

# *Sensory Health and Aging Well*

Kathy Pichora-Fuller

Professor, Department of Psychology

University of Toronto

and

Adjunct Professor, Department of Gerontology

Simon Fraser University

Canadian Consortium on Neuro-degeneration in Aging  
Team 17: Sensory-Cognitive Communication



Kathy Pichora-Fuller



Paul Mick



Natalie Phillips



Walter Wittich



Réseau Québécois  
de Recherche sur  
le Vieillissement

# Outline

- Sensory changes with age
- Effects on health
- Effects on everyday activities

**Aging well with sensory loss**

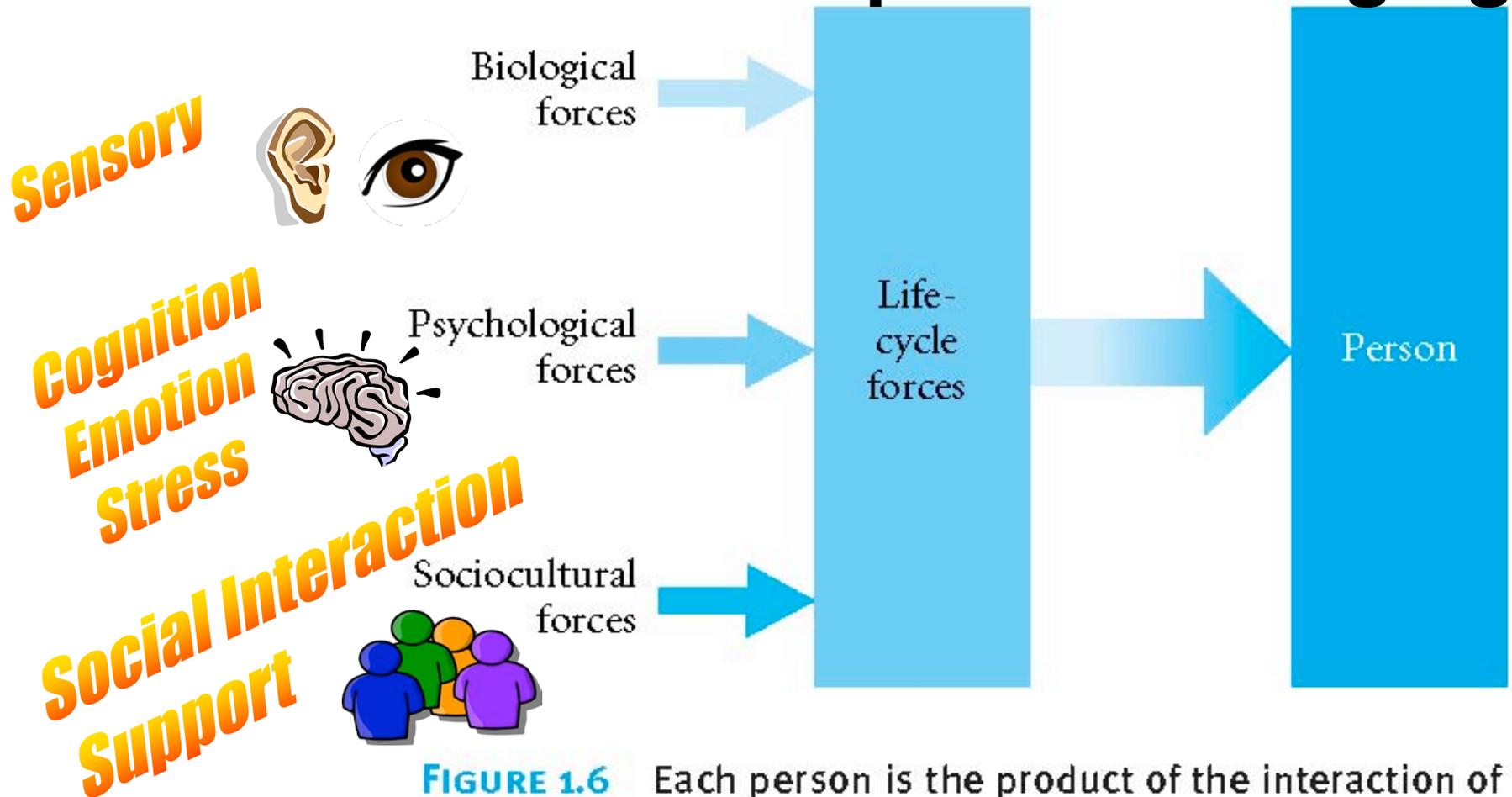


World Health  
Organization

# World Health Organization (WHO) Definition of “health” (1948)

- Health is a complete state of well-being:
  - **Physical** well being
  - **Mental** well being
  - **Social** well being
- Health is **NOT** merely the absence of disease or infirmity.

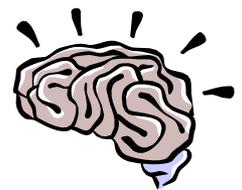
# Forces in adult development and aging



**FIGURE 1.6** Each person is the product of the interaction of biological, psychological, sociocultural, and life-cycle forces.

# Why are sensory factors important?

- Help people to live their lives optimally
- Improve quality of life
- Connect to others, environment, self
- “Communication” is key to participation



- Help people **AGE WELL**

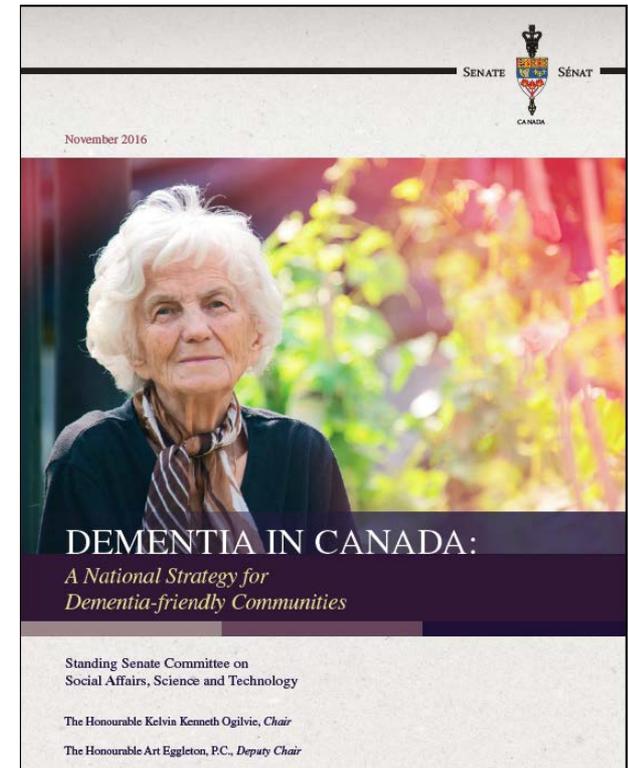
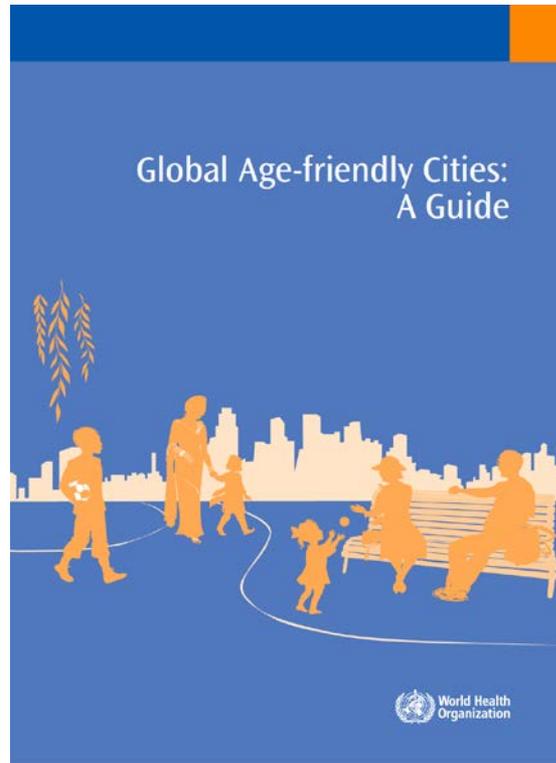
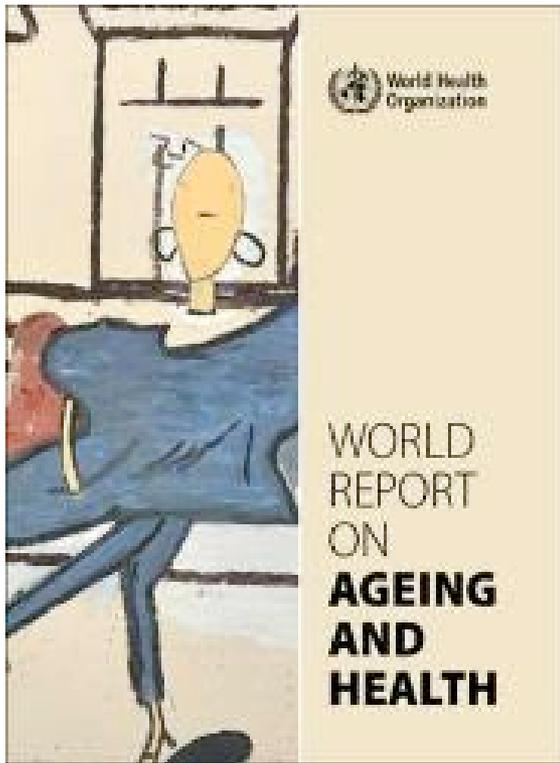
# Aging well with sensory loss

## WHO Vision

A world in which no person experiences hearing loss due to preventable causes... and those with unavoidable hearing loss can achieve their full potential through appropriate interventions, education and empowerment.

WHO programme for prevention of deafness and hearing loss (PDH): Activity Report 2018

# Age-friendly, dementia-friendly... sensory-friendly....



# Hearing accessibility

A place or activity is **hearing accessible** if participation in it is not compromised by difficulty hearing....

....regardless of hearing ability.

(Health and Welfare Canada Interdisciplinary Task Force on Hearing Impairment in the Adult, 1987)

# Three hearing accessibility options

Sign-language interpreting



Real-time captioning



Wireless sound transmitter



# Outline

- **Sensory changes with age**
- Effects on health
- Effects on everyday activities

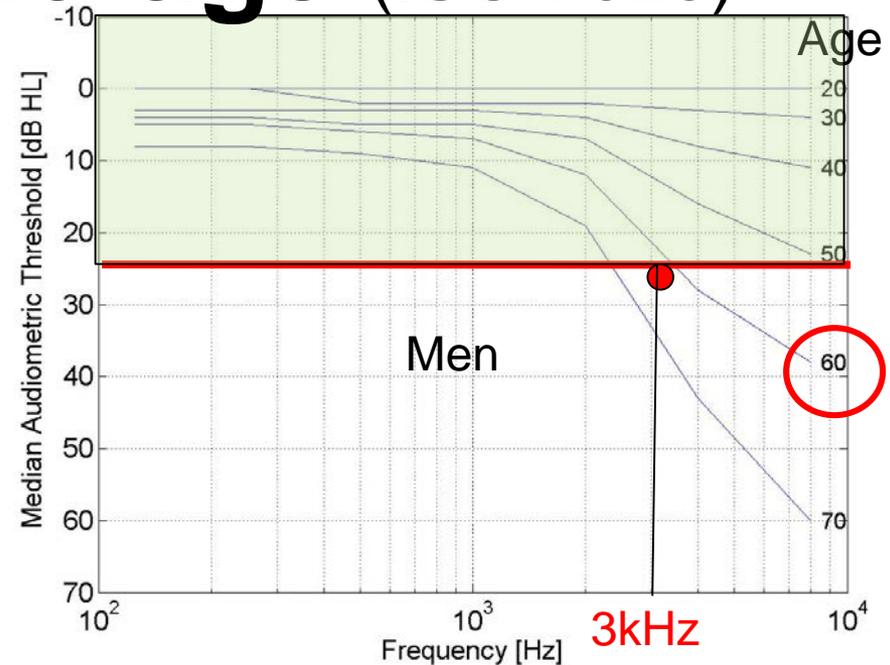
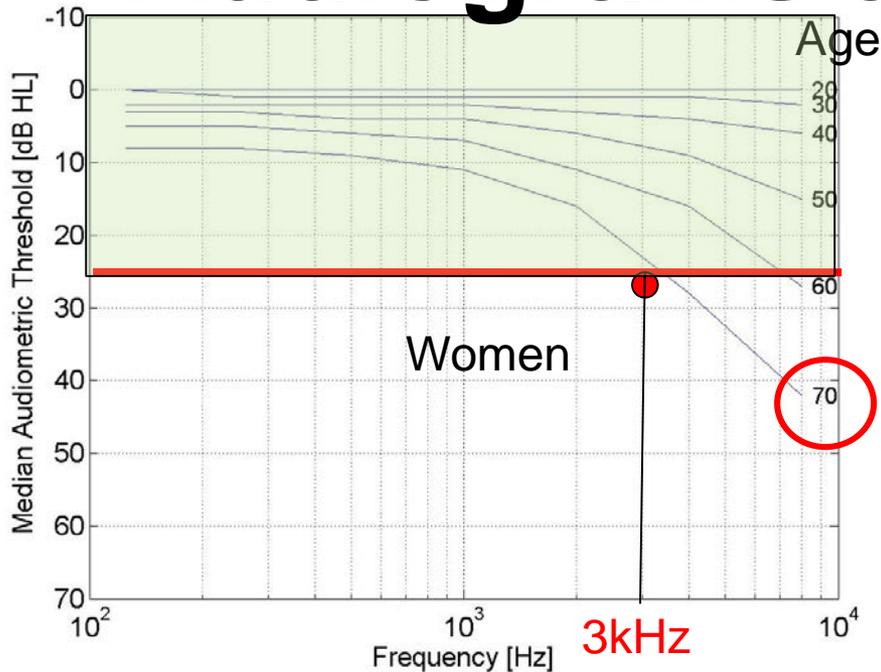
**Aging well with sensory loss**

# Sensory loss is common



- A 2015 report on the **Global Burden of Disease** (Vos et al., 2016) estimated that hearing loss and vision loss, respectively, were the **2nd and 3rd most common** impairments

# Audiograms and age (ISO 7029)



- High-frequency audiometric threshold elevation
  - Outer Hair Cell loss (also noise-induced hearing loss)
  - Endocochlear potentials ~ stria vascularis
    - (Mills, Schmeidt, Schulte, & Dubno, 2006)
- Neural – loss of synchrony
  - (Liberman & Kujawa, 2017)

**Heterogeneity**

# CLSA: Hearing, vision, balance

## “Comprehensive cohort”

- Age at baseline **45-85** years
- **30,000** community-dwelling participants
- **10 towns/cities** across Canada
- **No cognitive impairment** at baseline
- **Clinical, biological, social measures**
  - over 4000 variables recorded
- Baseline data collection finished in 2015
- Follow-ups every 3 years for 20 years



<https://www.clsa-elcv.ca/>

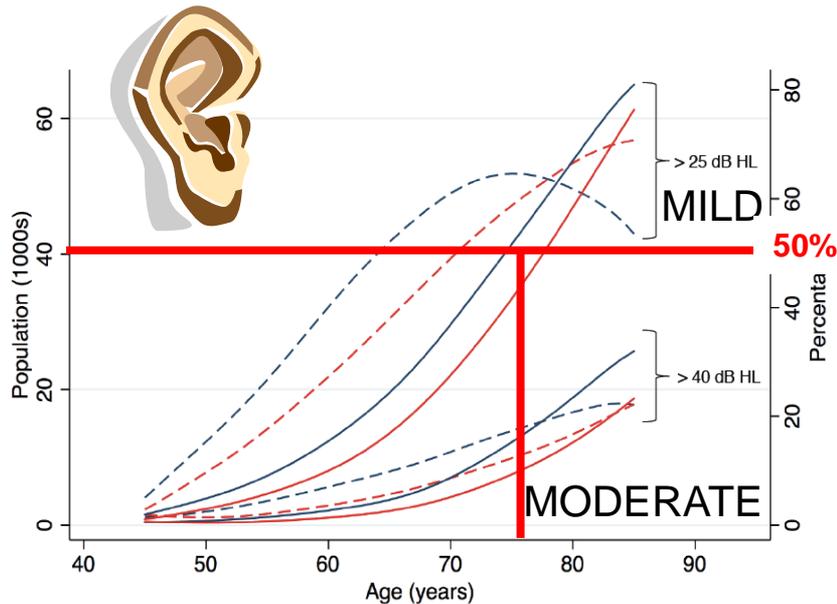
## Criteria for Impairments

**Hearing:** mean better-ear audiogram pure-tone (1, 2, 3, 4 kHz) thresholds > 25 dB HL

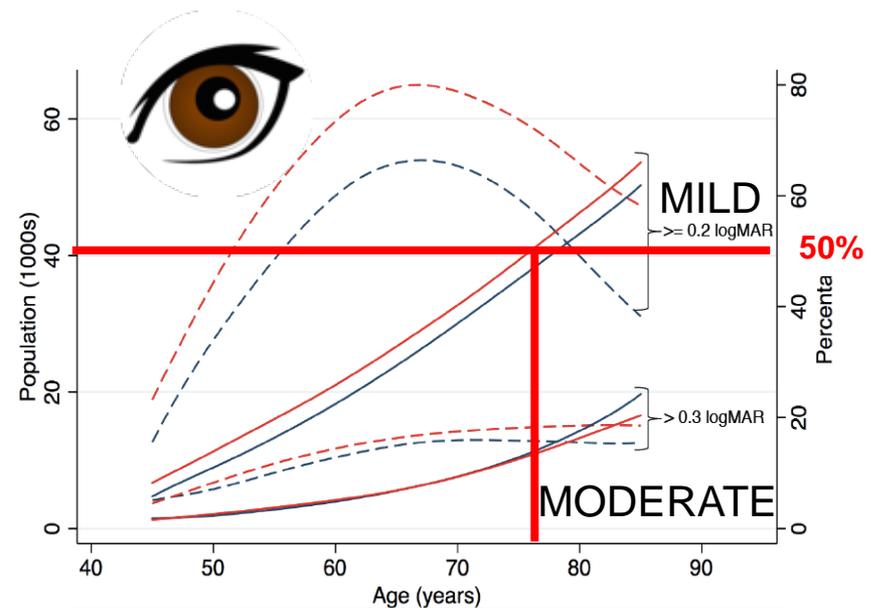
**Vision:** retro-illuminated ETDRS at 2 metres visual acuity < 0.2 logMAR (20/32 or 6/10)

**Balance:** with eyes open, time standing on better foot balance < 5 seconds

# Sensory loss increases with age



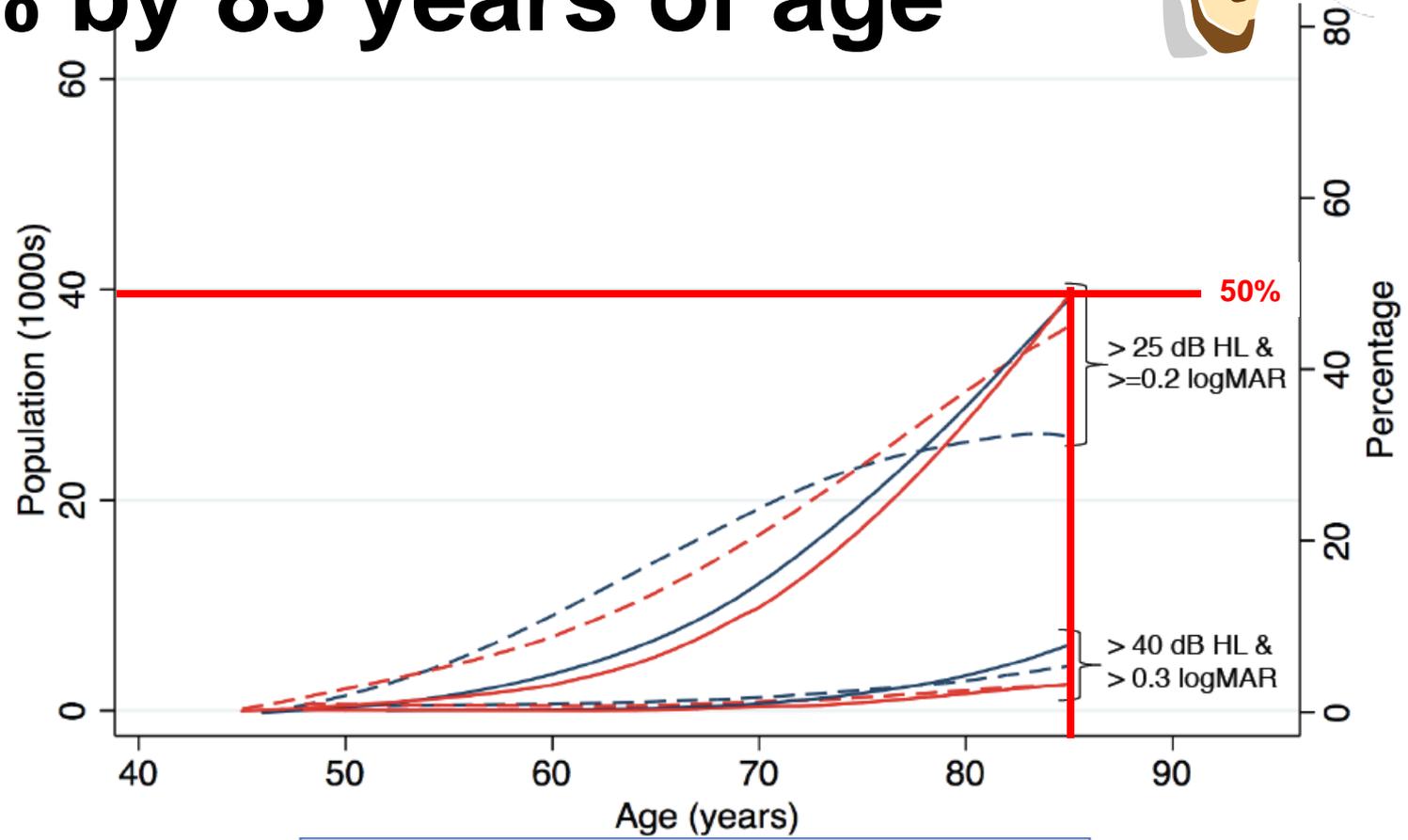
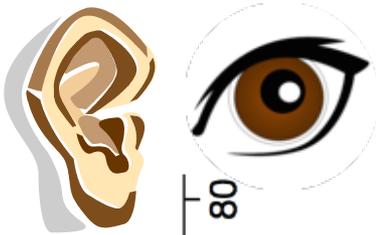
- Dashed lines: prevalence **COUNT** (left axis)
- Solid lines: prevalence **PROPORTION** (right axis)
- **Red:** Females; **Blue:** Males



- Dashed lines: prevalence **COUNT** (left axis)
- Solid lines: prevalence **PROPORTION** (right axis)
- **Red:** Females; **Blue:** Males

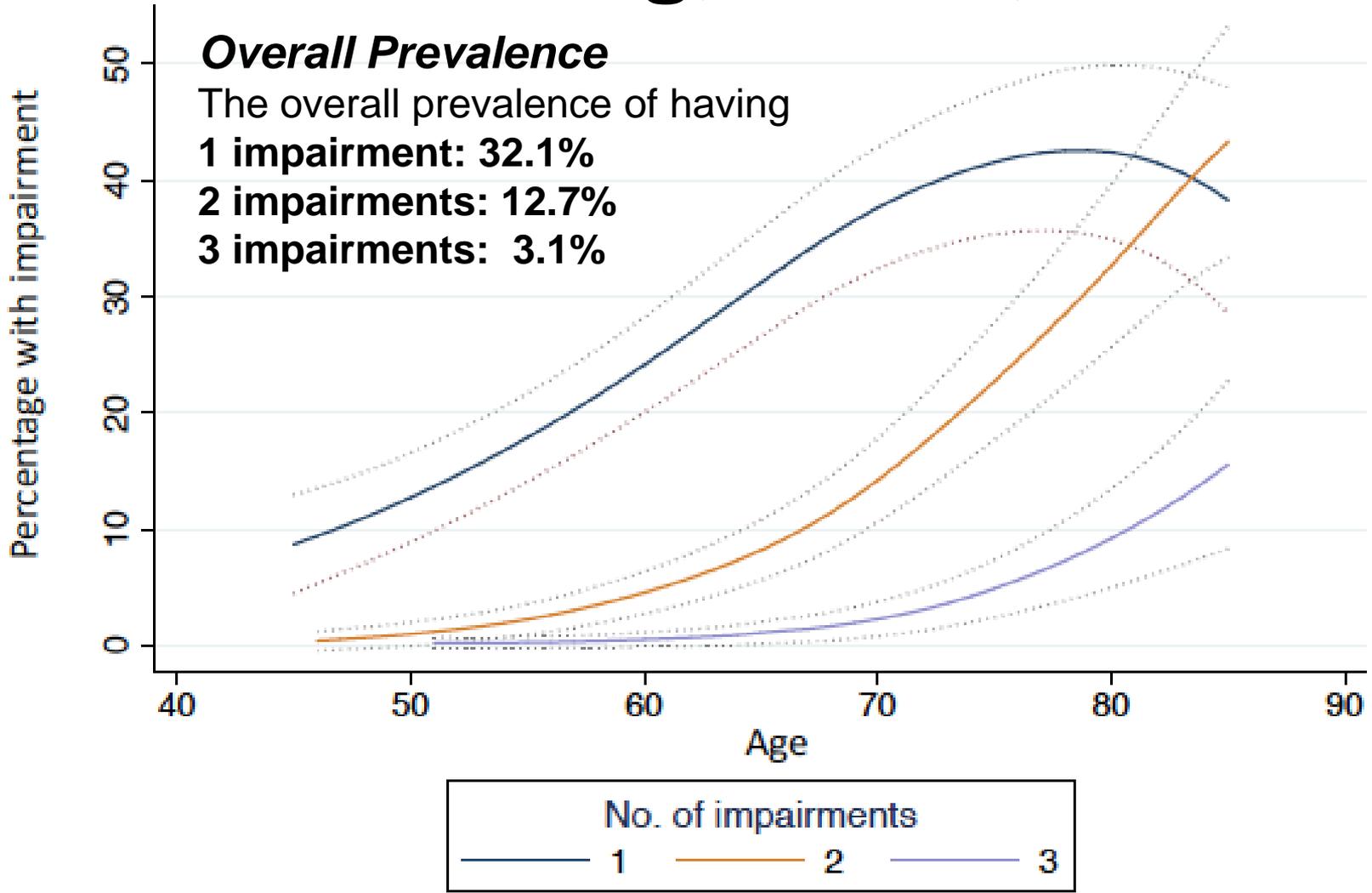
**50% before 75 years**

# Dual hearing & vision loss 50% by 85 years of age



- Dashed lines: prevalence **COUNT** (left axis)
- Solid lines: prevalence **PROPORTION** (right axis)
- **Red:** Females; **Blue:** Males

# Combined hearing, vision, balance



# History and future of trends

## *Hearing*

## *Vision*

### Total older Canadians with loss (2016)

males - 1.5 million

males - 1.8 million

females - 1.2 million

females - 2.2 million

### % increase in overall growth in older population from 2011

males – 8%

females – 7.6%

### % increase in those with sensory loss from 2011

males - 15.7%

**almost  
double**

males – 13.5%;

females – 11.8%

females – 11.3%

# Outline

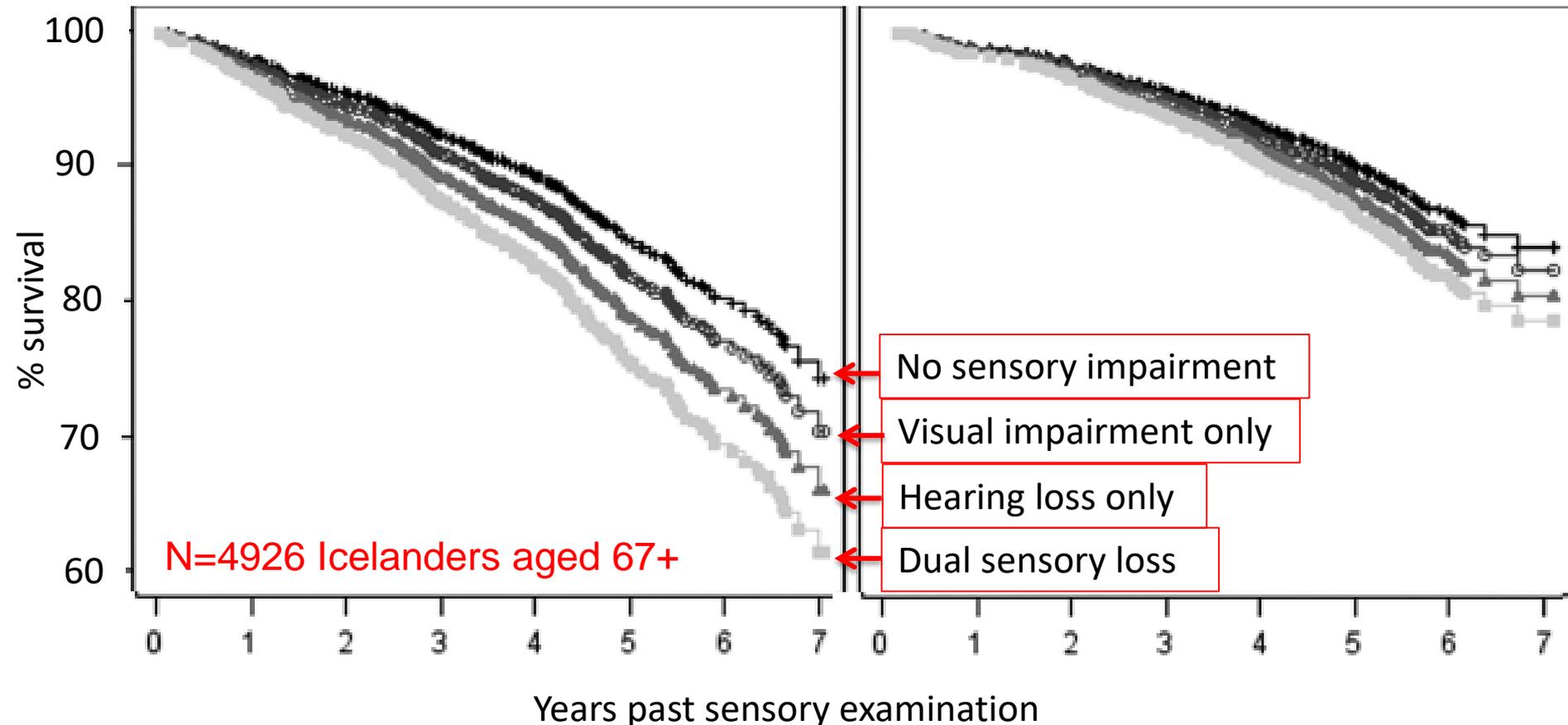
- Sensory changes with age
- **Effects on health**
- Effects on everyday activities

**Aging well with sensory loss**

# All cause mortality ~ sensory impairment

Males

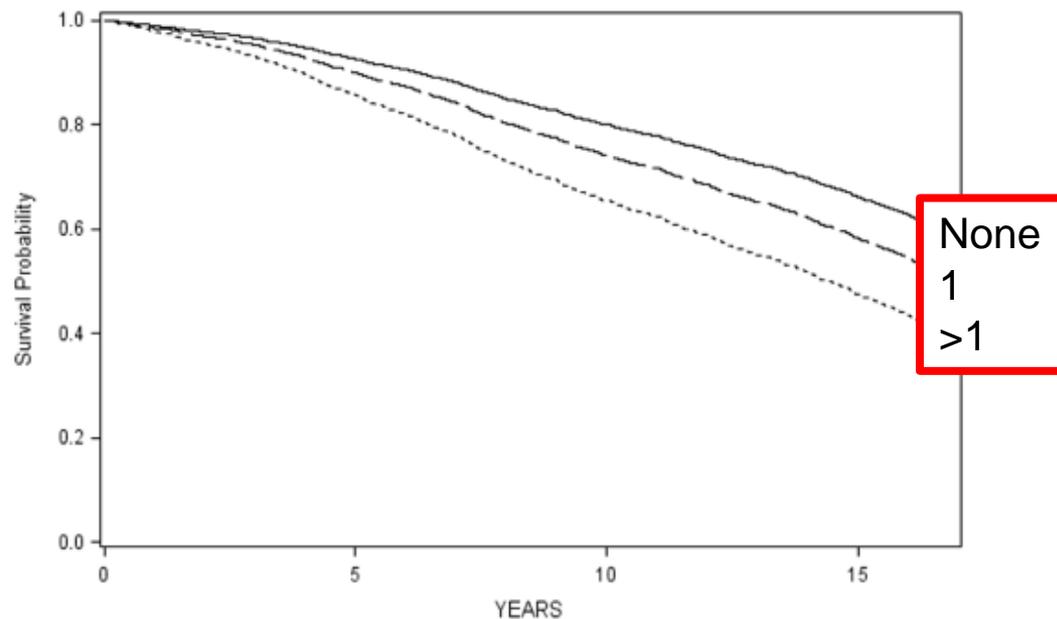
Females



Kaplan Meier plots for all-cause mortality rates by type of sensory impairment adjusted for relevant confounders  
Fisher *et al*, Age Ageing 2013, and Feeny *et al J*, Clin Epidemiol, 2012

# Number of sensory impairments & mortality

USA, N=2,418, age: 57-97 years, 45.4% died in 15-year period starting in 2000



Hazard ratios adjusting for age & sex  
One impairment: 1.40  
Two or more impairments: 2.12

But only olfaction was significantly related to mortality after adjusting for subclinical atherosclerosis and Inflammation.

**Figure 1.** Age- and sex-adjusted probability of survival by number of sensory impairments in the Epidemiology of Hearing Loss Study. Solid line = no sensory impairment; dashed line = one sensory impairment; dotted line = two or more sensory impairments.

Schubert, C.R., Fisher, M.E., Rinto, A.A., Klein, B.E.K., Klein, R., Tweed, T.S., & Cruickshanks (2017). *Journal of Gerontology Medical Sciences*, 72(5), 710-715.

# Hearing Loss & Other Health Issues

Stam, Kostense, Lemke, Merkus, Smit, Festen, & Kramer. (2014). Comorbidity in adults with hearing difficulties: Which chronic medical conditions are related to hearing impairment? *International Journal of Audiology*, 53(6), 392-401.

- N = 2000, 18-70 years old (Netherlands)
- 79% of individuals with self-reported hearing loss also reported at least one other chronic health condition
- More likely to report additional health conditions compared to those respondents with normal hearing

# Hearing loss and health risks

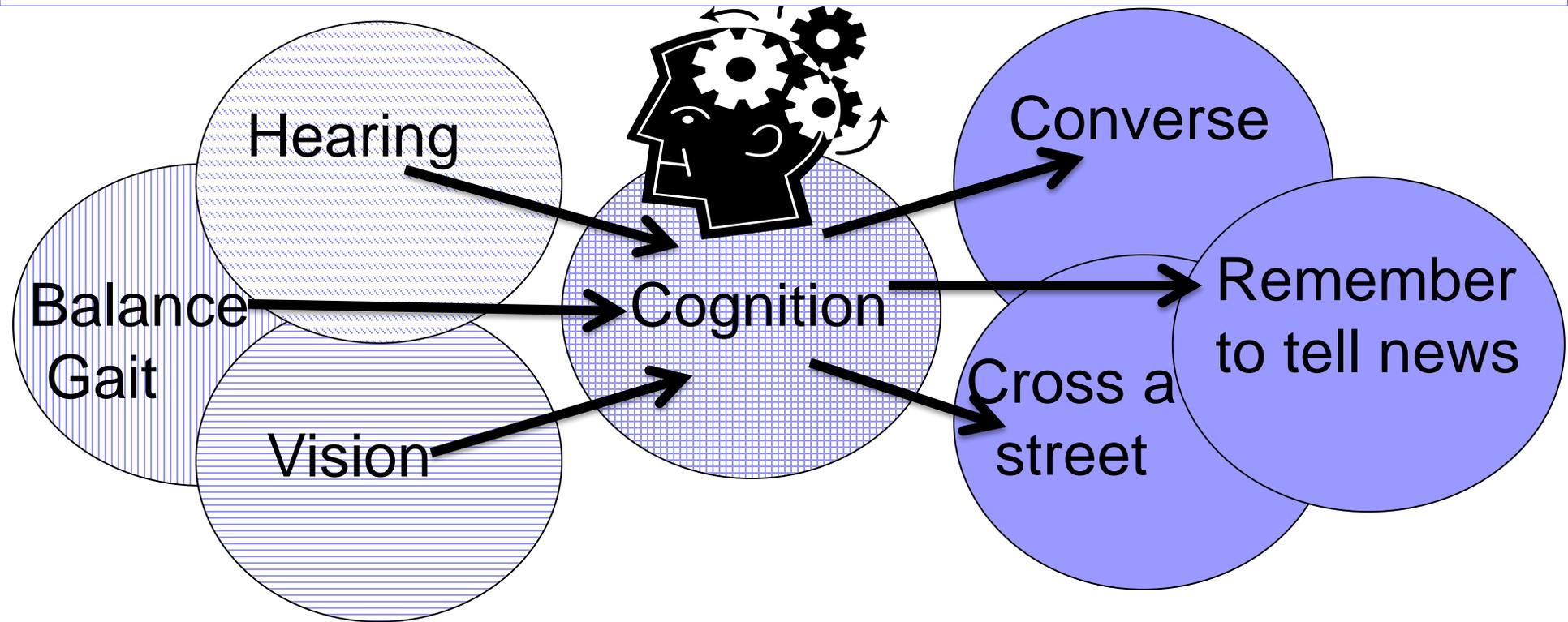
## ■ Risk factors for hearing loss

- Diabetes Bainbridge et al., Ann Int Med, 2008
- Cardiovascular disease/hypertension McKee et al., Disability & Health, 2018

## ■ Health states associated with hearing loss in cross sectional or longitudinal observational studies:

- Mortality Fisher et. al. Age Ageing 2014
- Cognitive decline & dementia Lin et. al. 2011, 2014
- Social isolation and loneliness Mick et. al. JAMA OHNS 2014
- Falls and injuries Lin & Ferrucci, Arch Int Med, 2012
- Frailty Kamil RJ et. al. JAGS, 2014
- Depression Li et. al. JAMA OHNS 2014

Pichora-Fuller, M.K., Mick, P.T., Reed, M. (2015). Hearing, cognition, and healthy aging: Social and public health implications of the links between age-related declines in hearing and cognition. *Seminars in Hearing*, 36, 122-139.



**Senses - Cognition - Life**

# Speech understanding in noise

(CHABA, JASA, 1988)

## ■ Little problem in ideal listening conditions

- Quiet
- One talker
- Familiar person, topic, situation
- Simple task, focused activity



## ■ Difficulty in challenging listening conditions

- Noise
- Multiple talkers
- Strangers, accents, new topic, novel situation
- Complex task, many concurrent activities
- Fast pace

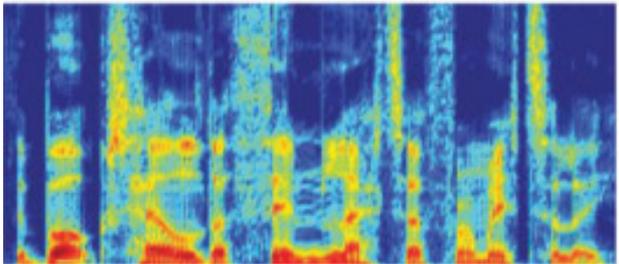


## ■ Avoid by withdrawal from social interaction!

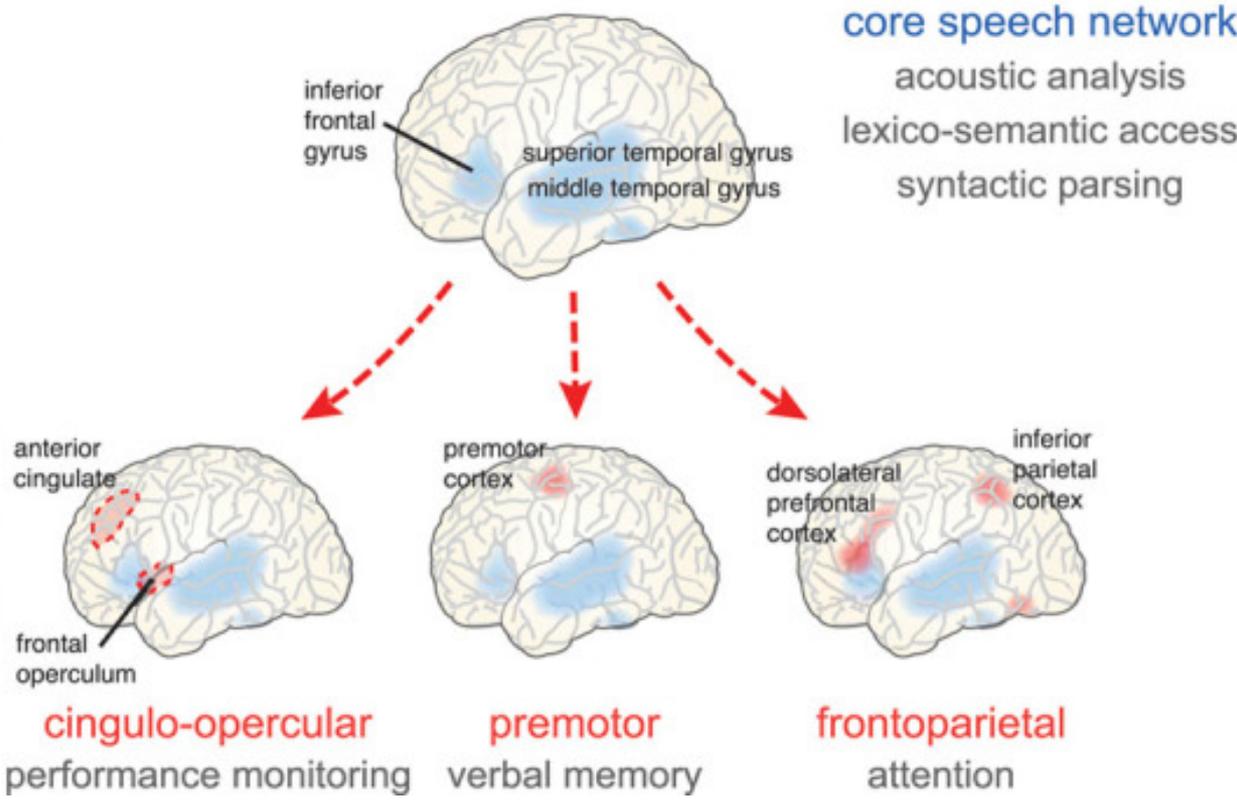
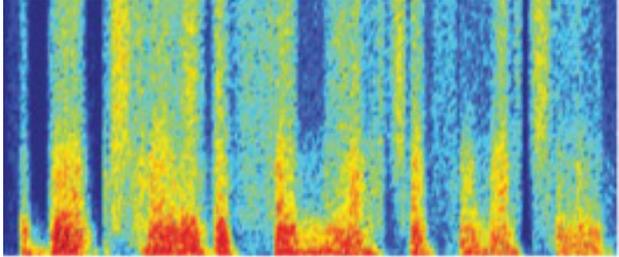


# Brain activation when sound is degraded

Acoustically clear speech



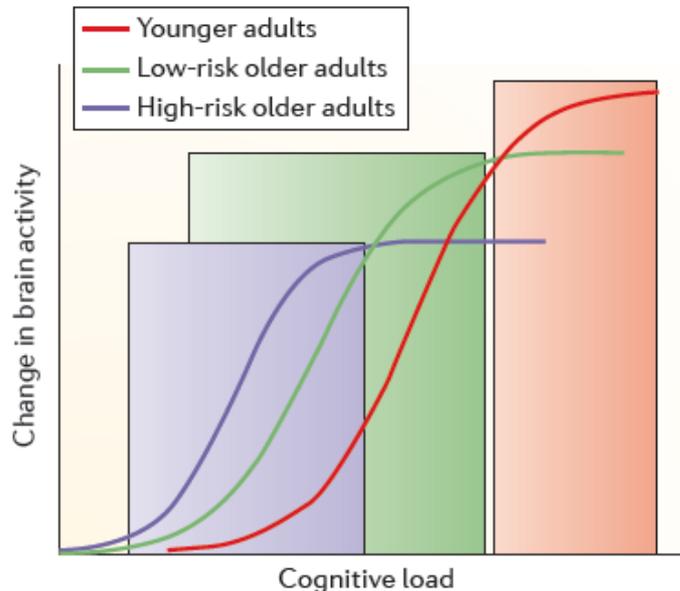
Acoustically degraded speech



Peelle J. E. (2018). Listening effort: How the cognitive consequences of acoustic challenge are reflected in brain and behavior. *Ear and hearing*, 39(2), 204-214.

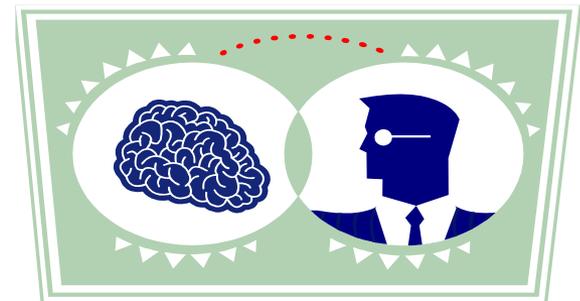
# Cognitive neuroscience of aging

- Same performance achieved with different processing
- More widespread activation ~ brain reorganization
  - Young brain activity more lateralized
  - Old brain activity more distributed
    - **HAROLD**: Hemispheric asymmetry reduction in older adults (Cabeza, 2002)
    - **PASA**: Posterior-anterior shift in aging (Davis et al., 2008)



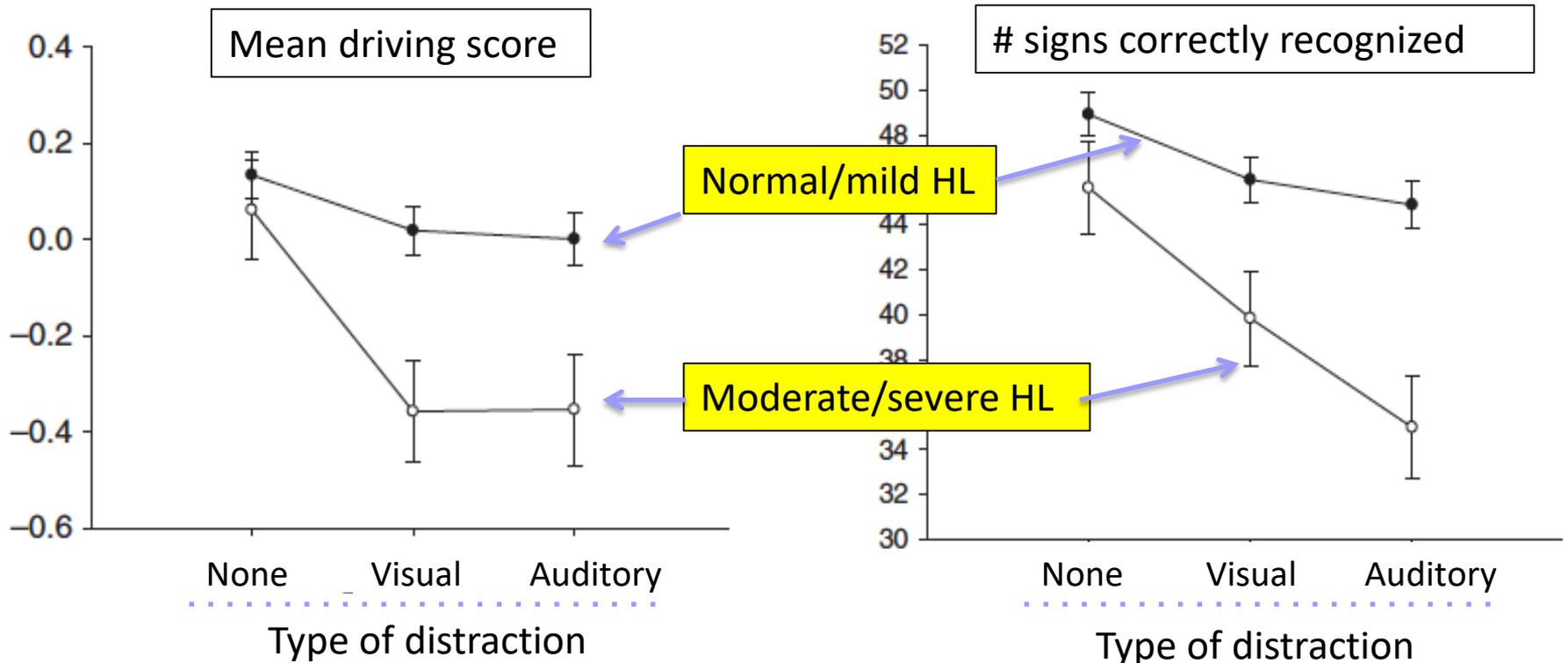
## Compensation

(Grady, *Nature Reviews Neuroscience*, 2012)



# Hearing loss and driving

107 seniors with normal visual acuity and cognition on a closed road circuit



**Hearing loss**

Increased perceptual effort drains  
cognitive resources available for other purposes

Reduced perception of hazards

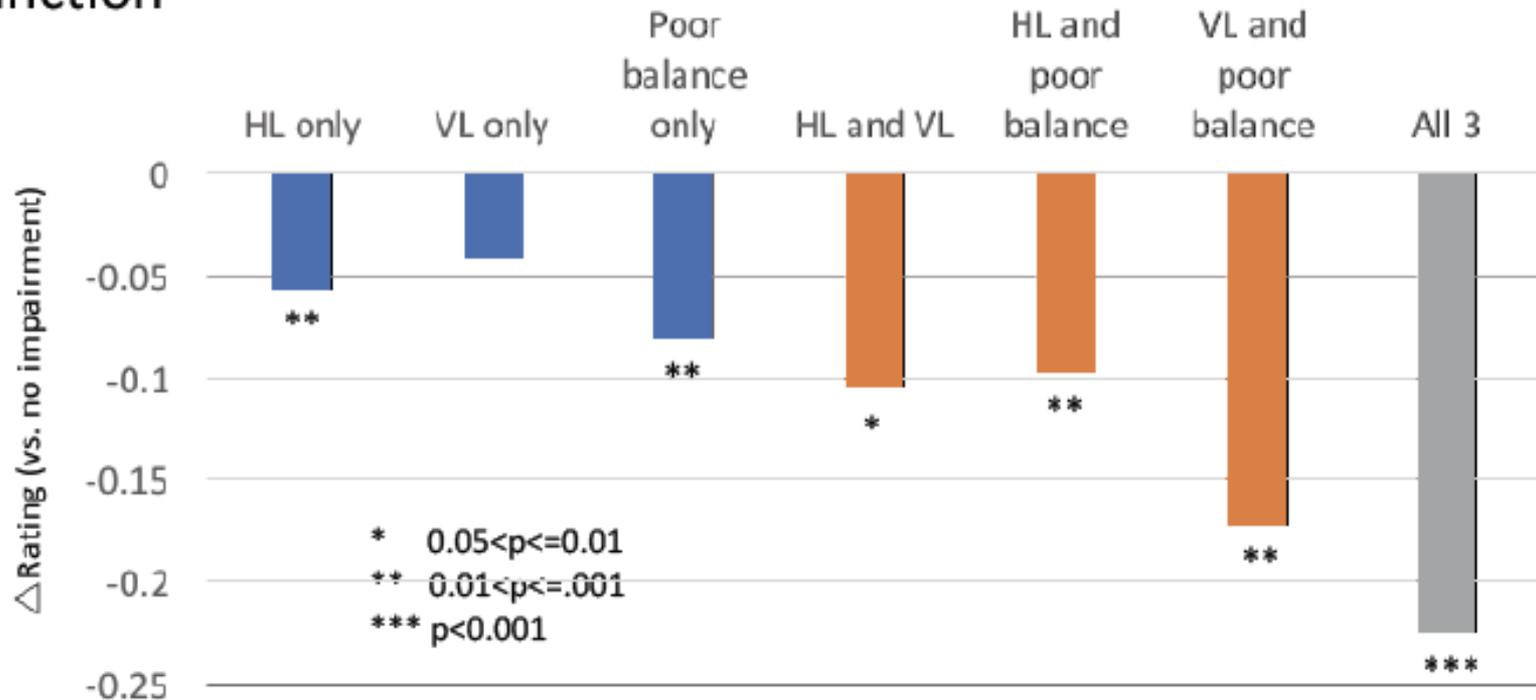


Falls ?

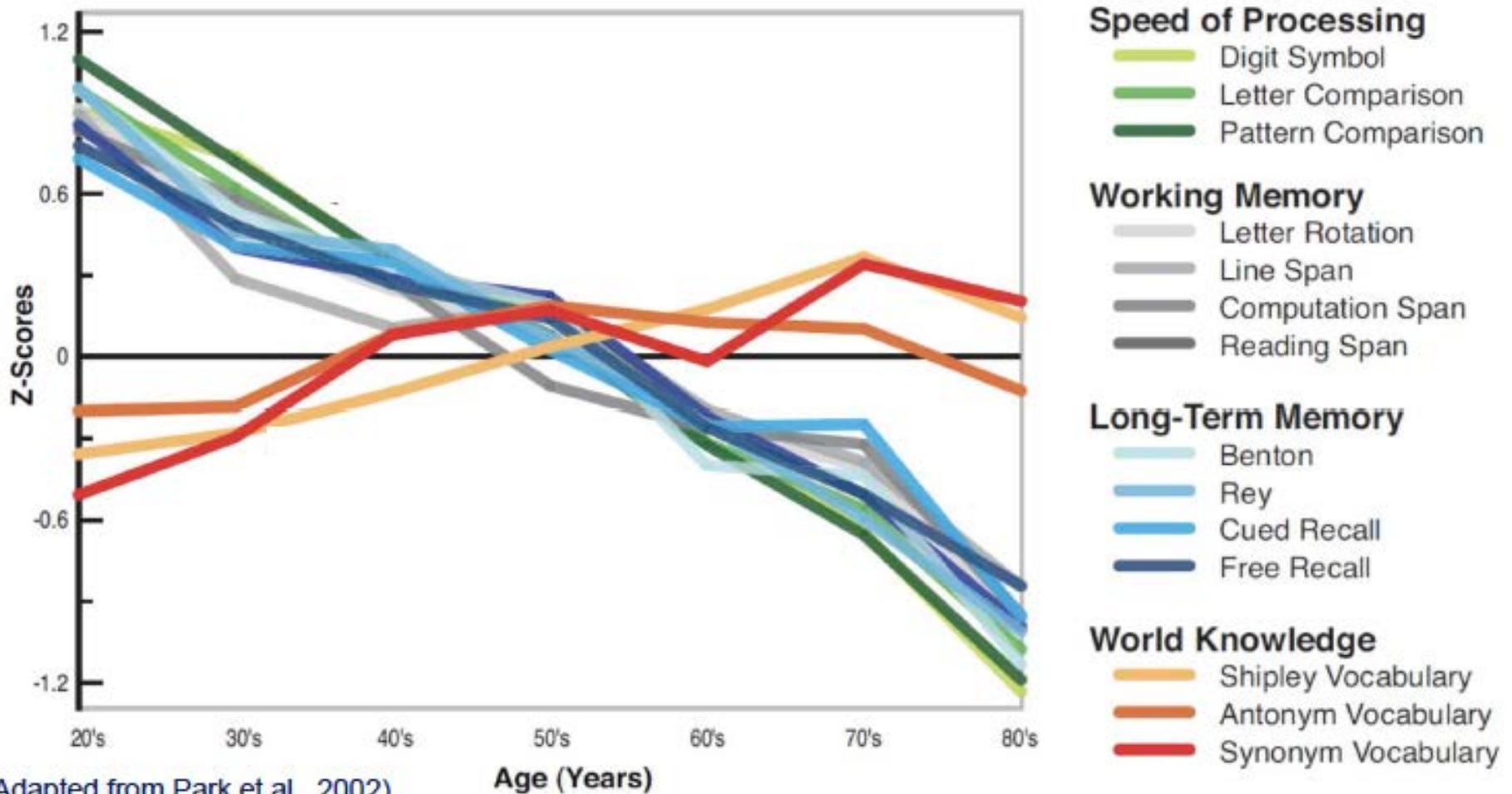


# Sensory loss ~ health and cognition

- General health (shown)
- Executive function
- Memory

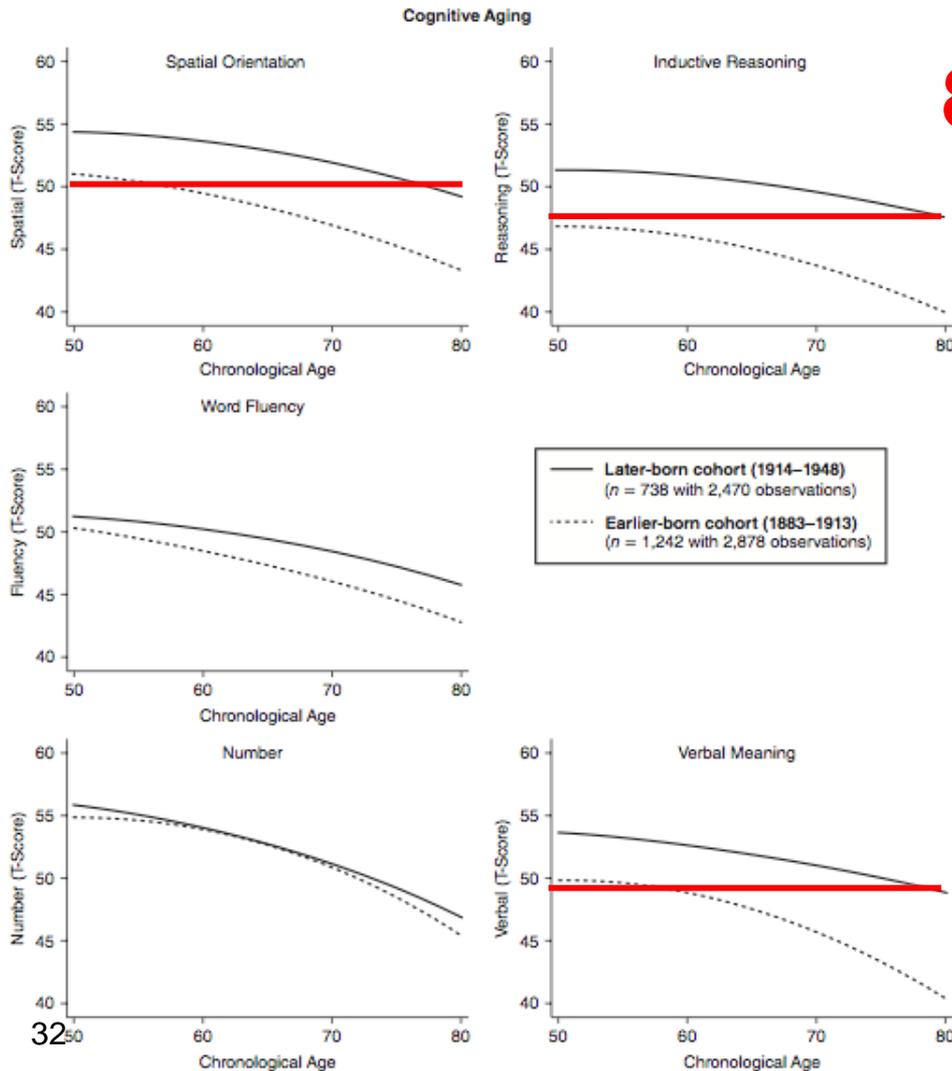


# When does cognitive aging start?



**FIGURE 7.3**

Data from the SLS Showing Cohort Differences in Patterns of Change between Ages 50 and 80 on Five Primary Activities



**80 now is like 50 then**

Later cohort (born 1914-1948) scored better than earlier cohort (born 1883-1913) on all cognitive abilities except number and had slower declines

Source: Gerstorf, D., Ram, N., Hoppmann, C., Willis, S. L., & Schaie, K. W. (2011). Cohort differences in cognitive aging and terminal decline in the Seattle Longitudinal Study. *Developmental Psychology*, 47(4), 1026–1041. doi: 10.1037/a0023426

# Outline

- Sensory changes with age
- Effects on health
- **Effects on everyday activities**

**Aging well with sensory loss**

# Health is...



**Social interaction  
communication**

*“...the capacity of people to adapt to, respond to, or control life’s challenges and changes.”*

(Frankish et al., 1997)



# Person – Environment Interactions

## Physical and Social Environment



# Aging Well: Belonging and Agency

- **Belonging** (experience-driven) – “reflects a sense of positive connection with other people and the environment”
  - *... be who you want to be....*
- **Agency** (behaviour-driven) – “refers to the process of being a change agent in one’s own life by means of intentional and proactive behaviours”
  - *.....do what you want to do.....*

# SOC Model (Baltes)

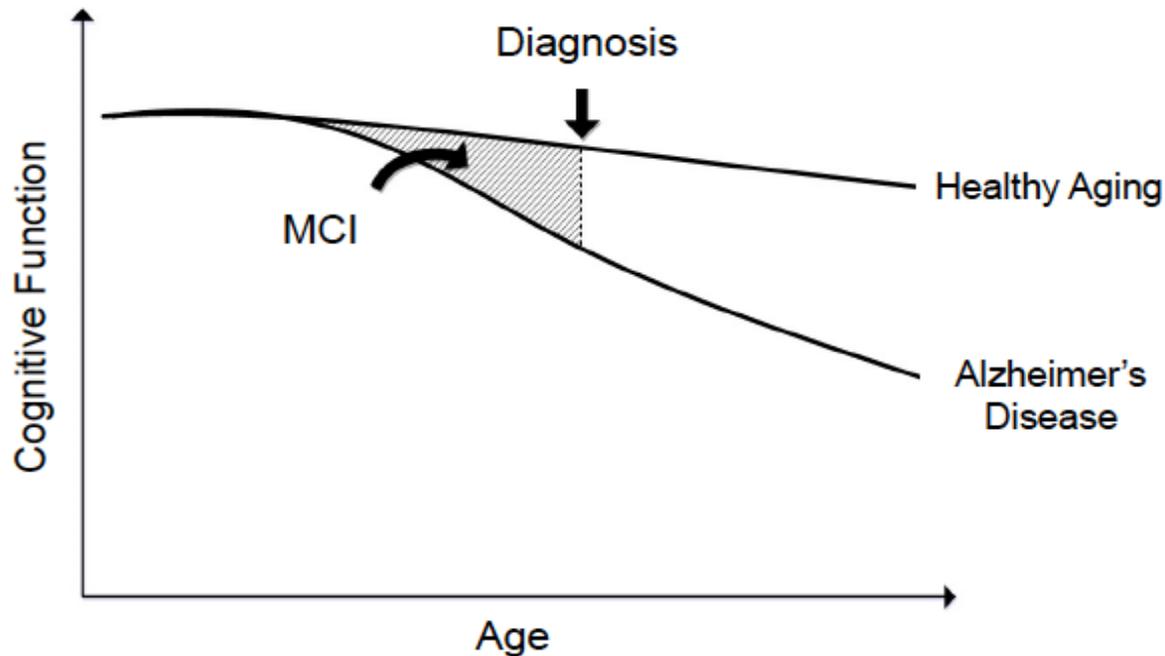
## Selective Optimization with Compensation

- How to optimize an overall sense of competence
  - Apply three key adaptive mechanisms for aging
    - **Selection**
      - Select subset of options to focus resources on
    - **Optimization**
      - Find best way to achieve goal (e.g., improve by practice)
    - **Compensation**
      - Use alternative route to find solution

### The SOC model

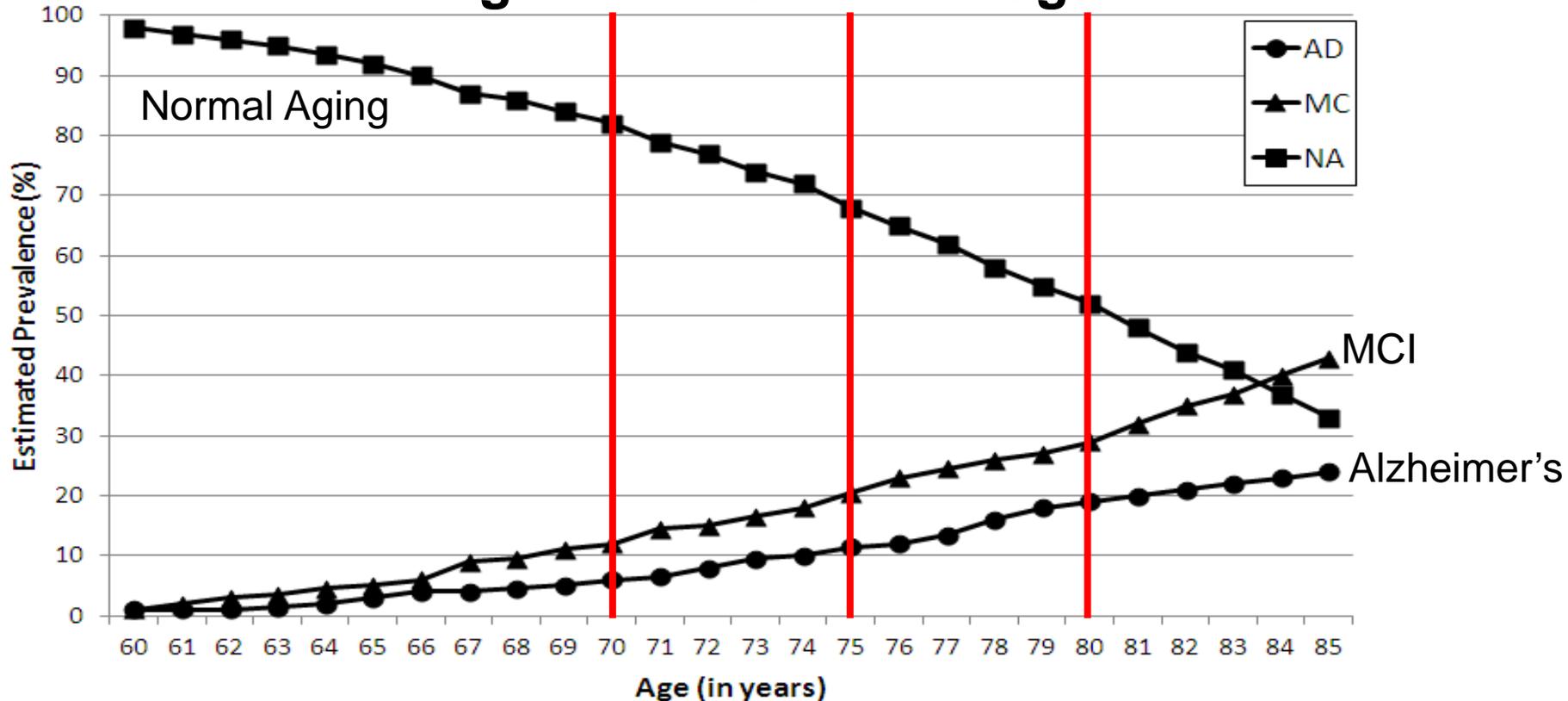
- <http://www.margret-baltes-stiftung.de/PBB-Website/SOC.html>

## Mild Cognitive Impairment (MCI): A continuum between normal aging and AD?



- at greater risk for progression to AD
  - MCI: 10-25% per year (~2/3 aMCI progress within 5 years)
  - healthy elderly controls: 1-2% per year
- Early detection of AD is crucial for implementing treatments  
(Petersen et al., 2001)

## Cognitive decline with age



**Figure 1.** Estimates of age-specific prevalences of Alzheimer's disease (AD), Mild Cognitive Impairment (MCI), and Non-Affected (NAs), aged 60–85 years, assuming 1.0% rate for conversion from NA to MCI at age 60.

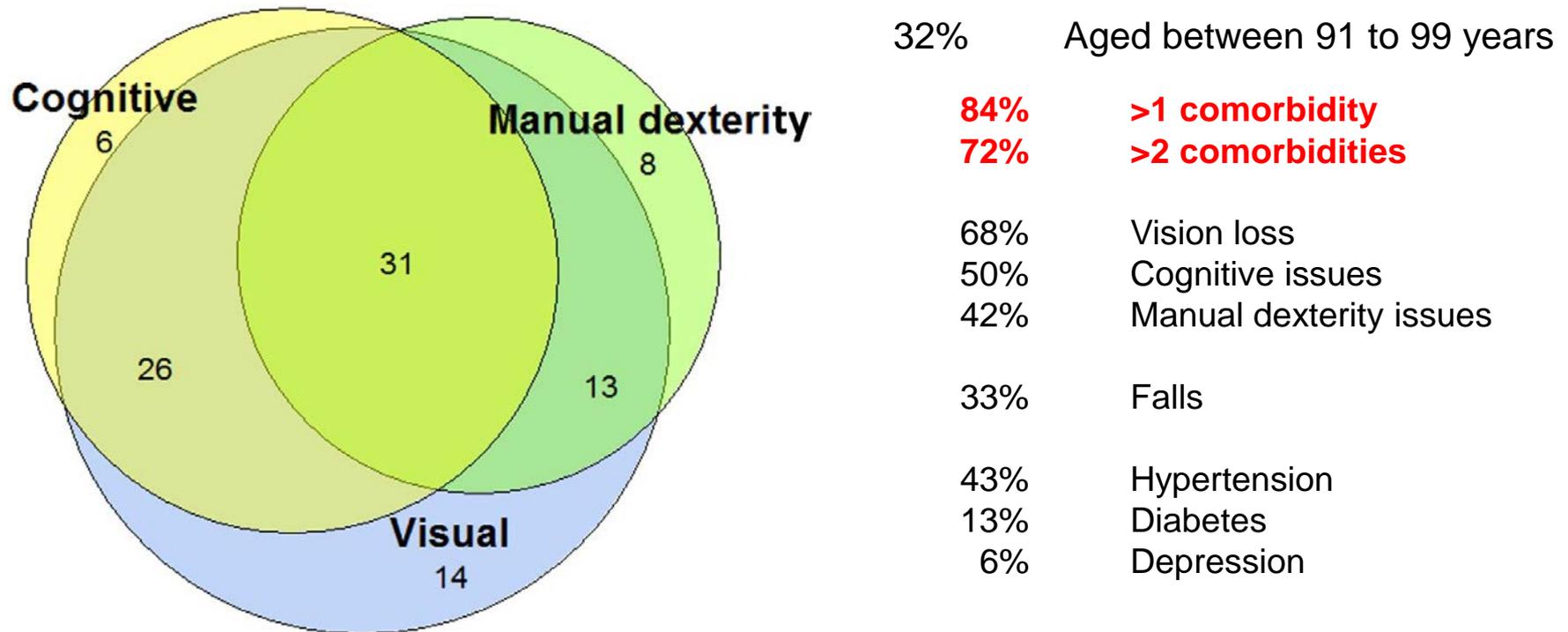
(Adapted with permission from Yesavage JA, O'Hara R, Kraemer H, et al.

Modeling the prevalence and incidence of Alzheimer's disease and mild cognitive impairment.

J Psychiat Res 2002;36:281-286.)

# Hearing aids for those with multiple health problems?

135 Baycrest clients (mean age=86±7 who completed a Hearing Aid Evaluation in 2015)



**Figure 1.** Representation of comorbidities overlap (98/135 clients).

This figure *does not include*:

- 16 individuals with missing data for at least one of the comorbidities
- 1 individual with manual dexterity and cognitive issues
- 20 individuals who did not present with any of these comorbidities



# Home Care & Long-term Care

 PLOS ONE 2018



Dawn Guthrie  
Wilfrid Laurier University  
Waterloo, Ontario

## RESEARCH ARTICLE

Combined impairments in vision, hearing and cognition are associated with greater levels of functional and communication difficulties than cognitive impairment alone: Analysis of interRAI data for home care and long-term care recipients in Ontario

Dawn M. Guthrie<sup>1,2\*</sup>, Jacob G. S. Davidson<sup>1</sup>, Nicole Williams<sup>1</sup>, Jennifer Campos<sup>3,4</sup>, Kathleen Hunter<sup>5,6</sup>, Paul Mick<sup>7</sup>, Joseph B. Orange<sup>8</sup>, M. Kathleen Pichora-Fuller<sup>9</sup>, Natalie A. Phillips<sup>10</sup>, Marie Y. Savundranayagam<sup>11</sup>, Walter Wittich<sup>12,13,14</sup>

# Home Care (N = 291,284)

1/5 have triple loss

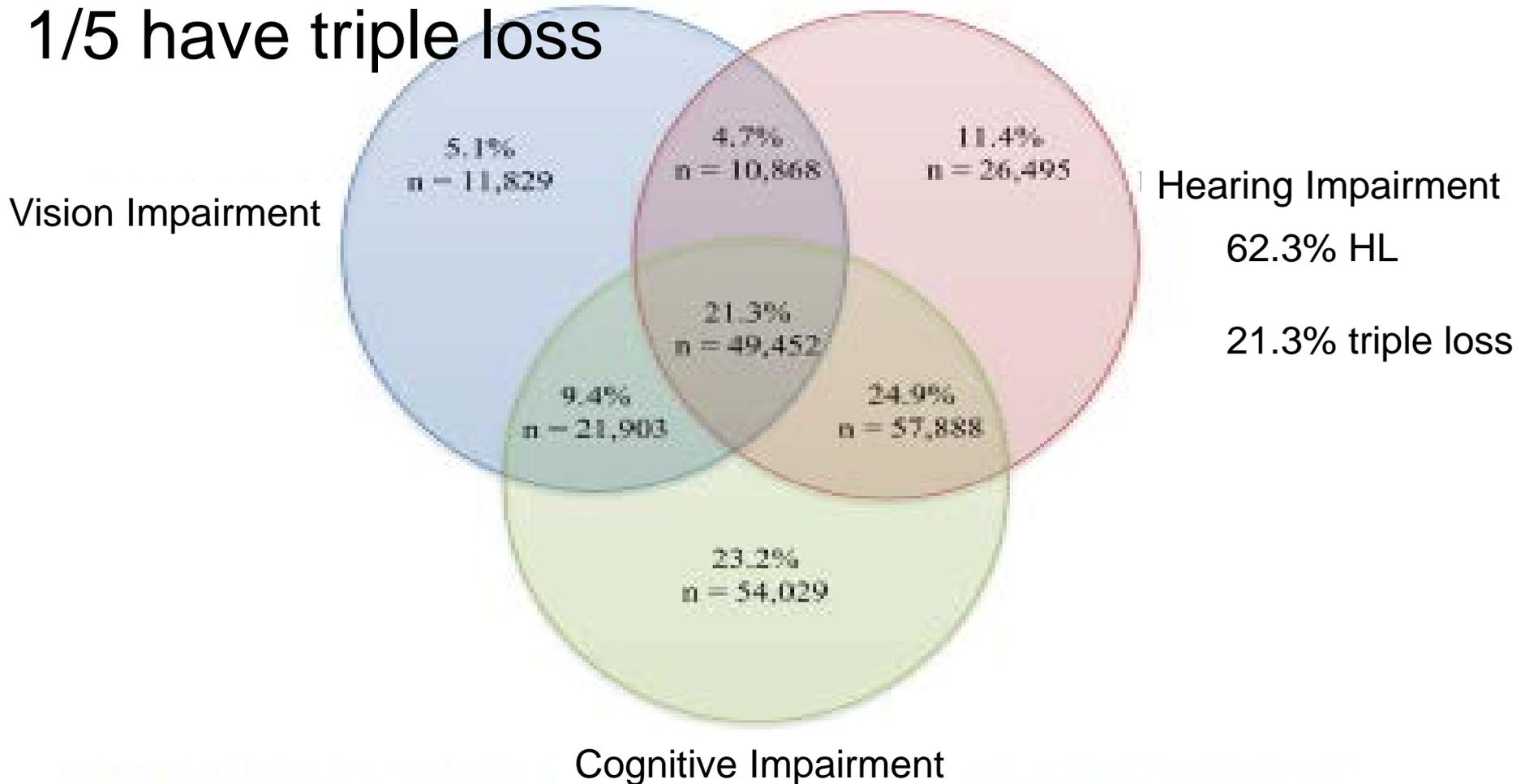


Fig. 1. Distribution of home care clients with hearing and vision sensory and/or cognitive impairments. In this sample, 20.1% (n = 54,029) had some of these impairments.

# Long-term Care (N = 100,578)

## 1/3 have triple loss

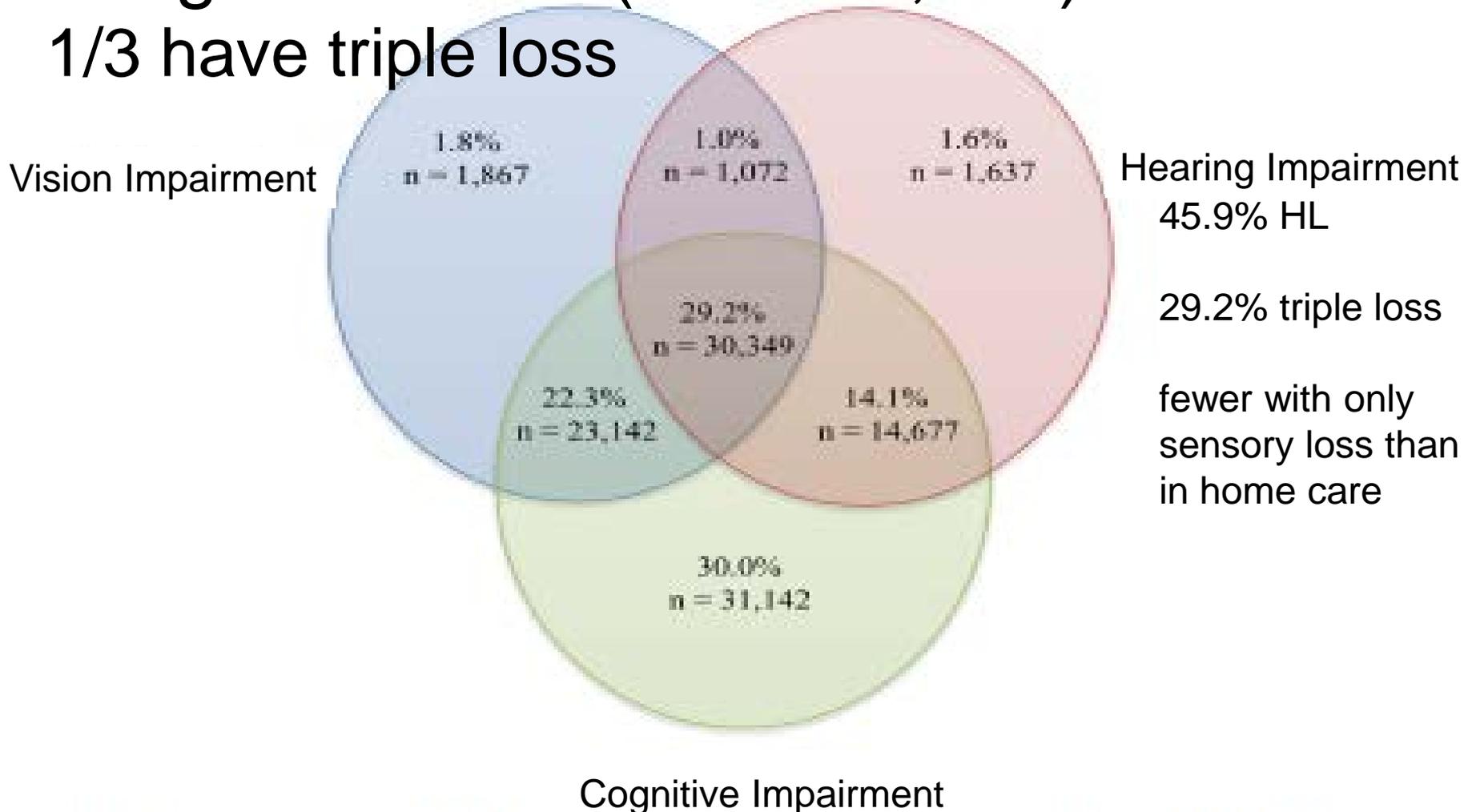


Fig 2. Distribution of long-term care residents with hearing and vision sensory and/or cognitive impairments. In this sample, 61% (n = 60,993) had none of these impairments.

## Results

The rate of people having all three impairments (i.e., CI+DSI) was 21.3% in home care and 29.2% in LTC. Across the seven groups, individuals with all three impairments were the most likely to report loneliness, to have a reduction in social engagement, and to experience reduced independence in their activities of daily living (ADLs) and instrumental ADLs (IADLs). Communication challenges were highly prevalent in this group, at 38.0% in home care and 49.2% in LTC. In both care settings, communication difficulties were more common in the CI+DSI group versus the CI-alone group.

## Conclusions

The presence of combined sensory and cognitive impairments is high among older adults in these two care settings and having all three impairments is associated with higher rates of negative outcomes than the rates for those having CI alone. There is a rising imperative for all health care professionals to recognize the potential presence of hearing, vision and cognitive impairments in those for whom they provide care, to ensure that basic screening occurs and to use those results to inform care plans.



Alzheimer's & Dementia 11 (2015) 70-98

2015

Alzheimer's  
&  
Dementia

## At the interface of sensory and motor dysfunctions and Alzheimer's disease

Mark W. Albers<sup>a,\*</sup>, Grover C. Gilmore<sup>b</sup>, Jeffrey Kaye<sup>c</sup>, Claire Murphy<sup>d</sup>, Arthur Wingfield<sup>e</sup>,  
David A. Bennett<sup>f</sup>, Adam L. Boxer<sup>g</sup>, Aron S. Buchman<sup>f</sup>, Karen J. Cruickshanks<sup>h,i</sup>,  
Davangere P. Devanand<sup>j</sup>, Charles J. Duffy<sup>k</sup>, Christine M. Gall<sup>l</sup>, George A. Gates<sup>m</sup>,  
Ann-Charlotte Granholm<sup>n,o</sup>, Takao Hensch<sup>p</sup>, Roe Holtzer<sup>q</sup>, Bradley T. Hyman<sup>a</sup>, Frank R. Lin<sup>r</sup>,  
Ann C. McKee<sup>s</sup>, John C. Morris<sup>t</sup>, Ronald C. Petersen<sup>u</sup>, Lisa C. Silbert<sup>c</sup>, Robert G. Struble<sup>v</sup>,  
John Q. Trojanowski<sup>w</sup>, Joe Verghese<sup>q</sup>, Donald A. Wilson<sup>x</sup>, Shunbin Xu<sup>f</sup>, Li I. Zhang<sup>y</sup>

***“Based on the data presented and discussed at this workshop, it is clear that sensory and motor regions of the central nervous system are affected by AD pathology and that interventions targeting amelioration of sensory-motor deficits in AD may enhance patient function as AD progresses.”***

The Lancet Commissions July 20, 2017

## Dementia prevention, intervention, and care

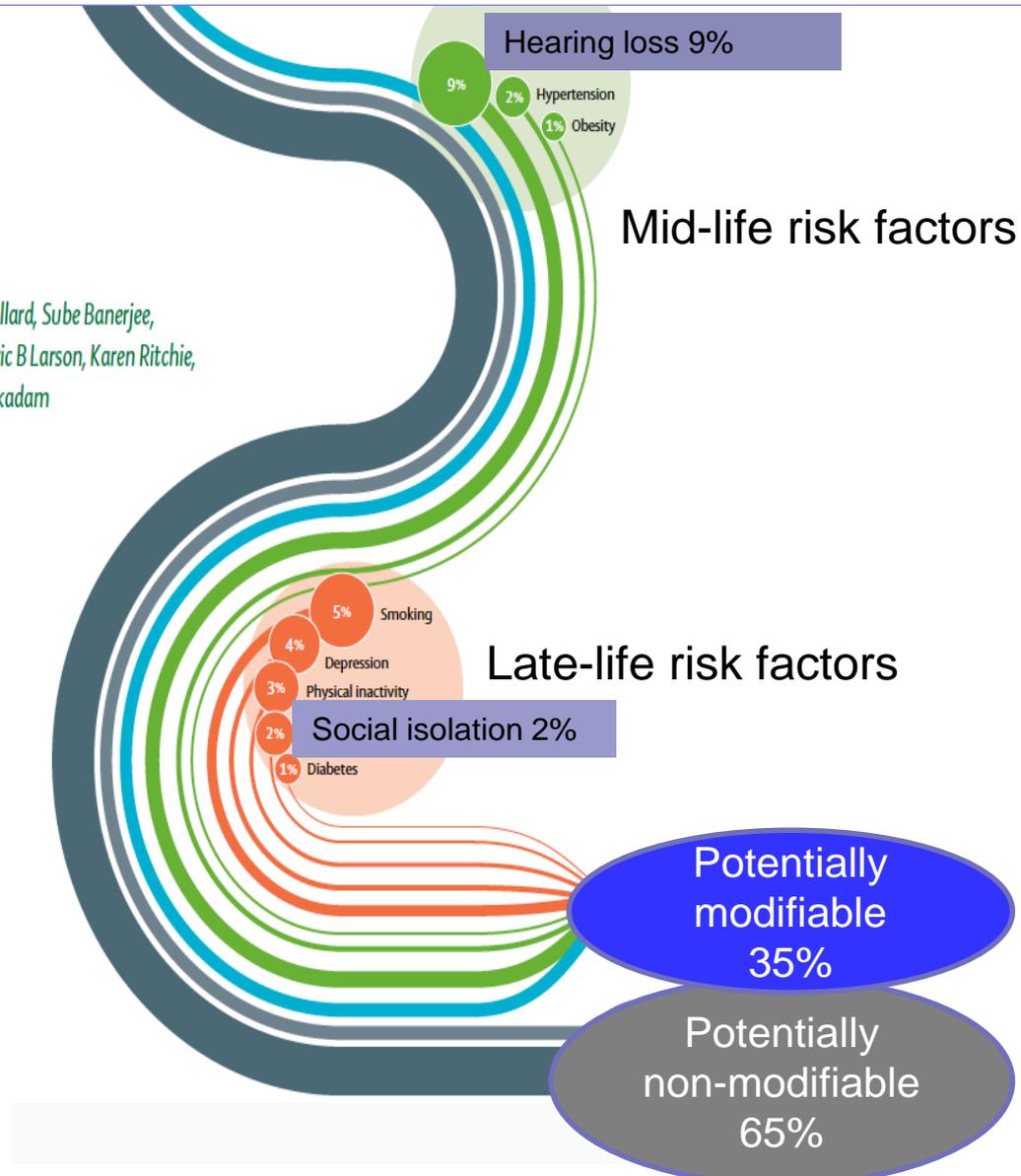
*Gill Livingston, Andrew Sommerlad, Vasiliki Orgeta, Sergi G Costafreda, Jonathan Huntley, David Ames, Clive Ballard, Sube Banerjee, Alistair Burns, Jiska Cohen-Mansfield, Claudia Cooper, Nick Fox, Laura N Gitlin, Robert Howard, Helen C Kales, Eric B Larson, Karen Ritchie, Kenneth Rockwood, Elizabeth L Sampson, Quincy Samus, Lon S Schneider, Geir Selbæk, Linda Teri, Naaheed Mukadam*

### Risk factors for dementia:

#### A life course model

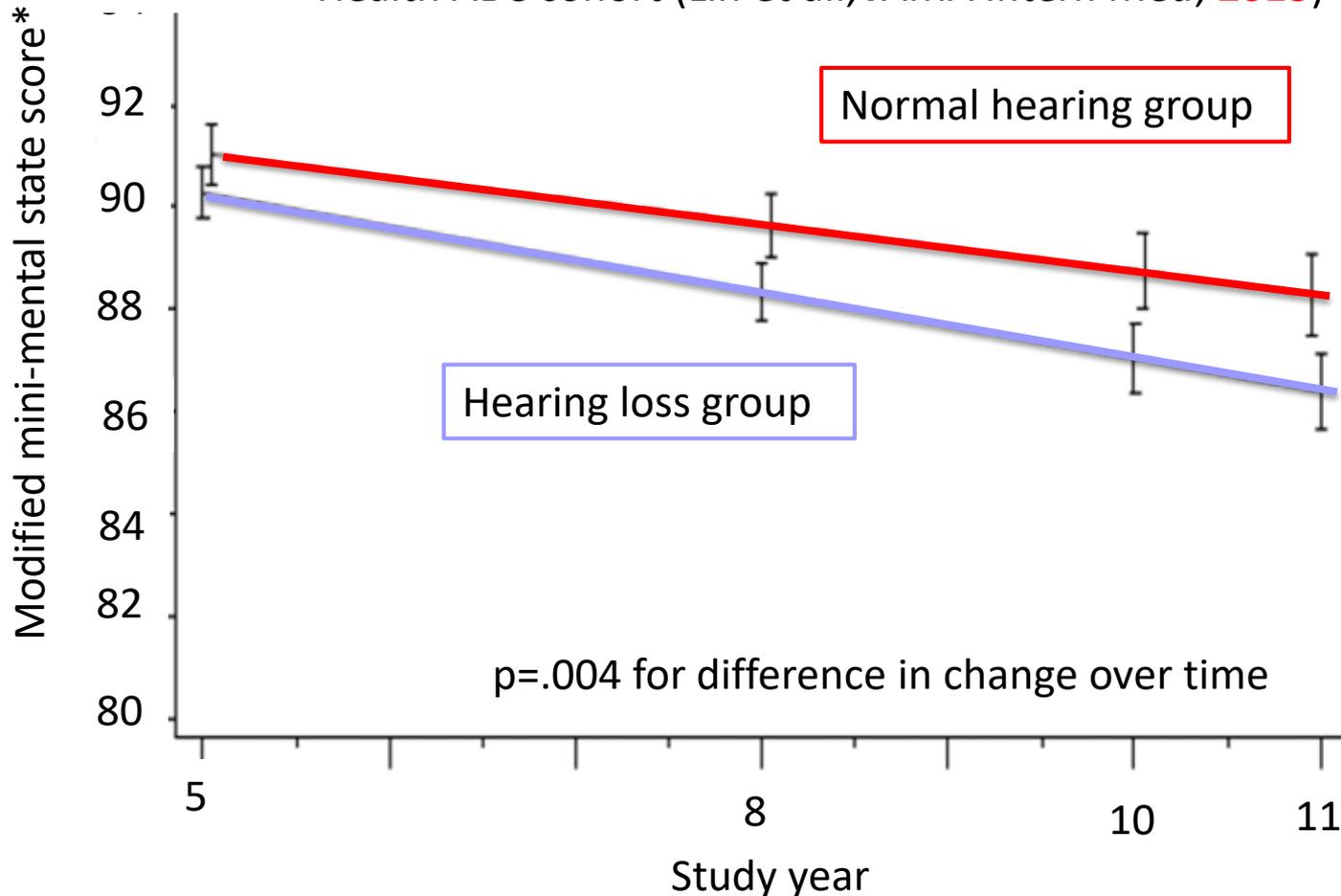
Numbers indicate population attributable fractions

2017



# Hearing loss and cognitive decline

Health ABC cohort (Lin et al., *JAMA Intern Med*, 2013)

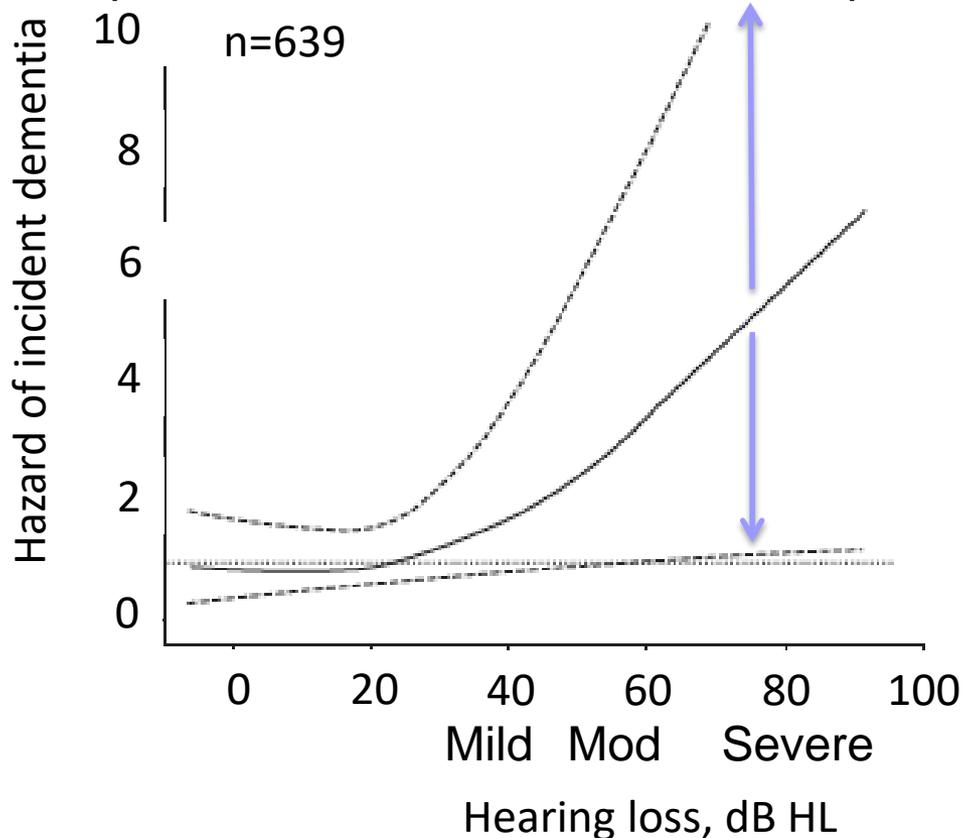


- Note: very similar results for the digit-symbol substitution test

# Hearing loss and Incident Dementia

Baltimore Longitudinal Study of Aging cohort

(Lin et al., Arch Neurol, 2011)



HL severity	HR (95% CI)
mild	1.89 (1.00-3.58)
moderate	3.00 (1.43-6.00)
severe or more	4.94 (1.09-22.4)

Cox proportional hazards model adjusted for age, sex, race, education, diabetes, smoking and HTN. Hazard ratios relative to normal hearing.



January 22nd, 2013  
11:03 AM ET

## Hearing loss may push decline in memory, thinking

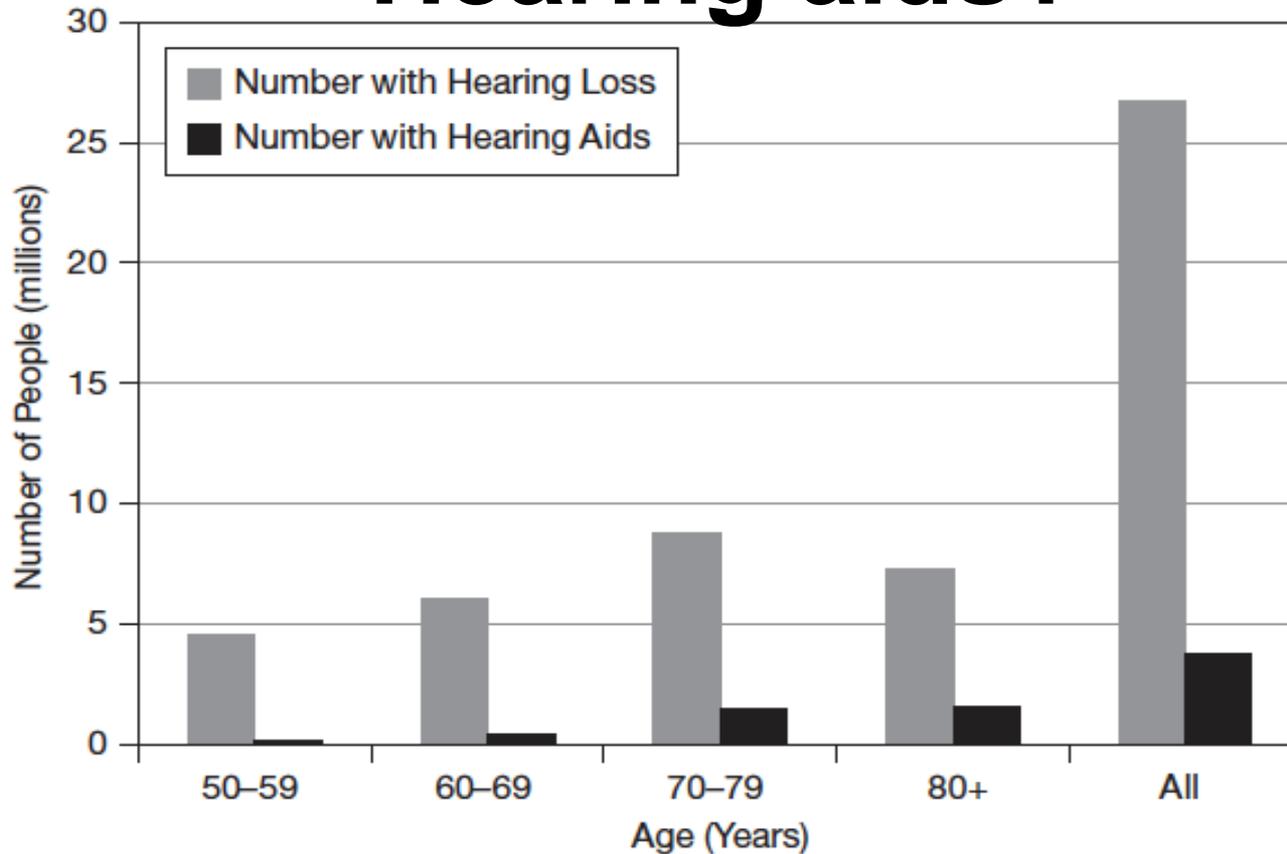
Older Americans who have hearing loss have an accelerated decline in thinking and memory abilities, compared to those with normal hearing, according to a study published in **JAMA Archives of Internal Medicine**.

Those with hearing loss experience a 30% to 40% greater decline in thinking abilities compared to their counterparts without hearing loss, according to the findings published Monday.



PHOTO ILLUSTRATION

# Hearing aids?

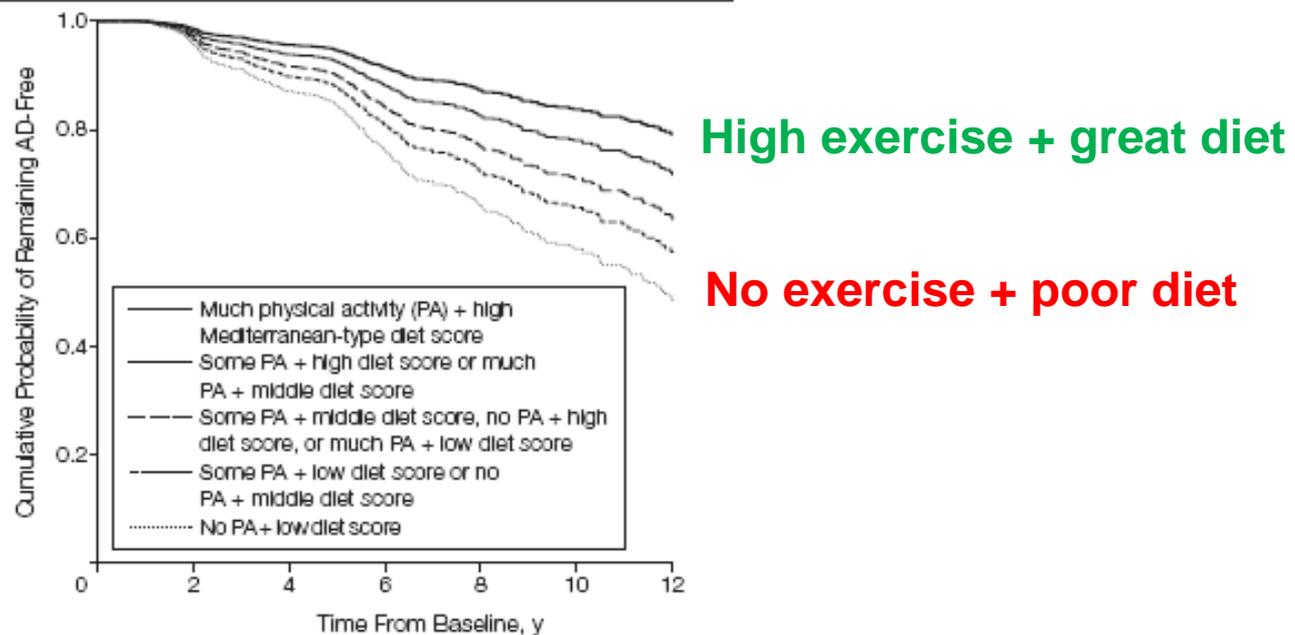


**FIGURE 10.2** Prevalence and number of individuals 50 years or older with hearing loss using hearing aids in the United States.

Source: Adapted from Chien and Lin (2012) based on data from the 1999–2006 National Health and Nutrition Examination Survey.

# Interactive effects of physical activity and diet

**Figure 3.** Alzheimer Disease (AD) Incidence in Individuals by No, Some, or Much Physical Activity and Low, Middle, and High Mediterranean-Type Diet Adherence Scores



No. at risk	0	2	4	6	8	10	12
Much PA + high diet	200	192	141	60	45	35	19
Some PA + high diet or much PA + middle diet	496	470	332	135	106	73	37
Some PA + middle diet, no PA + high diet, or much PA + low diet	573	526	374	168	121	82	35
Some PA + low diet or no PA + middle diet	421	377	241	99	72	48	27
No PA + low diet	190	165	103	39	27	18	9

Scarmeas et al. (2009)  
*JAMA*, 302, 627-637.

Survival curves are based on Cox analysis. No physical activity was defined as a median of 0 hours per week of activity; some physical activity was defined as median of 0.1 hours per week of vigorous, 0.8 hours per week of moderate, 1.3 hours per week of light activity, or a combination thereof; and much physical activity was defined as a median of 1.3 hours per week of vigorous, 2.4 hours per week moderate, or 3.8 hours per week of light activity, or a combination thereof.

# Mild cognitive impairment

(e.g, Troyer & Murphy, 2007)

- Active lifestyle ~ risk of future dementia
  - **Cognitive** engagement
    - Tasks involving problem-solving, decision-making, learning, remembering new information
  - **Social** interaction
    - Rich social stimulation and active social network
    - Participating in group activities and interactions
  - **Physical** activity
    - Some activities are done in groups, with music
- Enriched environments
- Group interventions
- **Sensory-related disorders???**

# Baltimore Experience Corp, Michelle Carlson, Johns Hopkins

<http://www.carlsonlab.org/#!Baltimore%20Experience%20Corps/zoom/mainPage/i3240h>



# Outline

- Sensory changes with age
- Effects on health
- **Effects on everyday activities**

**Aging well with sensory loss**

# Health is...



**Social interaction  
communication**

*“...the capacity of people to adapt to, respond to, or control life’s challenges and changes.”*

(Frankish et al., 1997)



# Person – Environment Interactions

## Physical and Social Environment



# Aging Well: Belonging and Agency

- **Belonging** (experience-driven) – “reflects a sense of positive connection with other people and the environment”
  - *... be who you want to be....*
- **Agency** (behaviour-driven) – “refers to the process of being a change agent in one’s own life by means of intentional and proactive behaviours”
  - *.....do what you want to do.....*

# SOC Model (Baltes)

## Selective Optimization with Compensation

- How to optimize an overall sense of competence
  - Apply three key adaptive mechanisms for aging
    - **Selection**
      - Select subset of options to focus resources on
    - **Optimization**
      - Find best way to achieve goal (e.g., improve by practice)
    - **Compensation**
      - Use alternative route to find solution

### The SOC model

- <http://www.margret-baltes-stiftung.de/PBB-Website/SOC.html>

# Words of an older woman with hearing loss...

*“When you are hard of hearing you **struggle to hear**;  
When you struggle to hear you **get tired**;  
When you get tired you **get frustrated**;  
When you get frustrated you **get bored**;  
When you get bored you **quit**.  
-- **I didn't quit today.**”*



## **Coping with challenge:**

**Quit (Avoid) ~ risk of social isolation**

**Persist (Control) ~ maintain social interactions**

# Social Relationships and Mortality Risk: A Meta-analytic Review

2010

Julianne Holt-Lunstad<sup>1,3\*</sup>, Timothy B. Smith<sup>2,3</sup>, J. Bradley Layton<sup>3</sup>

“Across 148 studies (308,849 participants), the random effects weighted average effect size was OR = 1.50 (95% CI 1.42 to 1.59), indicating a 50% increased likelihood of survival for participants with stronger social relationships.”

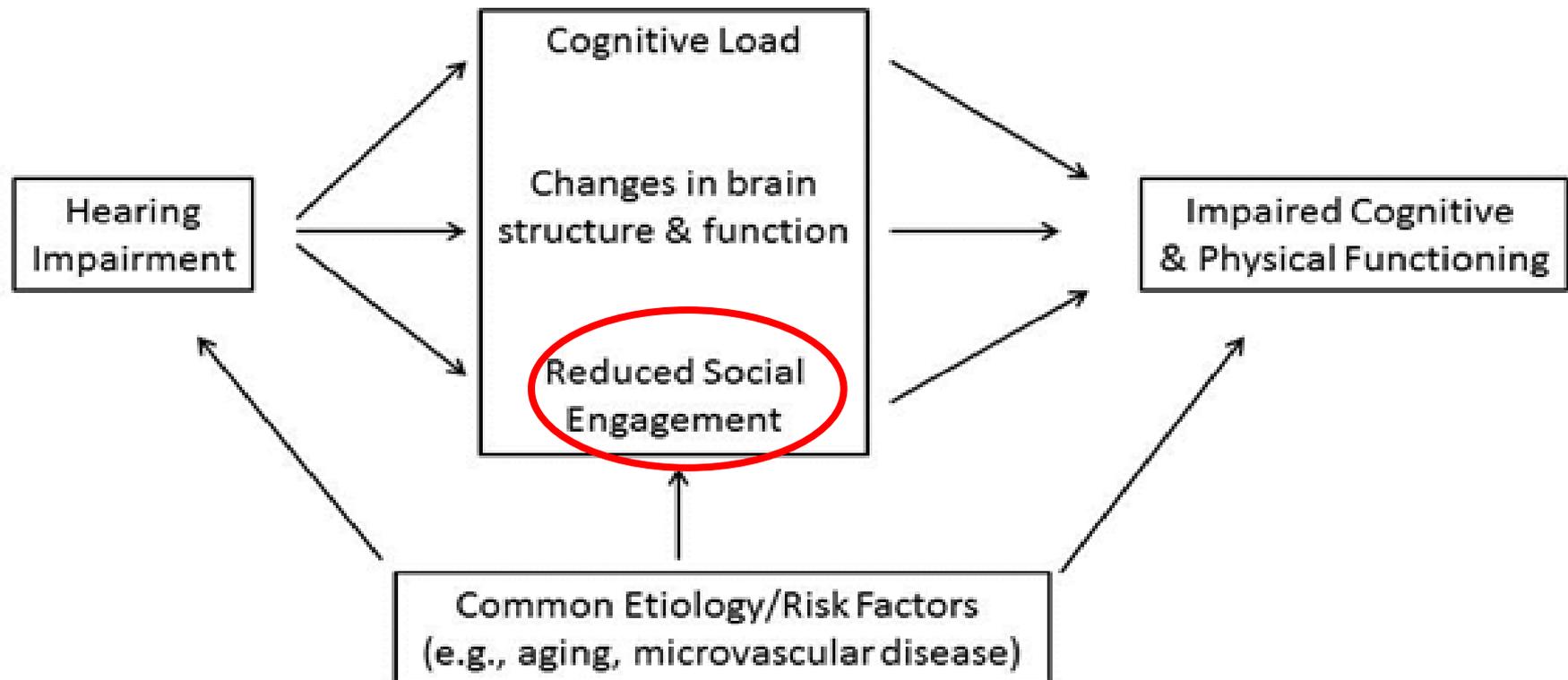
# Hearing Screening & Health

Mick, P.T., & Pichora-Fuller, M.K. (2016).

Is hearing loss associated with poorer health in older adults who might benefit from hearing screening? *Ear and Hearing*.

- The 60-69 year olds with **unacknowledged or unaddressed hearing loss** had significantly increased risk of prevalent **lower cognitive scores** and **social isolation** .

# Cause of Auditory-Cognitive Links?



Possible association between hearing impairment and impaired cognitive and physical functioning in older adults (Lin & Albert, 2014).

# Sensory-Social Links

## A CLSA Tracking Cohort Study

*Canadian Family Physician* Journal (2018)

Mick, Parfyonov, Phillips, Wittich, Pichora-Fuller



### ■ Hearing

□ “Is your hearing, using a hearing aid if you have one...”



- Excellent, very good, good; VERSUS
- Fair, poor/non-existent or deaf

### ■ Vision

□ “Is your eyesight, using corrective lenses if you have them...”



- Excellent, very good, good; VERSUS
- Fair, poor/non-existent or blind

# Outcome Measures

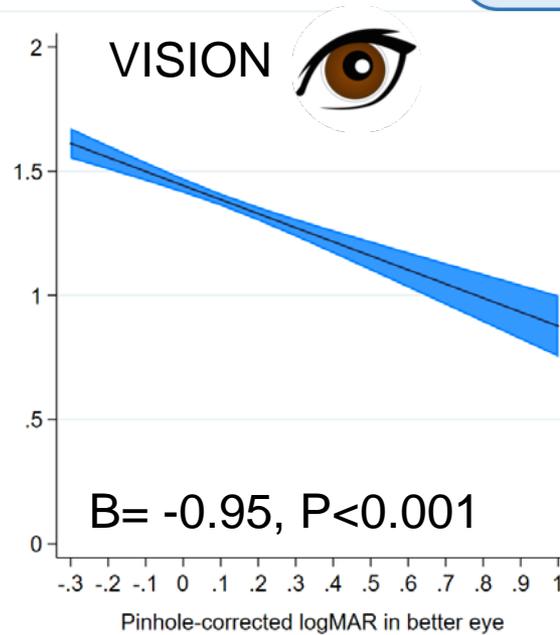
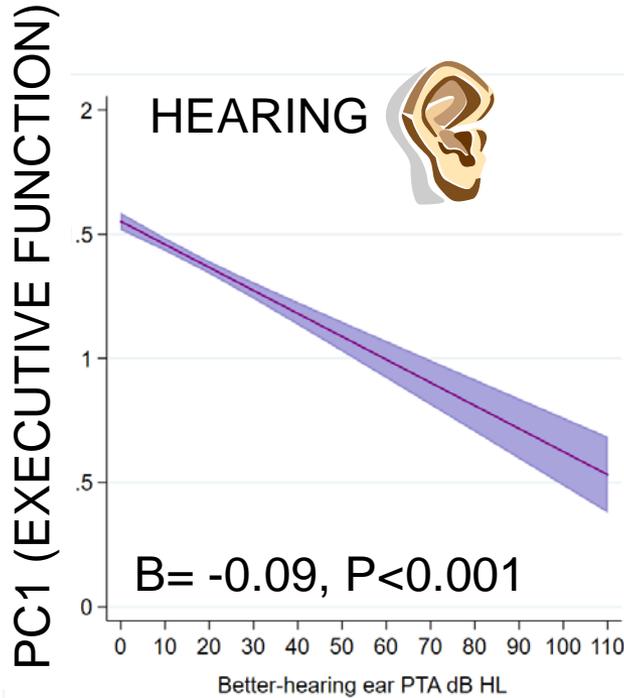
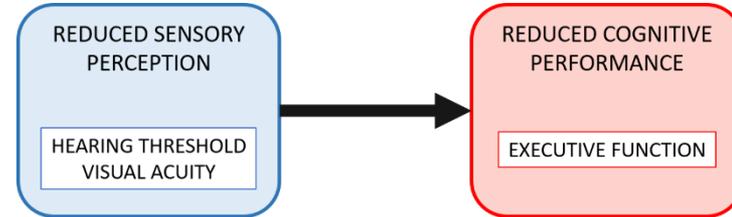
- Social network diversity
- Social participation
- Availability of social support
- Loneliness



# Summary of significant results

	Hearing loss	Vision loss	Dual loss
Low social network diversity		X (men)	X (age 65-85)
Low social participation		X	X (age 65-85)
Low availability of social support	X	X	X
Loneliness	X	X	X

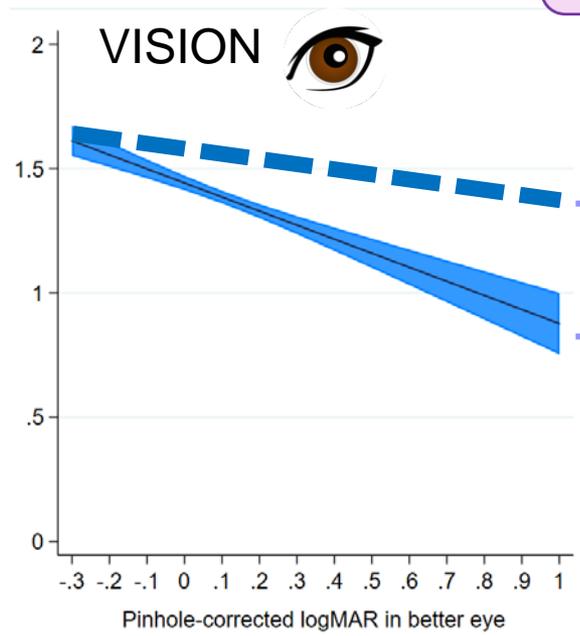
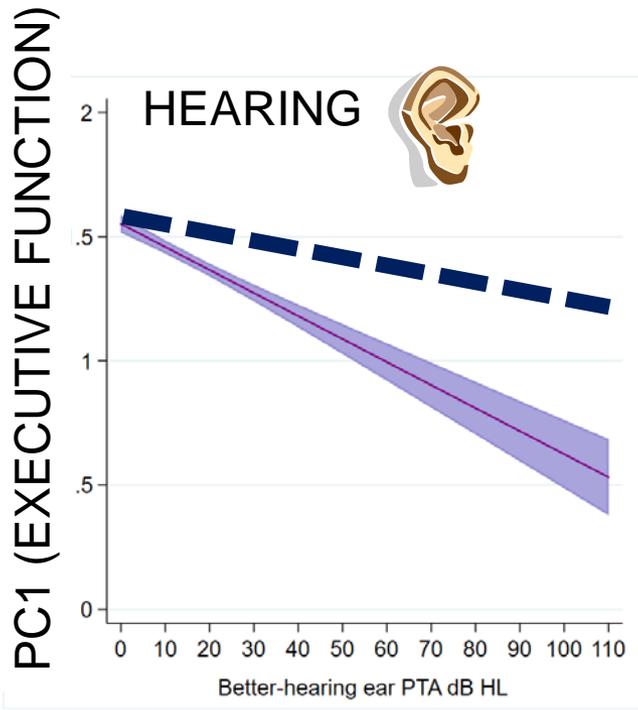
# Is sensory decline directly associated with cognitive decline (N = > 30,000)?



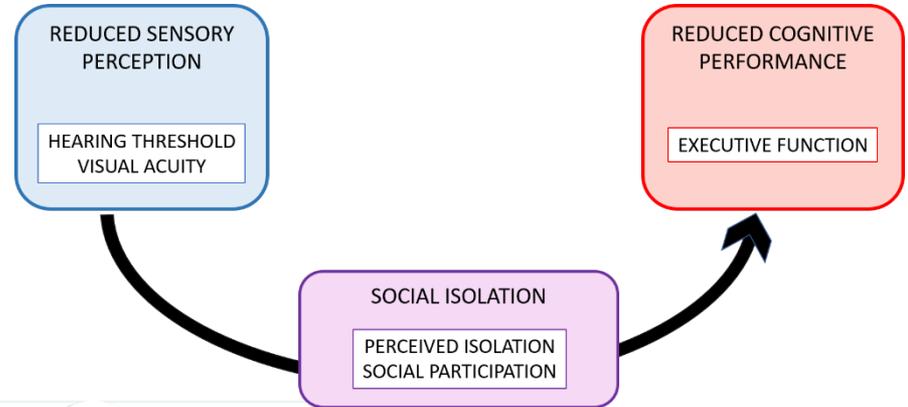
**YES.** Those with worse hearing and vision also have lower cognitive scores.

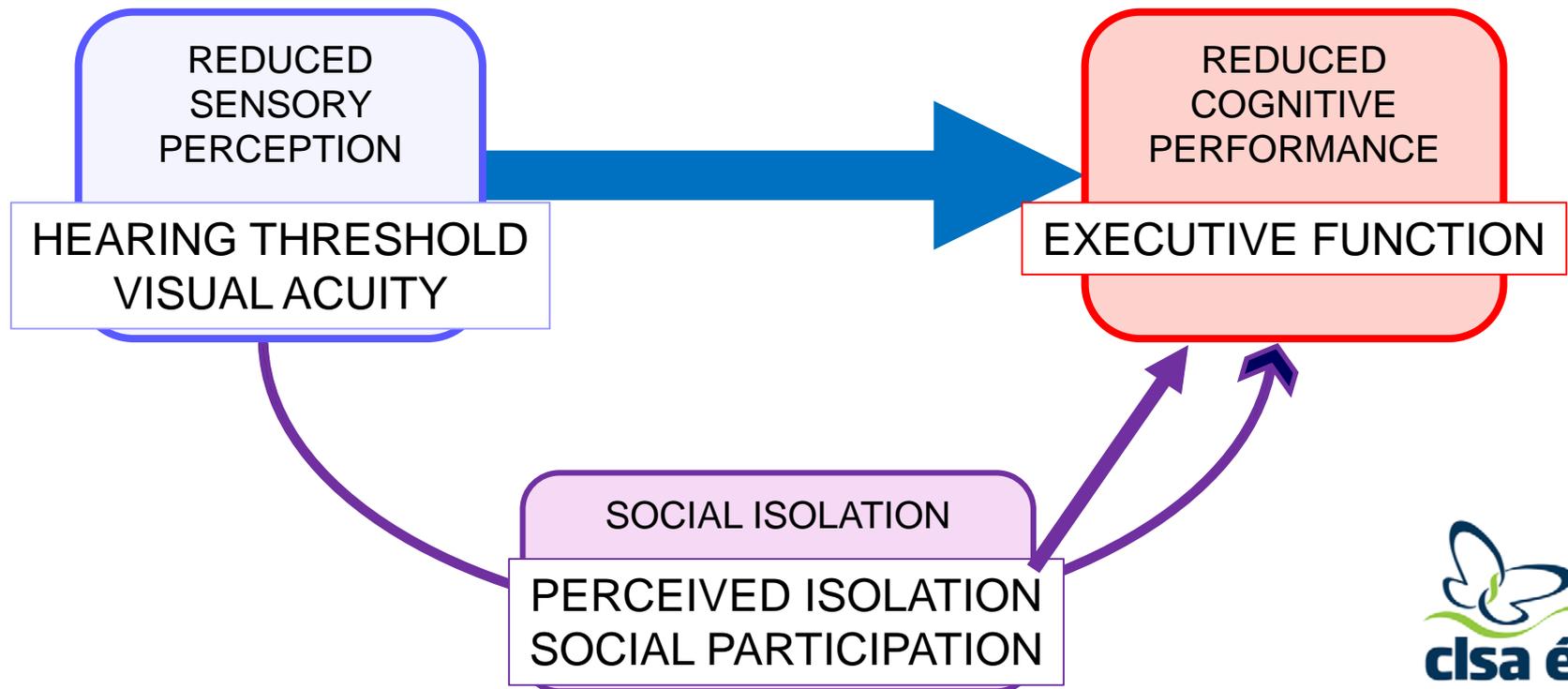
Predicted relationships from **Model 1** adjusting for vision and hearing thresholds, age, sex, cultural background, education, income, number of comorbidities, test language, bilingual status

# Is the sensory-cognitive association mediated by social participation?



+ social variables  
 Mediation effect  
 Direct effect



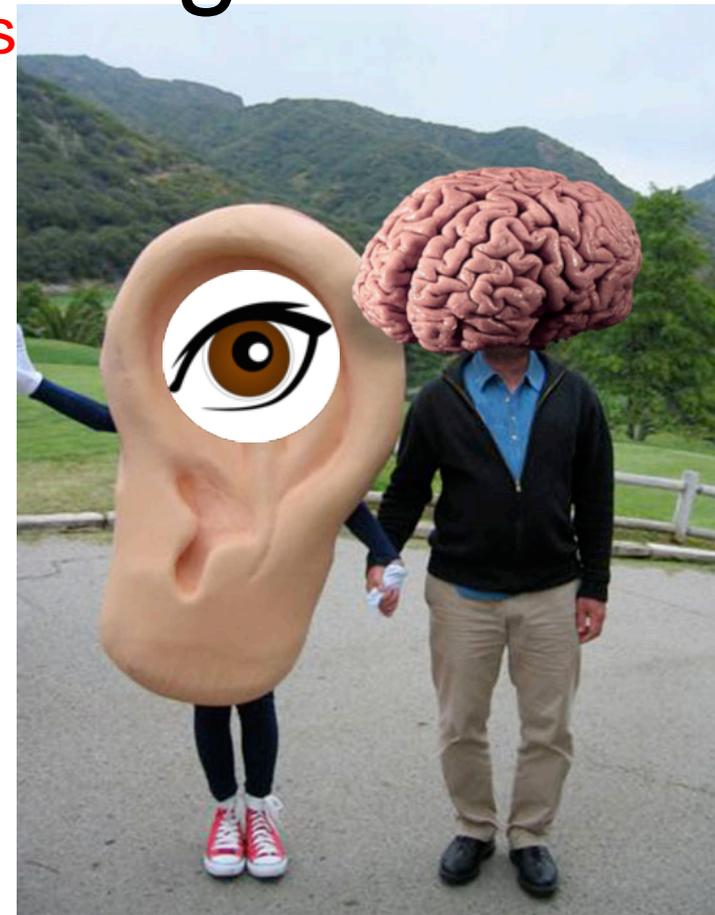


- 1) Sensory function and social isolation directly associated with cognition
- 2) Sensory-cognitive association weakly mediated by social isolation

*“use it or lose it”*

# What could we change?

- **Earlier identification of sensory problems**
  - Primary care/home care/geriatric care
  - E-health, do-it-yourself
- **Better inter-professional team work**
  - Optimize health communication
  - Sensory-friendly testing/assessment
  - Decision-making in light of multi-morbidities
- **Self-management, rehabilitation, policy**
  - Appropriate design/use of technologies
  - Changing personal behaviours and social attitudes (stigma)
  - Increasing accessibility, sensory-friendly communities
- **Longitudinal and intervention research**



<http://blogs.crikey.com.au/culture-mulcher/2010/07/12/genius-radio-the-nerve/ear-brain/>