	<0.0001
Difference Comparing:		
Mild to None	-0.47 -0.14 0.20	0.411
Moderate/severe to None	**-0.86 -0.47 -0.08**	**0.018**

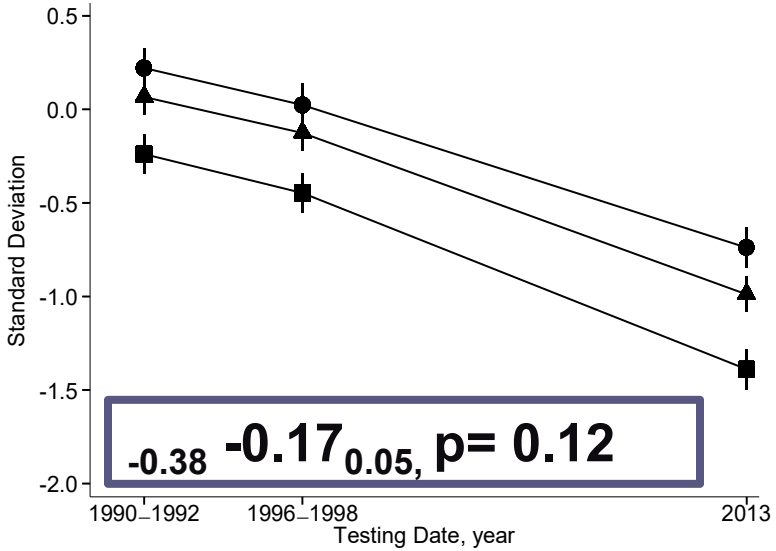
MEMORY



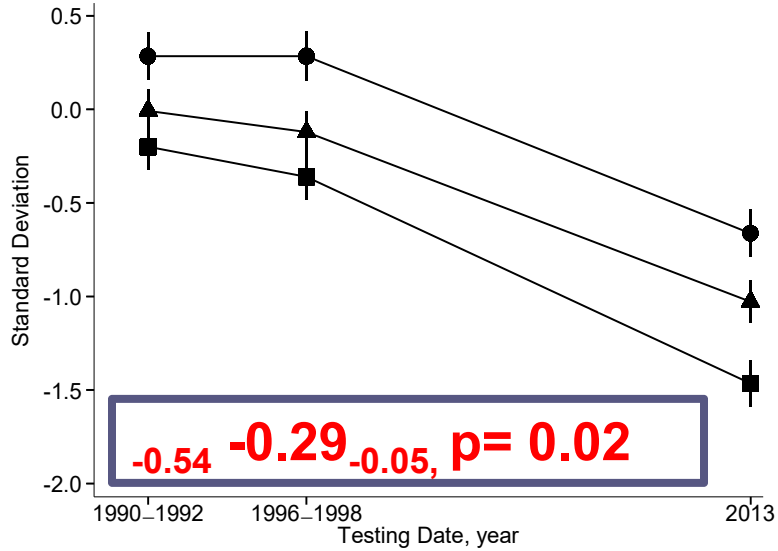
LANGUAGE



SPEED & ATTENTION

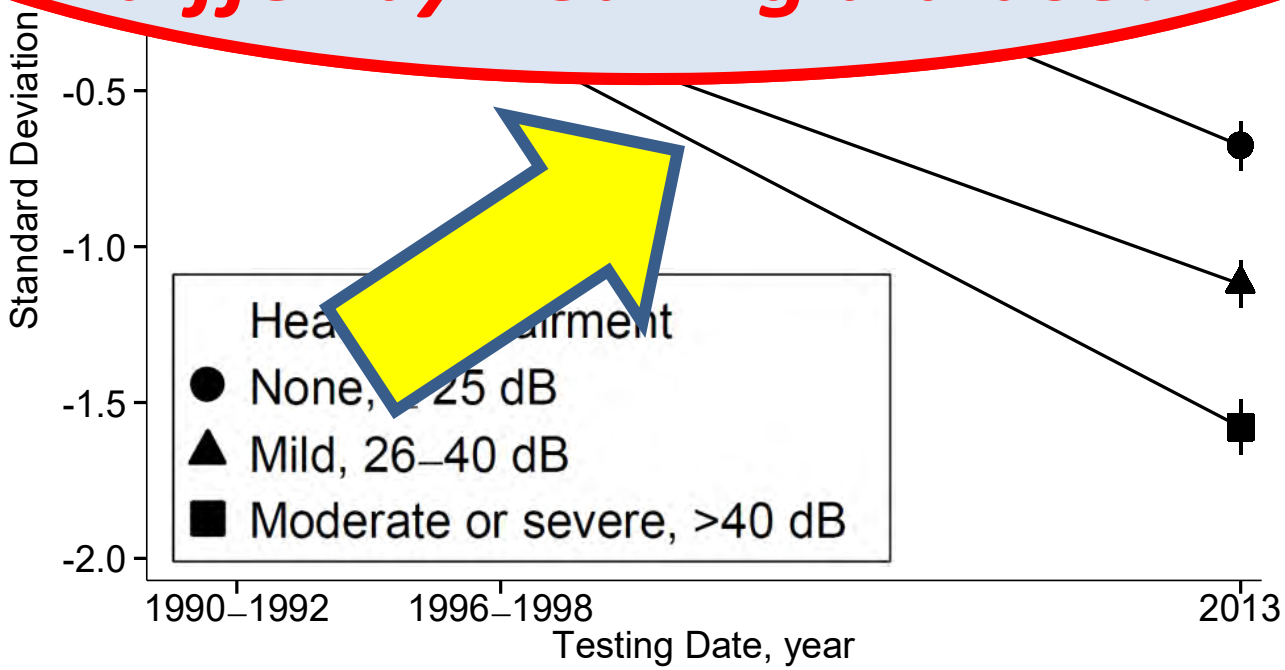


GLOBAL FUNCTION



Hearing [illegible] Decline

Among participants with hearing loss, do rates of cognitive decline differ by hearing aid use?



* Adjusted for age, age^2, sex, education, smoking status, diabetes, hypertension, and Wide Range Achievement Test (WRAT)

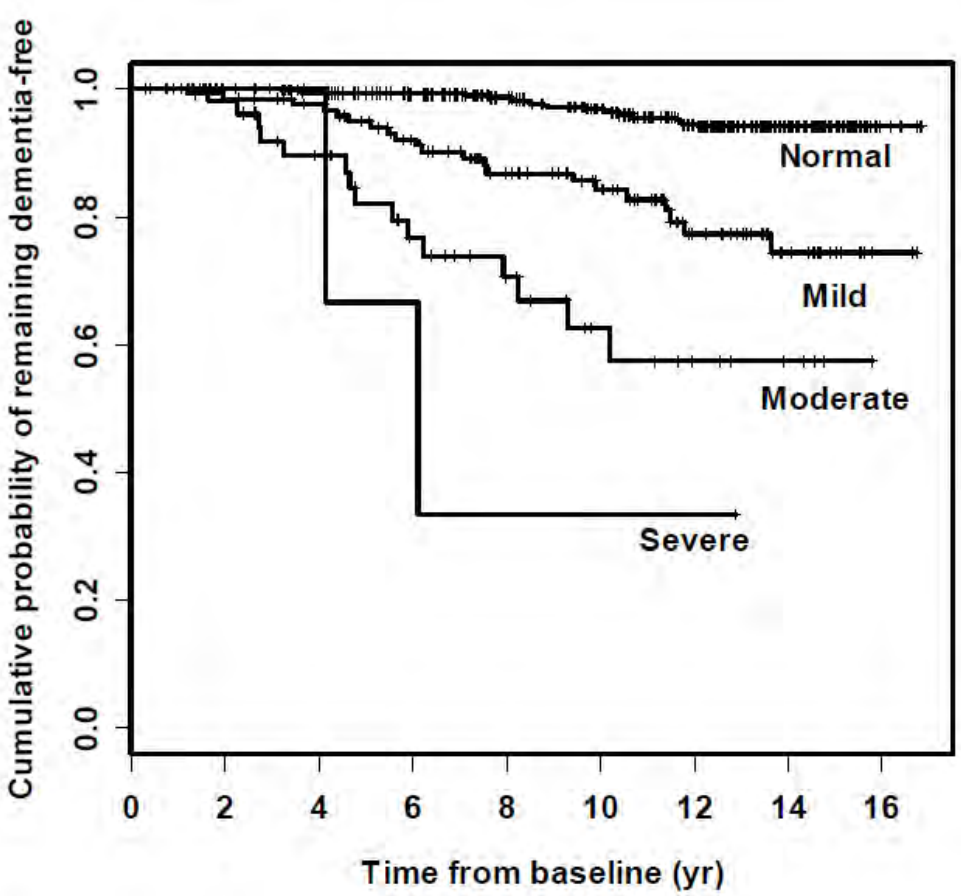
Rates of Cognitive Change (1990-2013) by Hearing Aid Use* (2013), N=85

MEMORY	Estimate 95% CI	P-value
No hearing aid, N=42	-2.28 -1.84 -1.39	<0.0001
Hearing aid, N=43	-1.25 -0.89 -0.52	<0.0001
Difference	**-1.53 -0.95 -0.38**	**0.001**
GLOBAL COMPOSITE		
No hearing aid, N=42	-1.70 -1.45 -1.20	<0.0001
Hearing aid, N=43	-1.21 -0.97 -0.74	<0.0001
Difference	**-0.83 -0.48 -0.14**	**0.006**

*Among participants with moderate/severe hearing loss

Hearing Loss & Incident Dementia

Dementia incidence in 639 adults followed for >10 years in the BLSA



Risk of incident all-cause dementia (compared to normal hearing)[a]

	HR	95% CI	p
Mild	1.89	1.00 – 3.58	.05
Moderate	3.00	1.43 – 6.30	.004
Severe	4.94	1.09 – 22.4	.04

[a] Adjusted for age, sex, race, education, DM, smoking, & hypertension

Lin et al., Arch Neuro., 2011

Question to be Answered

- If we treat hearing impairment, do we delay or prevent functional decline in older adults?

ACHIEVE Randomized Trial

- **Aging, Cognition, and Hearing Evaluation in Elders**

- ACHIEVE-Feasibility
  - 20 participants
  - Hearing intervention

- ACHIEVE-Pilot
  - 40 participants
  - Randomized: Hearing vs. Successful Aging
  - 6-mo follow-up

(Washington County, MD)

Hearing Intervention

Theresa Chisolm, PhD

Michelle Arnold
AuD, PhD, CCC-A

Victoria Sanchez
AuD, PhD, CCC-A

- Courtney Matthews

- Goal: eliminate or minimize activity limitations & participation restrictions from HL
- Individual needs assessment & goal-setting, development of self-management abilities
- 4 sessions (~1 hr each, over 2-3 mos)
- Hearing aids & other technologies

Successful Aging Intervention

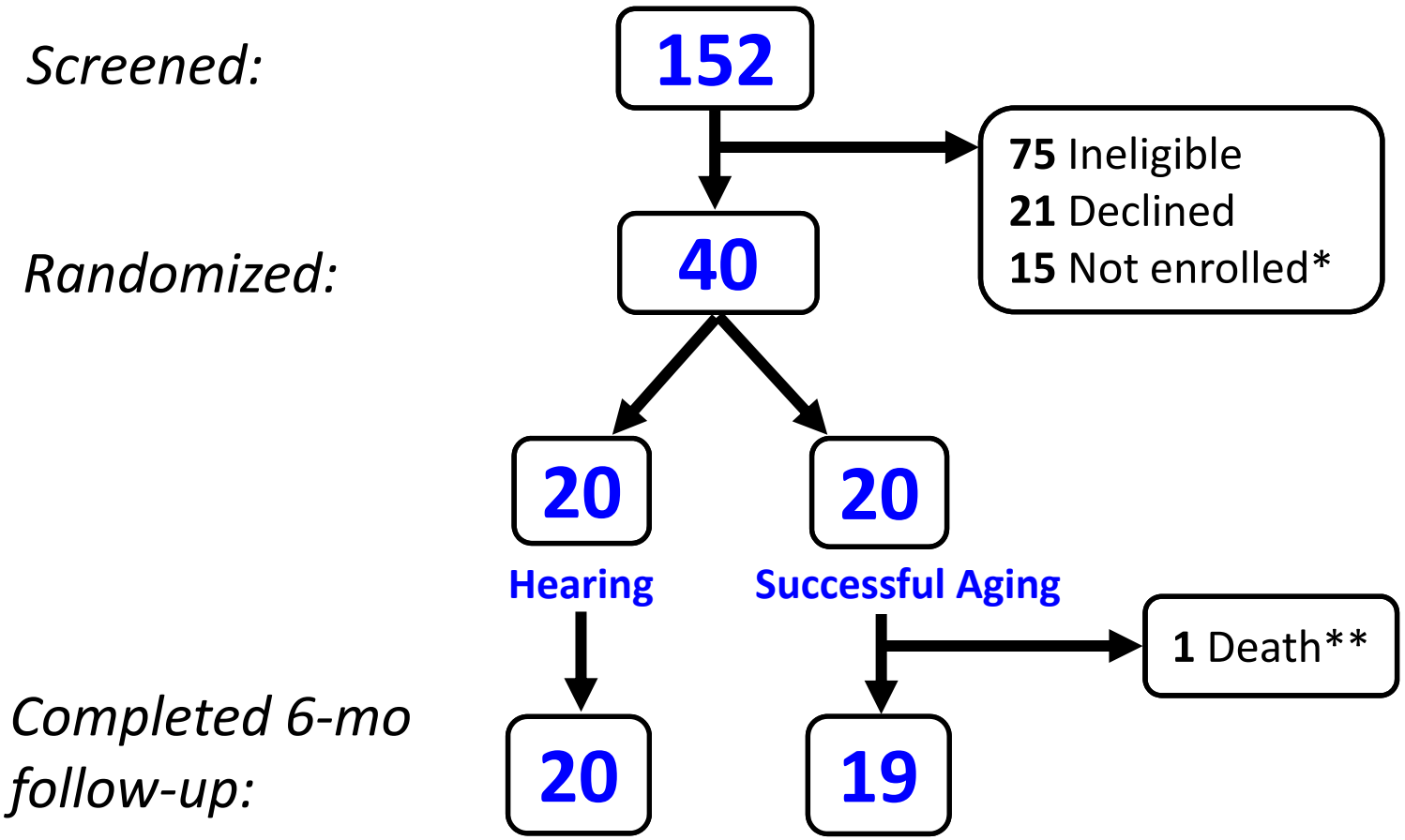
Nancy W Glynn, PhD

- Elizabeth Rogers

- Based on the 10 Keys™ to Healthy Aging program (Center for Aging and Population Health Prevention Research Center)
- 4 sessions (~1 hr each, over 2-3 mos)
- Aging Successfully With Pain RCT

ACHIEVE-P

Eligibility, Randomization and Follow-up



* Eligible but not enrolled because recruitment targets had been reached

** Unrelated to study intervention

ACHIEVE-P

6-Month Change in Standardized Proximal Outcomes, N=40

Outcome	Hearing Intervention Mean (SD), N=20	Successful Aging Intervention Mean (SD), N=20
Perceived handicap due to HI*†	**-1.40 (0.96)**	**0.02 (0.68)**
Loneliness*	-0.19 (0.87)	0.22 (0.94)
Social Network**		
Number of people‡	**0.17 (0.65)**	**-0.42 (0.66)**
Diversity	0.15 (1.25)	-0.12 (0.70)
Social Function**	0.00 (0.65)	-0.26 (0.91)
Mental Function**	0.26 (0.80)	-0.14 (0.60)
Physical Function**	0.11 (0.76)	-0.07 (0.40)

* Lower scores are better; **Higher scores are better

†$p<0.0001$; ‡$p<0.01$

ACHIEVE-P

6-Month Change in Standardized Cognitive Domain Score, N=40

Cognitive Domain	Hearing Intervention	Successful Aging Intervention
	Mean (SD), n=20	Mean (SD), n=20
Memory	0.48 (0.69)	0.19 (0.66)
Language	0.05 (0.38)	0.00 (0.42)
Executive Function	0.03 (0.42)	0.17 (0.47)
Global Function	0.16 (0.42)	0.14 (0.39)

Full ACHIEVE Randomized Trial

- 750 participants: 70-84 year-old cognitively-normal older adults with hearing loss 

- 1:1 randomization hearing vs. successful aging
- Follow-up at 6 mos & then annually for 3 years
- Primary outcome: change in global function
  - Powered to detect a minimum of a 0.30 SD difference
- Proximal outcomes: speech/audibility understanding, hearing aid use
- Secondary outcomes: domain-specific cognitive function, social fxn, physical fxn, physical activity

Access HEARS: Hearing care Equality through Accessible Research & Solutions

HEARS Intervention

1) Hearing Loss Screening
2) Device Orientation:
 - Self-fit amplification device
 - Individual programming
3) Counseling:
 - Expectation management
 - Communication Strategies

Carrie Nieman

Pilot Studies in Multiple Populations

Carrie Nieman

Sara Mamo

Older Adults in Assisted Living Facilities or with Cognitive Impairment

Janet Choi

Korean-American Older Adults – Korean Martyrs Catholic Church

Licensing & Dissemination

Non-profits
Local government

2016-2019

Pilot Studies

Multiple Communities

2014-2016

Intervention Development

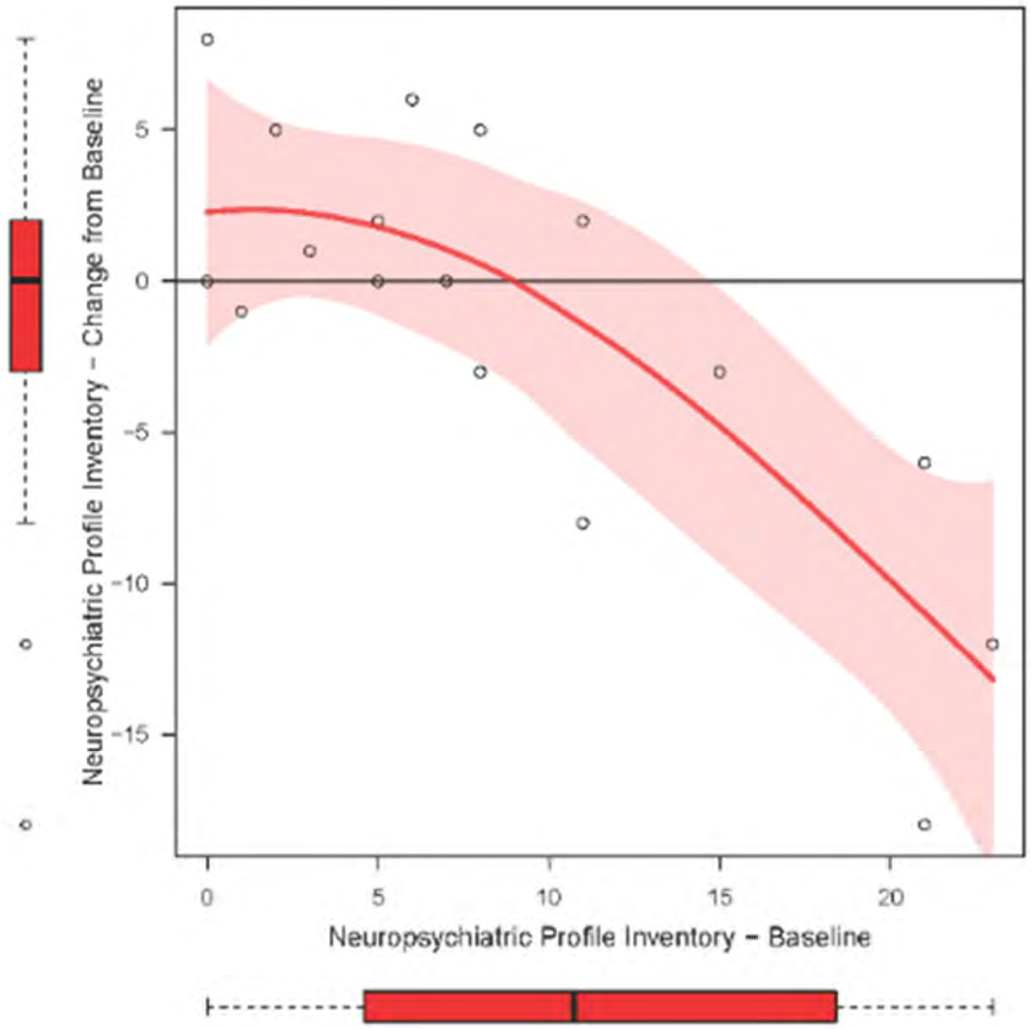
2013

Outcomes in participant & communication partner

Social Engagement
Communication
Activities
HRQL

Memory Clinic HEARS

Results (N=20) of Neuropsychiatric Inventory Scores Post Intervention



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