

# Visual impairment and speech understanding in older adults with acquired hearing loss



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# Vision an important component of speech communication

*'The profession of audiology has not been consistent in acknowledging the visual component of everyday communication. For example, most hearing assessment and hearing aid selection/ adjustment/programming techniques exclude the visual component completely, and appear to treat the person with impaired hearing as they were totally blind.'*

Erber, 2003, p. 2S23

*In what way do your intervention services take into account the vision component of your client?*

# Vision and speech communication

*Given that much daily interaction occurs face-to-face, the visual component of communication must be seriously considered in the overall rehabilitation process*

Erber, 2003, p. 2523

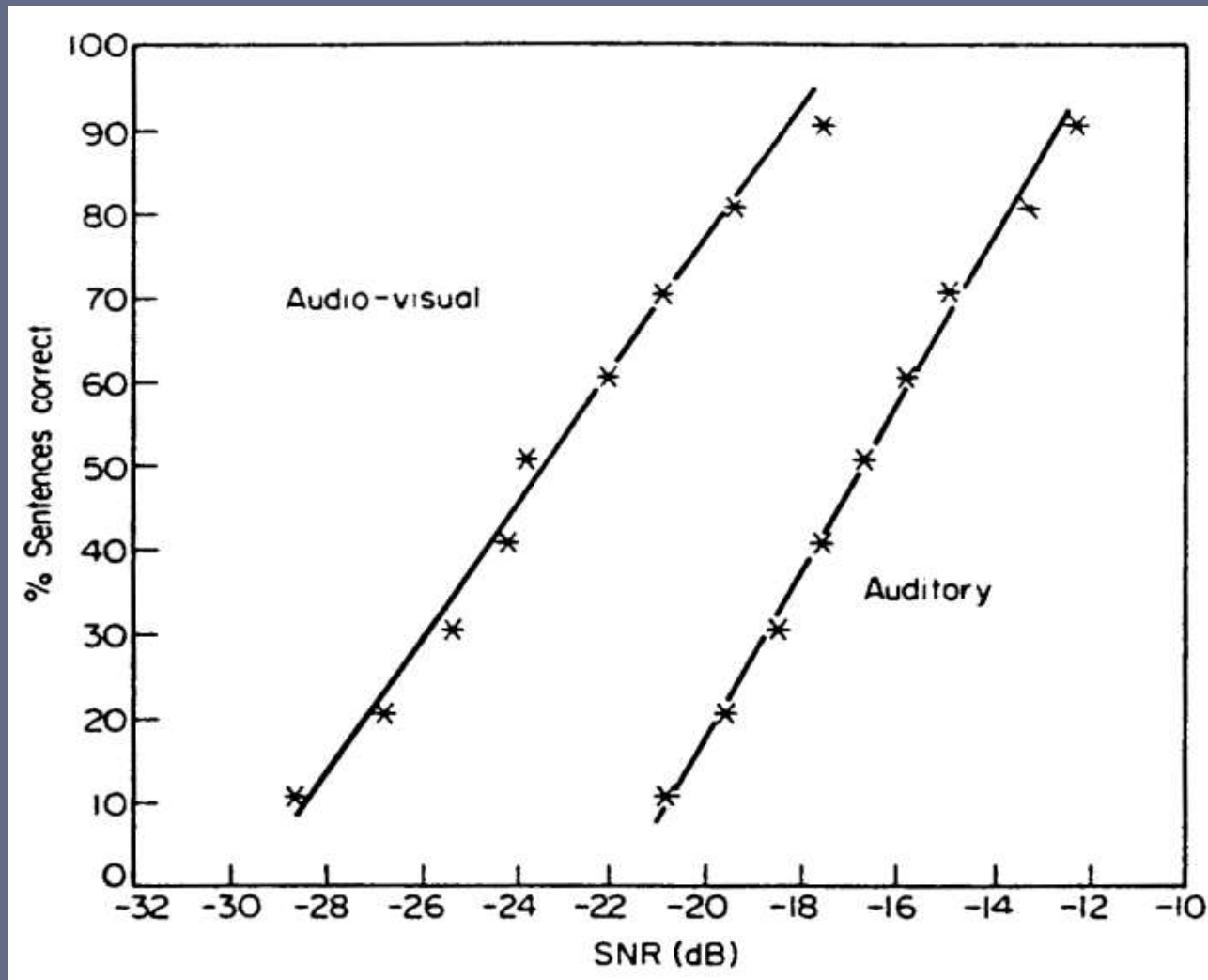
There is more and more evidence to suggest that speech-perception is an audiovisual phenomenon.

Except in some specific situations (e.g., telephone) the interlocutor has access to the visual-speech cues produced by the talker.

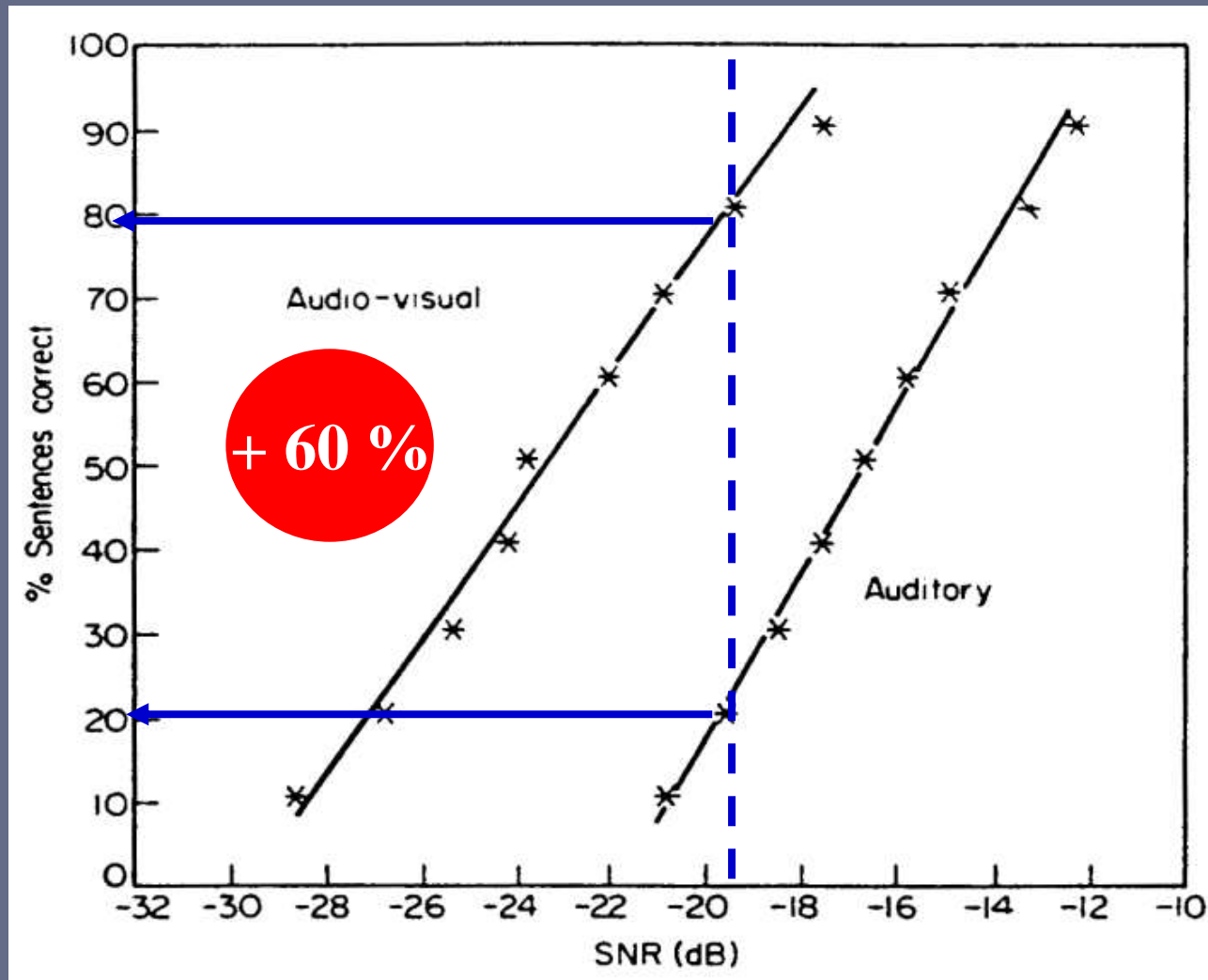
# McGurk illusion



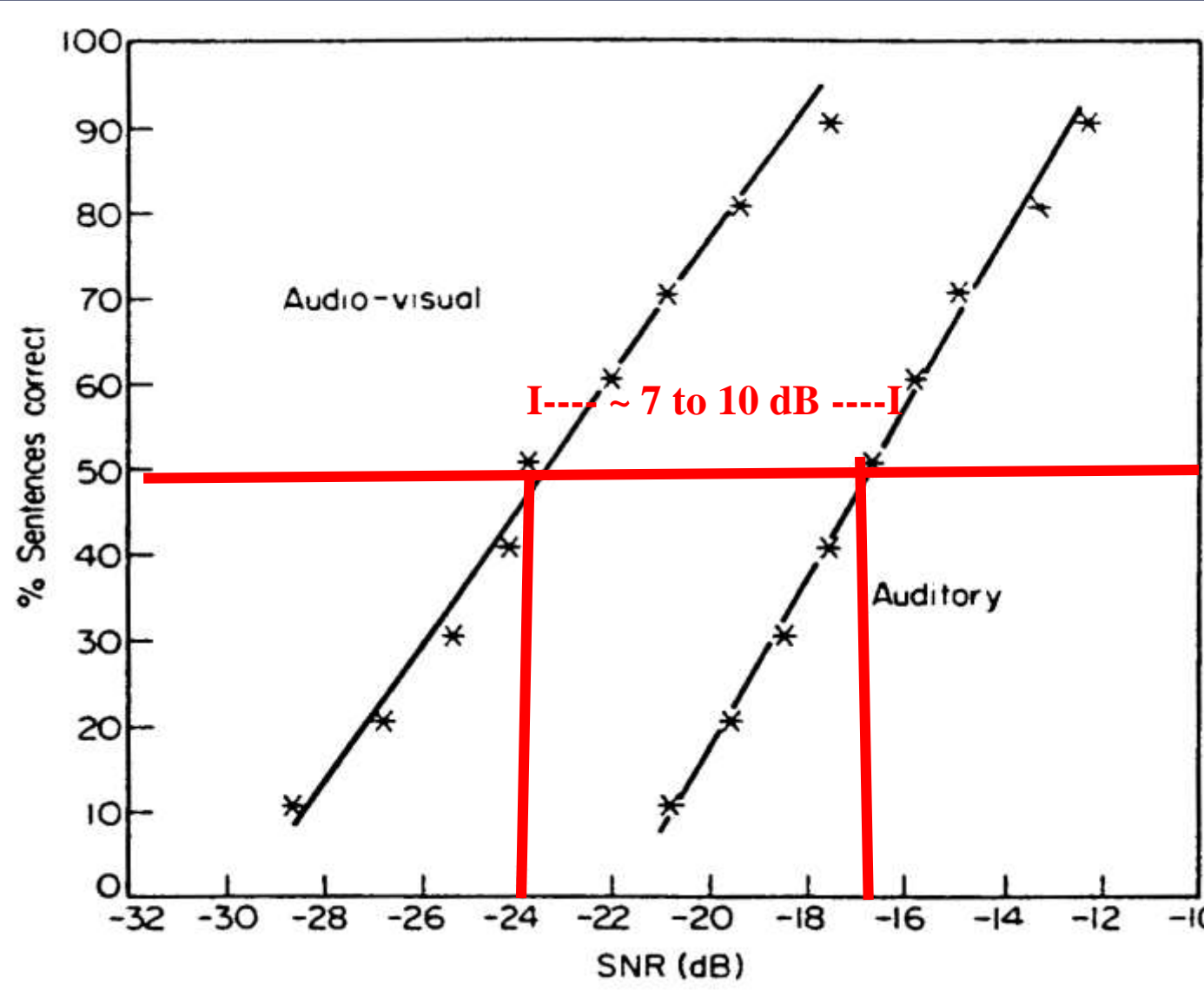
# Benefits of providing visual speech cues



# Benefits of providing visual speech cues



# Benefits of providing visual speech cues



Sumby & Pollack, 1954 showed improvements in SNR ranging from 5 to 18 dB

# Benefits of providing visual speech cues

Using a divided attention task (a dual task paradigm), with normal-hearing young adults we have shown that, relative to A-alone performance, providing visual-speech cues significantly:

**Improves Performance**

**Improves Response time**

**Decreases Effort**

...on a sentence recognition task

Fraser, Gagné, Alepins, Dubois, JSLHR, (2010)



# Speechreading (V-alone) in OA with normal (or corrected normal) visual acuity

There is an effect of age for words and sentences

Performance decreases as a function of age:  
likely beginning as early as the 5th decade  
certainly by the 7th decade

Dancer et al., 1994; Shoop & Binnie, 1979; Campbell et al., 2007;  
Spehar et al., 2004; Sommers et al. 2005, Tye-Murray et al., 2007  
Walden et al., 1993

# Speechreading (V-alone) in OA with normal (or corrected normal visual acuity)

There is an effect of age for words and sentences

Speechreading for words better in OA with hearing loss than OA with typical hearing

Tye-Murray et al., 2007

Despite speechreading differences in performance observed between OA and YA there are no differences in the patterns of confusion made between the 2 groups

Walden et al. 1993

# AV-Speech-perception in OA with normal (or corrected normal) visual acuity

## Audiovisual integration

Walden et al. 1993, compared middle-aged adults with HL and OA with similar HL

He concluded:

- OA benefit as much from the provision of visual cues to supplement their impaired auditory speech recognition performances as do middle-aged adults with impaired hearing
- OA are similar to YA in their ability to integrate audio and visual speech cues

# AV-Speech-perception in OA with normal (or corrected normal) visual acuity

## Audiovisual integration

- Helfer (1998) found that age was not related to AV benefit (i.e., OA and YA similar benefits)
- Cienkowski and colleagues (2002, 2004) there are no age related declines in AV integration

# AV-Speech-perception in OA with normal (or corrected normal) visual acuity

## Audiovisual integration

Sommers et al., 2005:

No age difference in A-enhancement or V-enhancement when v-alone performance was taken into account.

### ***Conclusion:***

***Poorer AV scores for OA due to poorer V-scores***

***No age difference in ability to integrate AV information***

# AV-Speech-perception in OA with normal (or corrected normal) visual acuity

## Take home message

Older adults :

Poorer A-alone than YA;

Poorer V-alone than YA

AV-integration:

OA appear to Integrate as well as YA but verdict not definitive

**However, there is no doubt that in OA with good vision, AV-performance is better than A-alone or V-alone**

**Conclusion:**

**AR services need to promote the use of VISION to enhance auditory speech understanding.**

What about the effects of visual  
impairment on AV-speech  
understanding

# Visual impairments in older adults

Generally estimated that between 9 and 18% of older adults (< 65 yrs) have a visual impairment



# Dual (hearing and vision) impairments in older adults

Brennan, Horowitz and Sue (2005) who found that 20% of seniors over the age of 70 presented with dual sensory impairment.

Up to 1 in every 5 OA that consults a hearing care professional because they have hearing problems also have significant (uncorrectable) vision problem!

# Visual impairments

Visual acuity:

A very basic (simplistic) measure of visual ability

The ability to identify symbols (often letters) of different sizes from a predetermined distance. (use of eye charts)

Normal visual acuity:

The ability that people with normal vision have to identify a visual symbol of a standardized size that is located at a distance of 20 feet (6 meters) from the participant

Normal visual acuity is: 20/20 (6/6)

# Visual impairments

Visual acuity:

Moderate visual impairment loss: e.g., 20/100 (6/30)

The person can identify at a distance of 20 feet what people with normal visual acuity can identify at 100 feet

Severe/profound vision loss: e.g., 20/200 (6/60)

The person needs to be at 20 feet to identify what people with normal visual acuity can identify at 200 feet

Often the criteria used to define 'legal blindness'

# Vision impairment

## Four major eye diseases that occur in OA:

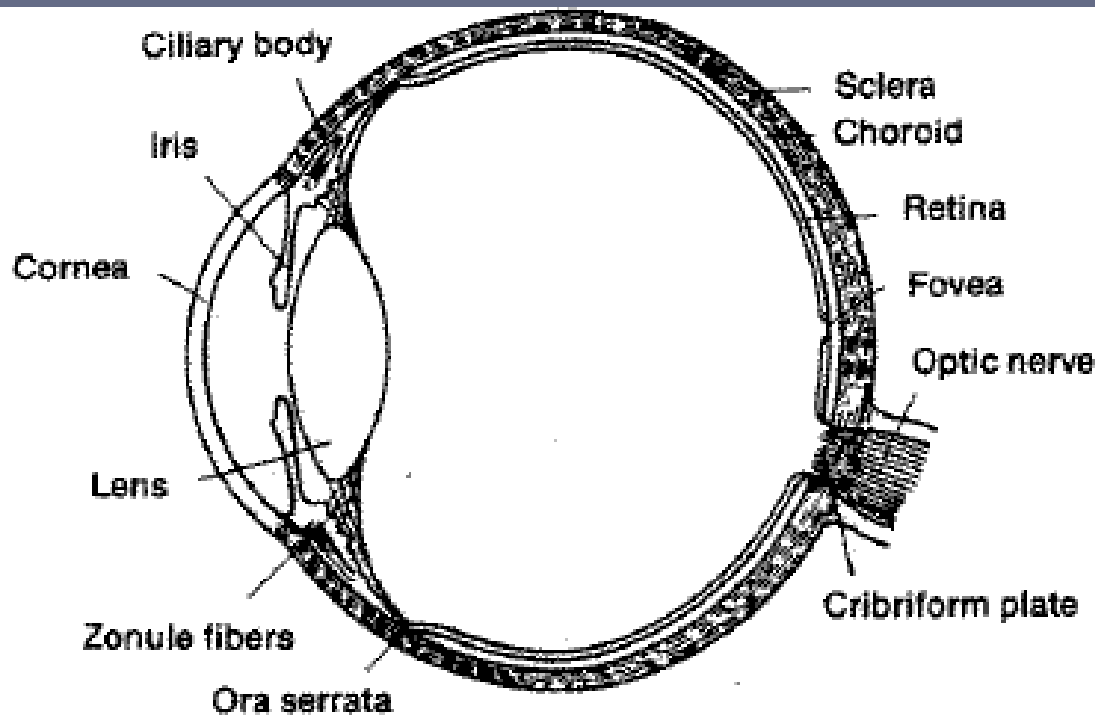


Figure 2-11 Section through the globe.

- Cataracts
- Macular degeneration
- Diabetic Retinopathy
- Glaucoma

# Normal visual perception



# Visual impairments in OA

## Cataracts:

Most common in OA

Clouding of the lens

Scattering of incoming light

Can be treated by surgery – lens replacement)



# Visual impairments in OA

## Glaucoma:

High fluid pressure within the eye

Apoptosis (death of cells) of retinal ganglion cells

Can damage optic Nerve and reduce Vision mainly in the Peripheral visual field



# Visual impairments in OA

## Diabetic Retinopathy:

Growth of unstable blood vessels that can bleed and scar the retina

Obscures incoming light

Damage of sensory cells

Causes patchy vision





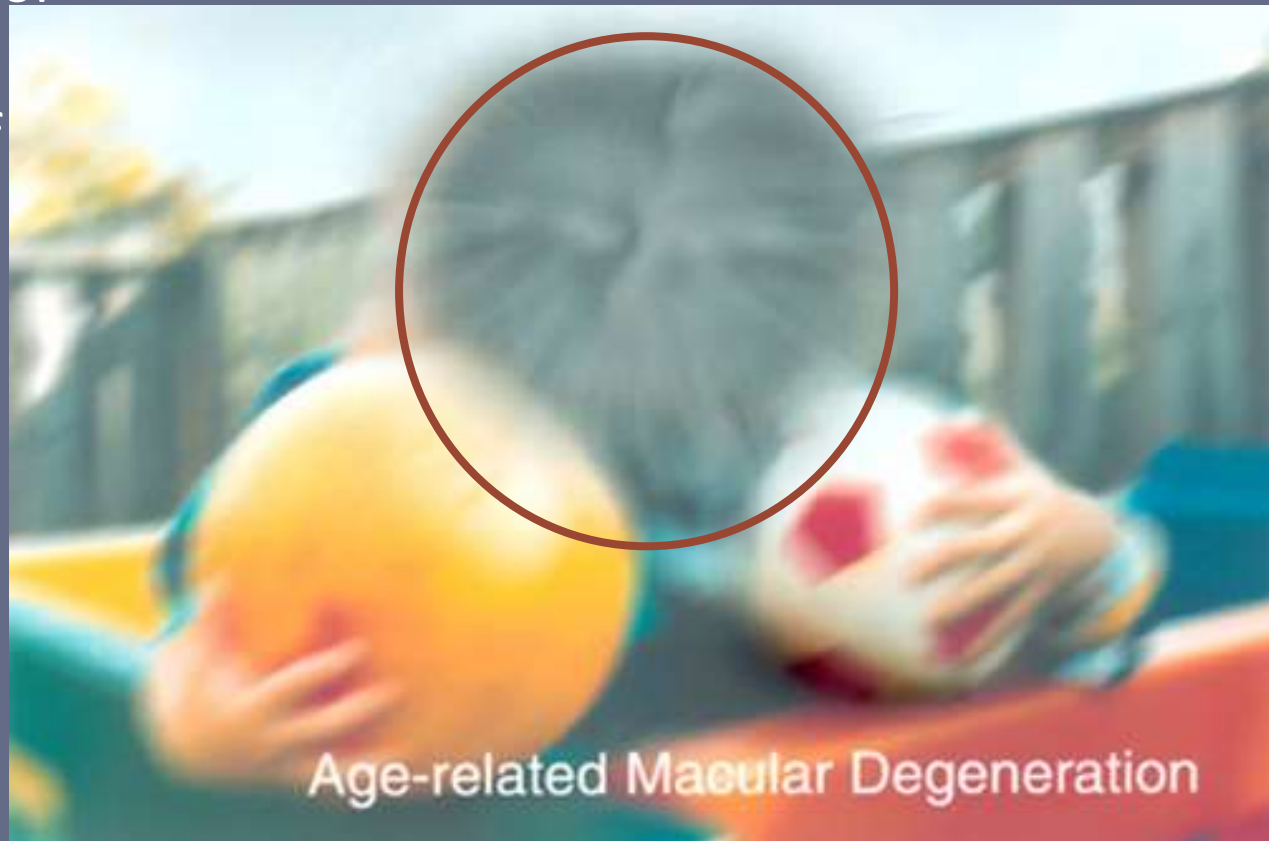
# Visual impairments in OA

## Age-related Macular degeneration (AMD):

Progressive photoreceptor loss in the central visual field (the central part of the retina – the macula)

Loss of vision (partial or complete) in the central part of the visual field

For most, this disorder cannot be resolved medically or surgically.



Age-related Macular Degeneration

# Visual impairments and Speech perception

Effects of poor visual acuity on Visual-only speech-perception.

Hardick, Oyer, & Irion (1970)

Conclusion:

Even a minor deviation in distance visual acuity in either or both eyes can cause speechreading performance to be significantly reduced

.

# Visual impairments in OA

## Visual acuity and visual speech-perception

Johnson and Snell (1986)

Speechreading and distance visual acuity in a group of 786 deaf college aged students (NTID)

## Conclusions

Speechreading performance will be deleteriously affected if visual acuity worse than 20/40 (6/12), in the better eye.

# Visual impairments in OA

Visual acuity and audiovisual speech-perception

# Erber 1979

Investigated the effects of reduced visual acuity on speechreading performance

Used translucent plexiglas (like the doors that are sometimes used in showers) to blur vision (simulate degrees visual acuity impairments)

The image seen by the observer becomes more and more blurred as the distance from the talker and the plexiglas increases

Simulated visual acuity impairments from 20/20 to 20/400



# Erber 1977: the shower study

## Participants:

2 YA (normal visual acuity and normal hearing)

14 young adolescents with severe or profound hearing loss

## Test conditions:

Used words presented visually-only and AV

# Erber 1977: the shower study

## Results:

If visual acuity is worse than 20/200 (6/60); the provision of visual speech cues does not improve auditory speech perception visual

## Conclusion:

under poorer optical conditions it seems that speechreading can serve only as a minimal aid to listening.



# Visual impairments in OA

Visual acuity and audiovisual speech-perception

# Hickson et al 2004

## Study objectives

- ☐ Does providing visual speech cues (in addition to auditory cues, improve speech-perception performance in OA?
- ☐ Is there a relationship between visual acuity and benefit provided by the addition of visual-speech cues

# Hickson et al 2004

Participants 77 OA

hearing:

36% had normal hearing

40% had a mild hearing loss

23% had moderate or greater loss

Vision:

66% had normal (normal corrected) visual acuity

34% had distance vision impairment

9 % had both near and distance vision impairments

# Hickson et al 2004

## Results:

The provision of visual-speech cues results in an average improvement of 28%

The correlation between visual acuity and benefit from visual speech cues was not significant (but there was a trend)

This likely due to the fact that most of the OA who took part in this study had normal or only a mild visual impairment

# Visual impairments in OA

## Visual acuity and audiovisual speech-perception

**informa**  
healthcare

### Original Article

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International Journal of Audiology 2010; 49: 904–911

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### **The effects of blurred vision on auditory-visual speech perception in younger and older adults**

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# Legault et al., (2010)

Investigate the effects of blurred vision (poor visual acuity) on AV-speech perception in YA and OA

Participants:

16 YA and 16 OA

-normal hearing (to at least 3KHZ)

-normal or corrected normal visual acuity

# Legault et al., (2010)

## Task:

Close set sentence recognition in noise  
noise set to yield  $\approx 50\%$  in YA

## Conditions:

A-alone in noise (yield approx. 50% in YA)

AV – 20/20 in noise (6/6)

AV 20/100 in noise (6/30)

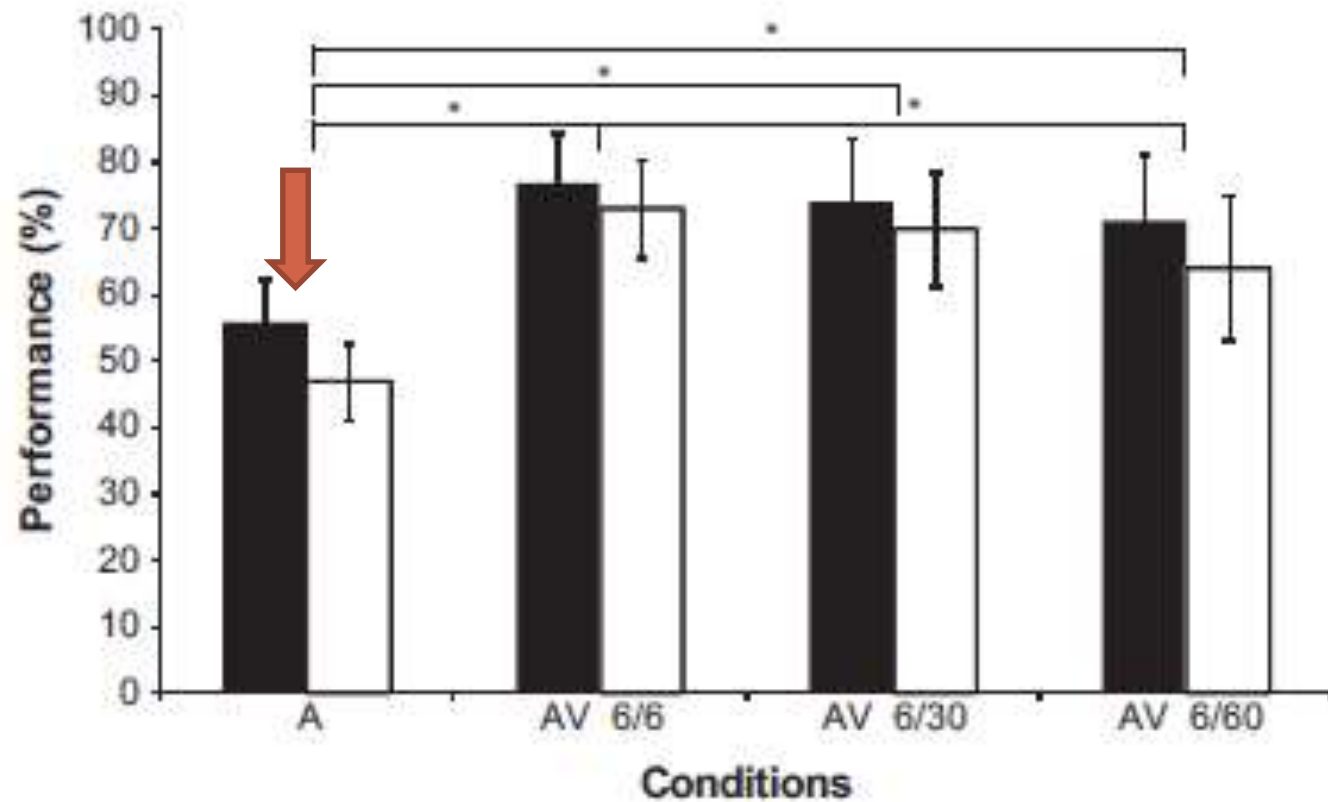
AV 20/200 in noise 6/60)

## Legault et al., (2010)

Optical lenses used by opticians were used to blur vision (to simulate visual acuity)

The lenses were individually adjusted so that, on the eye-chart test, the participant performed at the level expected from someone with a visual acuity impairment equal to the experimental condition tested (e.g., the minimum blurring required to read the corresponding line on the eye chart)





**Figure 1.** Mean percent correct keyword recognition scores ( $\pm 1$  s.d.) as a function of experimental conditions for younger (dark bars) and older adults (light bars). The four experimental conditions were: (1) Auditory-alone (in noise); (2) Audiovisual in noise with visual acuity adjusted to 6/6; (3) Audiovisual in noise with visual acuity adjusted to 6/30; 4. Audiovisual in noise with visual acuity adjusted to 6/60. An asterisk (\*) above the data points indicate that the difference between the experimental conditions was significant at the  $< 0.001$  level.

# Sentences list

- PILOT
- BABY
- POLICE
- TEACHER
- CAPTAIN
- STUDENT
- BUTCHER
- SLEPT
- ATE
- RAN
- JUMPED
- WALKED
- SAT
- READ
- ☐ BOAT
- ☐ TABLE
- ☐ CAR
- ☐ BENCH
- ☐ CHAIR
- ☐ PLANE
- ☐ BUS



# AUDITORY ONLY CONDITION

- The baby sat on the bench
- The butcher jumped on the boat
- The pilot ran on the plane
- The teacher slept on the chair
- The student read on the table
- The police walked on the car
- The captain ate on the bus
- The baby slept on the plane
- The teacher walked on the boat
- The pilot jumped on the bench

# AUDIOVISUAL CONDITION

- The pilot slept on the boat
- The baby ate on the table
- The butcher read on the car
- The captain ran on the bench
- The police jumped on the plane
- The student sat on the bus
- The teacher walked on the boat
- The baby ate on the chair
- The captain slept on the car
- The police sat on the table

# AV 20/100 CONDITION

- The pilot slept on the boat
- The baby ate on the table
- The butcher read on the car
- The butcher ran on the bench
- The police jumped on the plane
- The student sat on the bus
- The teacher walked on the bus
- The baby ate on the chair
- The captain slept on the car
- The police sat on the table

# AV 20/200 CONDITION

- The student ran on the boat
- The teacher sat on the chair
- The baby slept on the table
- The butcher read on the table
- The police ate on the bench
- The captain ran on the bus
- The pilot walked on the car
- The butcher ate on the boat
- The teacher jumped on the bus
- The student slept on the bench

# Legault et al., (2010)

## Conclusions:

1. There is a significant group difference in the AV benefit provided by the provision of visual cues. This difference is mainly explained by the group differences in the A-alone condition.
2. Provision of visual-speech cues improves auditory perception for both YA and OA
3. AV speech-perception performance is significantly better than A-alone performance even when the level of blurring is set to simulate a visual acuity of 20/200.



# Take home message

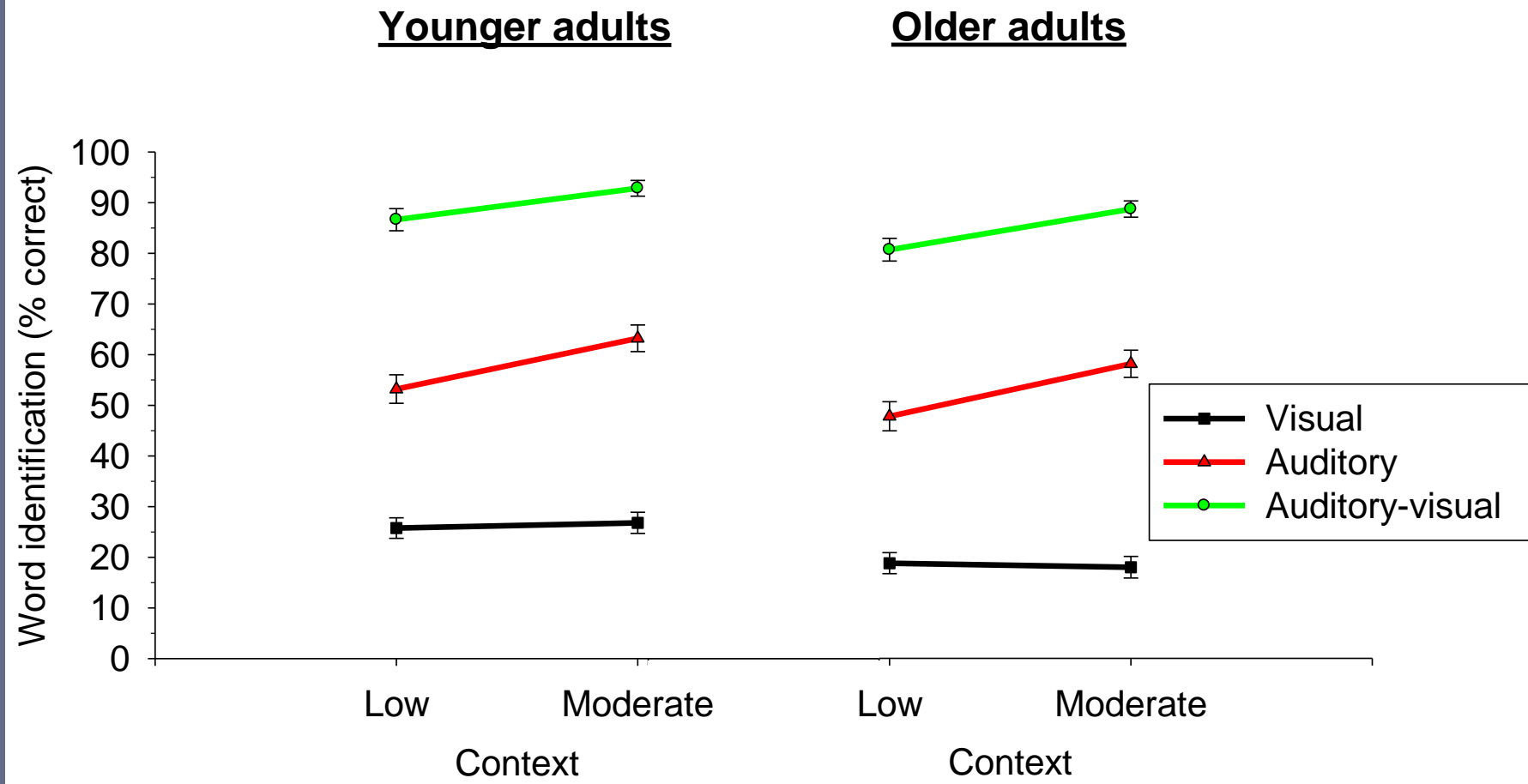
- ❑ The provision of Visual speech cues greatly improves auditory-speech perception in YA and OA
- ❑ Many OA with hearing loss also have some form of (correctable or non correctable) visual impairment)
- ❑ In AR it is important to investigate/question OA about any possible visual impairment
- ❑ It is important for OA to maintain appropriate vision health care

# Take home message

- ❑ Even old adults with severe visual impairments are likely to benefit from visual speech cues to improve their speech understanding performance (and to reduce the effort required)
- ❑ It is important to include visual- and AV- speech-perception in rehabilitative services provided to OA with hearing loss

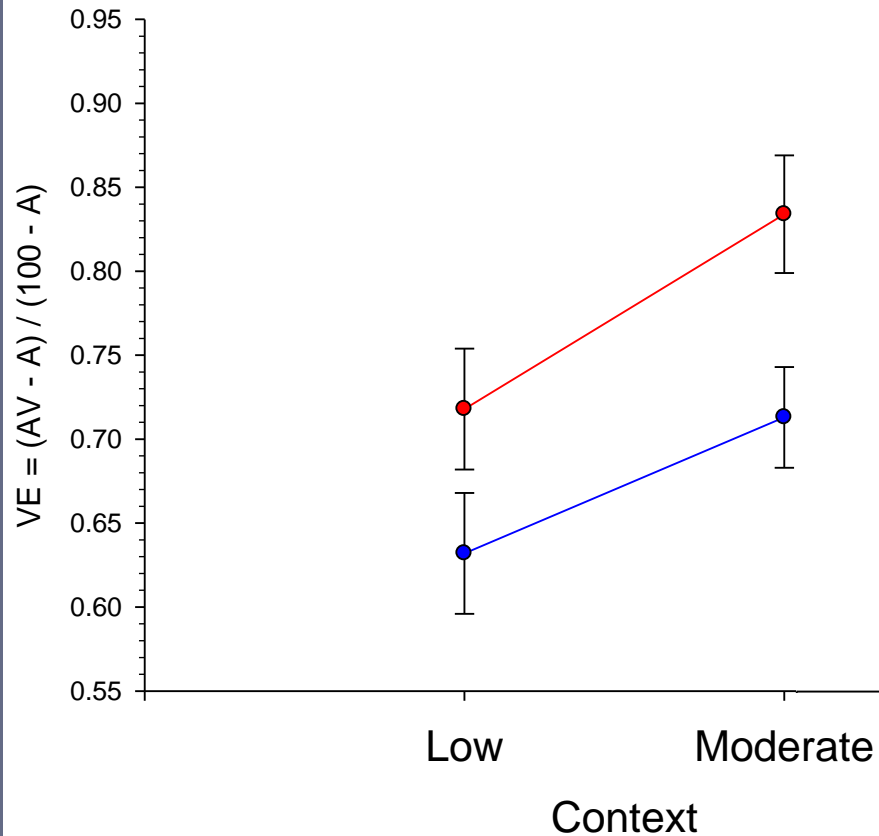
Dankie      Takk      Bedankt  
Dziękuję      Děkuji  
Thank you      Tak      Vielen Dank  
Tänu      Grazie      Merci  
Kiitos      Tack      Gracías  
ขอบคุณ      Спасибо

# Sentence Word Identification Rate as a Function of Modality and Context

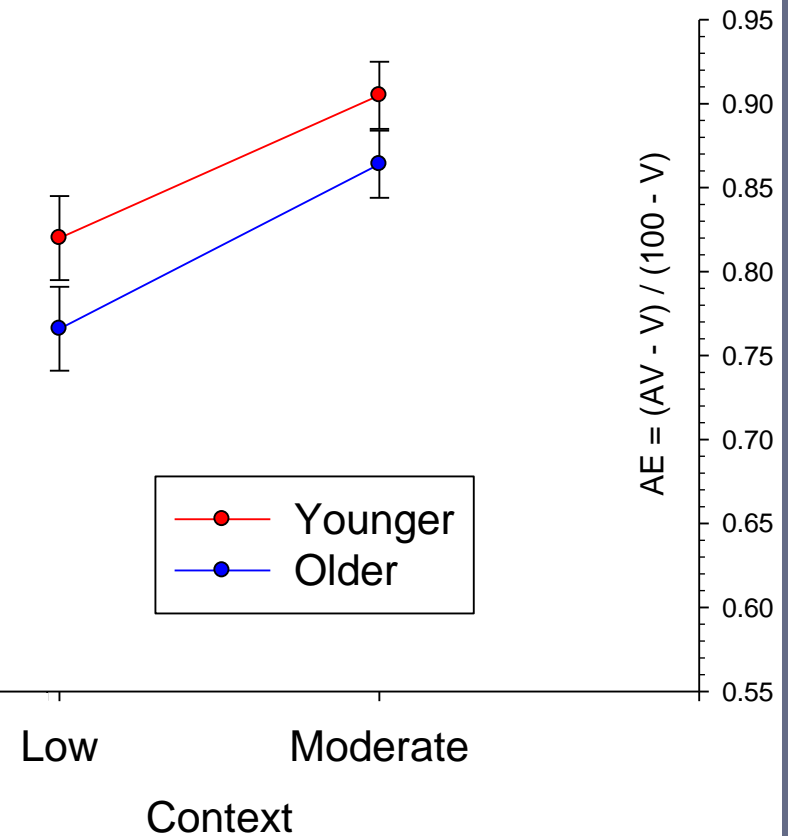


# Sentence Perception Enhancement Scores

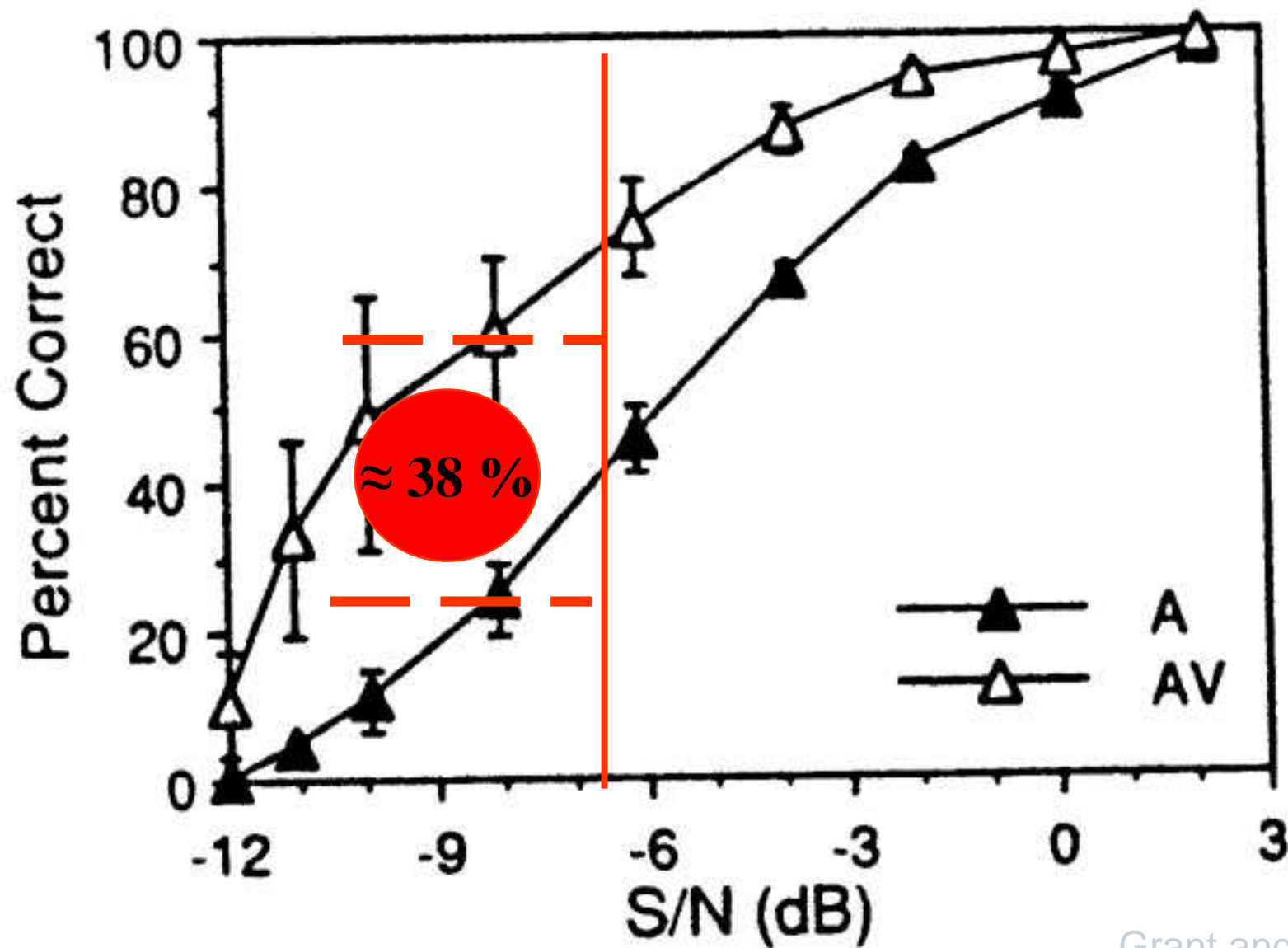
Visual enhancement

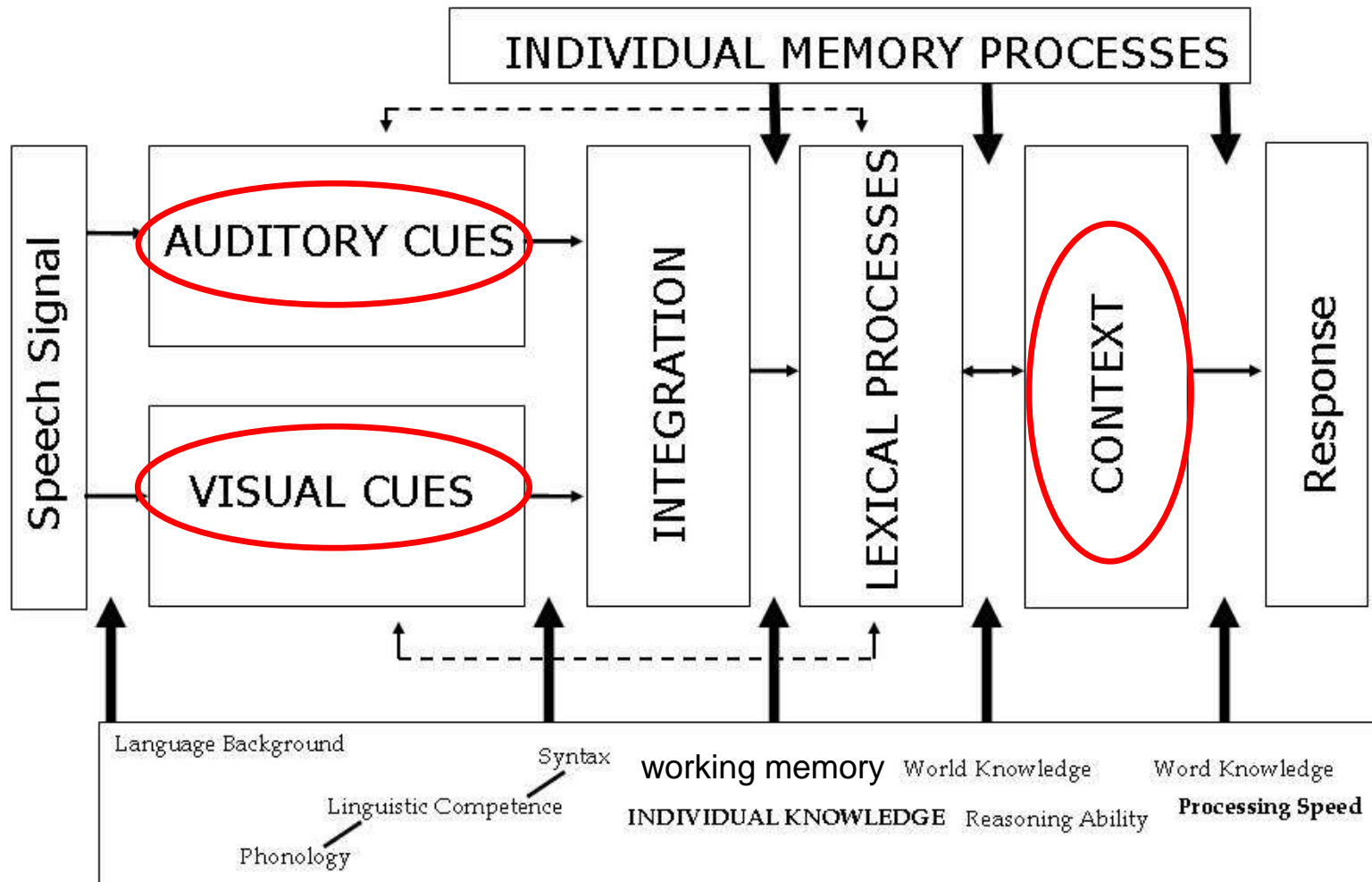


Auditory enhancement



## Benefits of providing visual speech cues





(adapted from Grant et al., 1998).

# Age-related sensory decline

## Audition

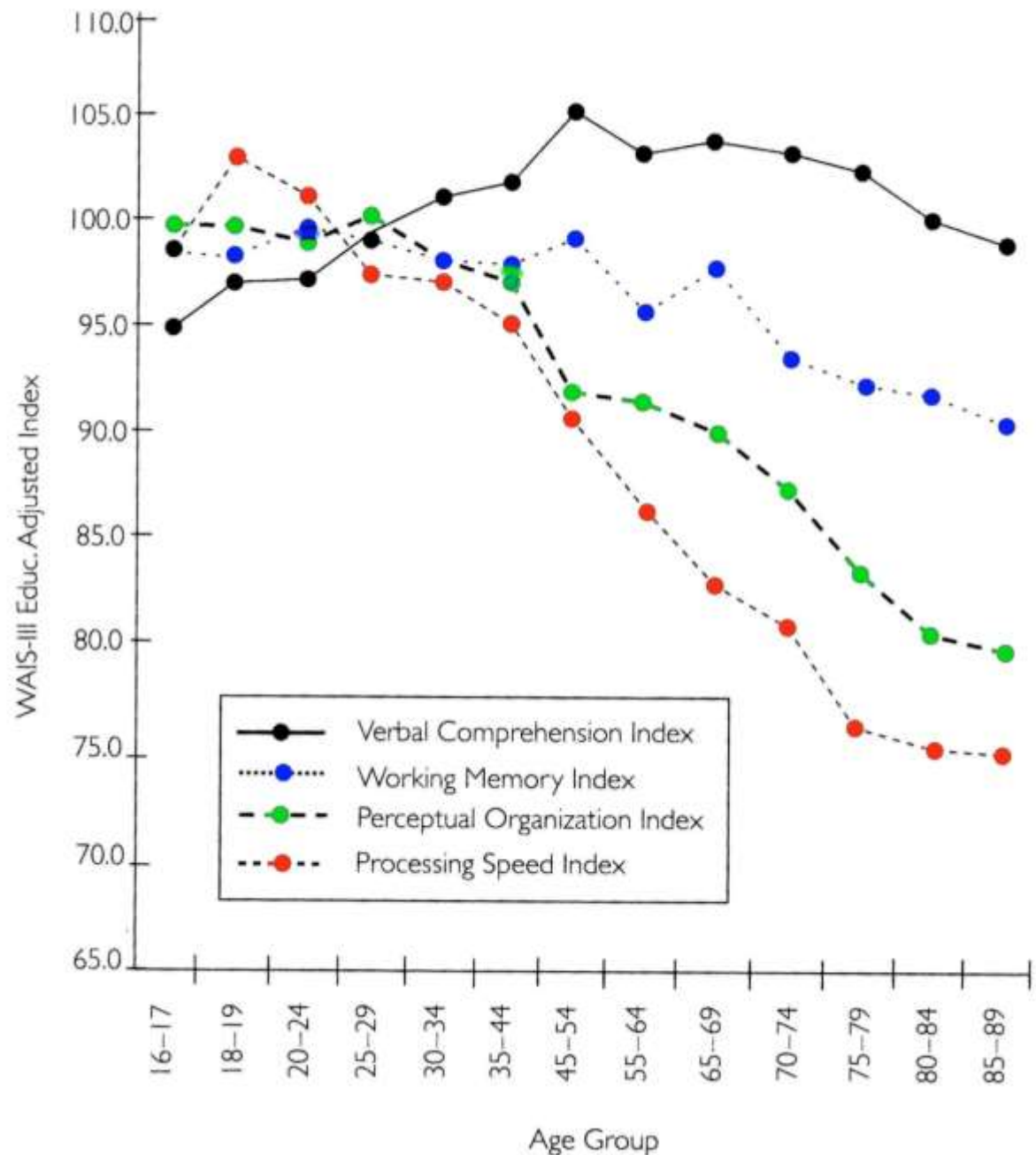
- presbycusis: age-related high frequency hearing loss
  - ~50% of adults 75+ years
- Speech perception in normal hearing older adults
  - adequate in quiet listening conditions
  - effortful and difficult when there are multiple signals or background noise (e.g., Pichora-Fuller et al., 1995)

## Vision

- ↑ lens opacity and yellowing, ↓ light admitted (Kline & Scialfa, 1996)
- ↓ acuity, contrast sensitivity



# Change in cognition across the lifespan



# To what extent do older adults benefit from AV speech?

*Poor* performance could be due to:

- poor perception of A and/or V cues
- difficulty integrating these cues
- difficulty employing linguistic constraints on-line
- cognitive factors
  - semantic failure, working memory limitations, or reductions in processing speed

*Good* performance could be due to:

- the Inverse Effectiveness hypothesis (Meredith & Stein, 1993)
  - the effectiveness of a multi-sensory interaction is inversely related to the effectiveness of the uni-sensory inputs
  - older adults might be 'permanently' in a sub-optimal sensory environment and thus could show larger AV benefits than younger adults
    - e.g., Hugenschmidt et al. (2007), Laurienti et al. (2006)

# Currently . . .

- Lack of consensus on the magnitude of the AV benefit exhibited by OAs
  - Garstecki (1983); Walden et al. (1993); Grant & Seitz (1998); Sommers et al., (2005); Tye-Murray et al. (2008)
- Little assessment of the joint contribution of sensory/perceptual factors and higher-order cognitive factors
- along with Nathalie Phillips, Concordia University (2010 – 2013)
  - large-scale project that uses an integrated information-processing approach to examine bottom-up (sensory/perceptual) and top-down (cognitive) factors

# Questions

- Are there age differences in AV speech benefit compared to unimodal presentations?
- To what extent do sensory and cognitive factors predict AV speech perception?
- Do people use all possible sources of benefit?
  - visual speech cues
  - sentence context cues

# Common methods for all studies

- age-appropriate pure tone hearing thresholds
  - $\leq 25\text{dBHL}$  from 0.25 to 4.0 kHz
- normal cognitive function  
(MoCA, Nasreddine, Phillips et al. 2005)
- normal or corrected-to-normal vision
- screened for contrast sensitivity



# Participants

	<u>Younger</u>	<u>Older</u>
N =	80 (19 M, 61 F)	60 (14 M, 46 F)
Age (years)	23.3 (3.2)	69.7 (6.7)
Education (years)	16.0 (1.6)	14.6 (3.3)
Hearing Threshold (dB)	4.1 (3.9)	13.7 (6.3)
Visual contrast sensitivity	1.7 (0.1)	1.6 (0.1)

# Examples

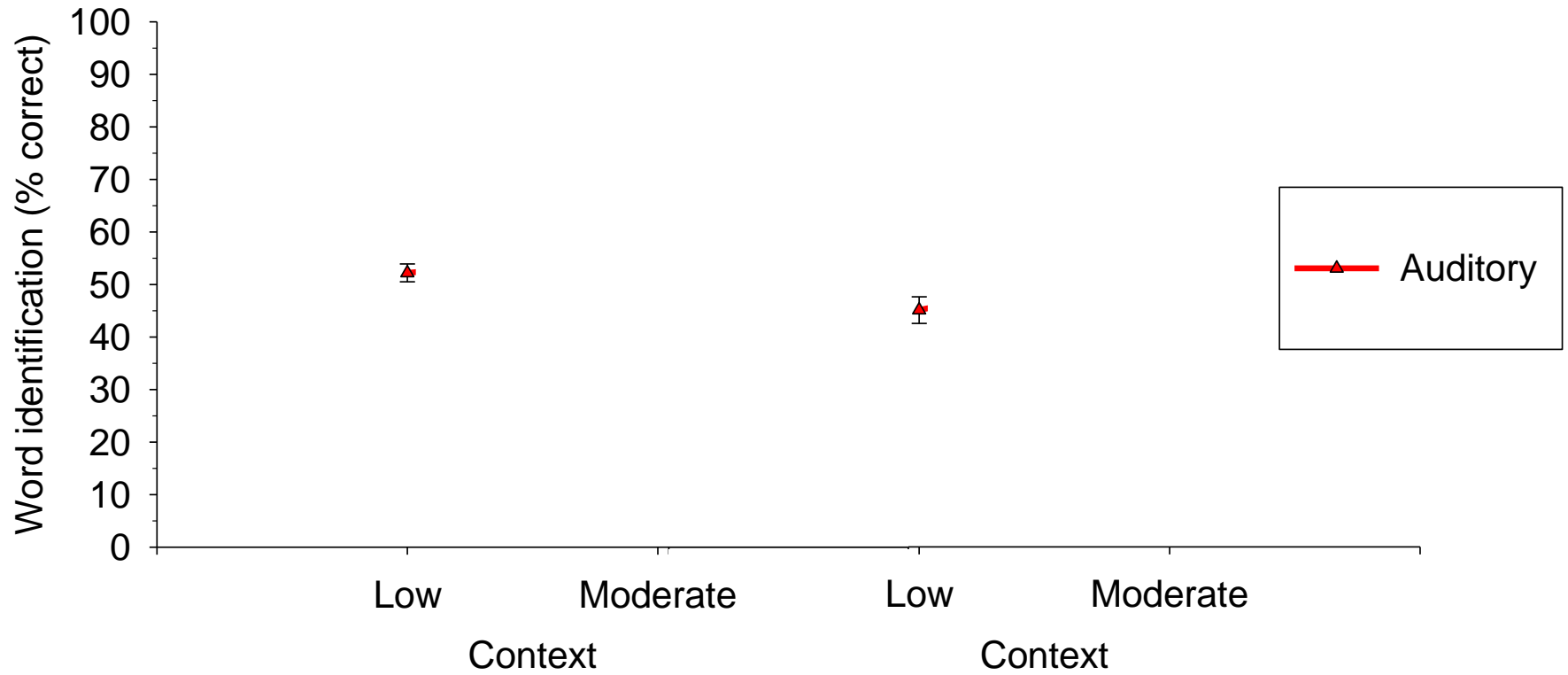
Low Constraint: “Kirk showed us his new cow.”

Moderate Constraint: “The farmer sold the cow.”

# Sentence Word Identification

Younger adults

Older adults

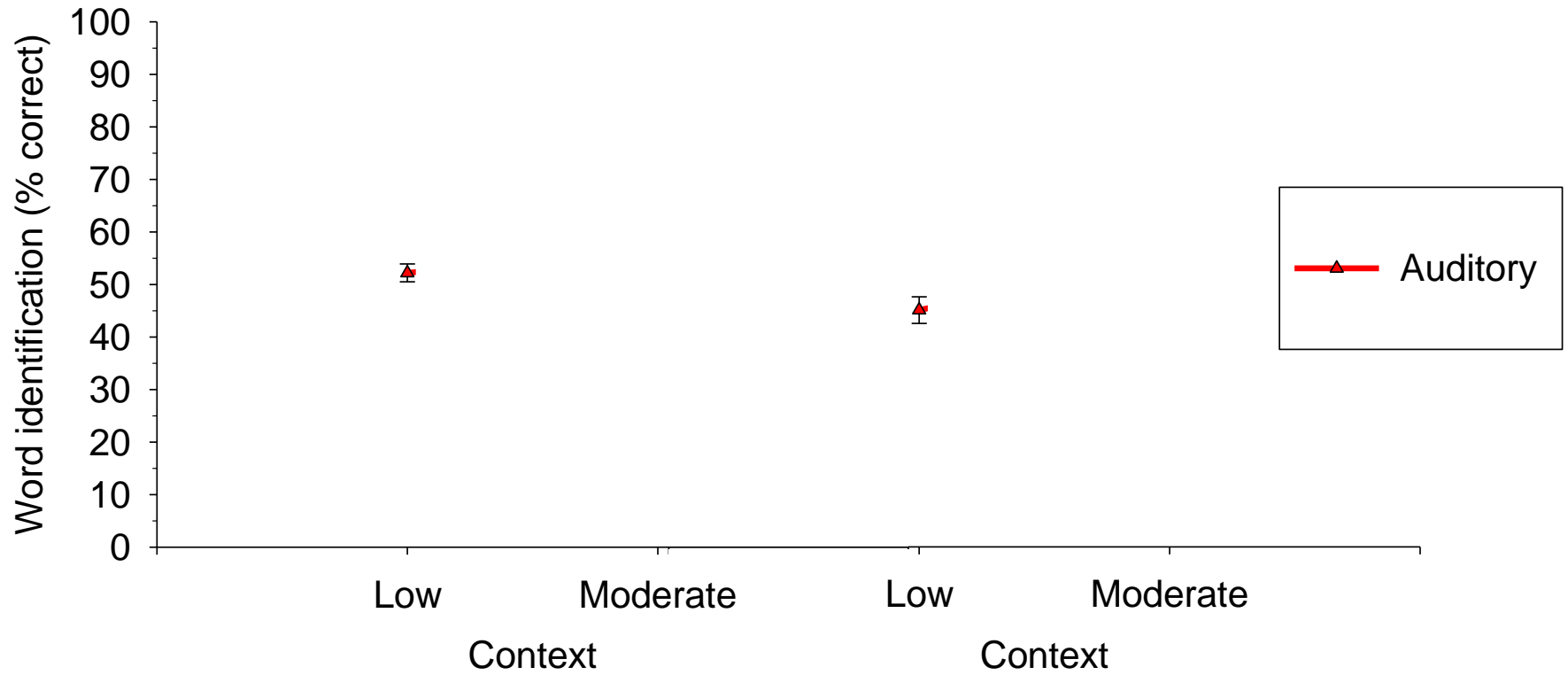




# Sentence Word Identification

Younger adults

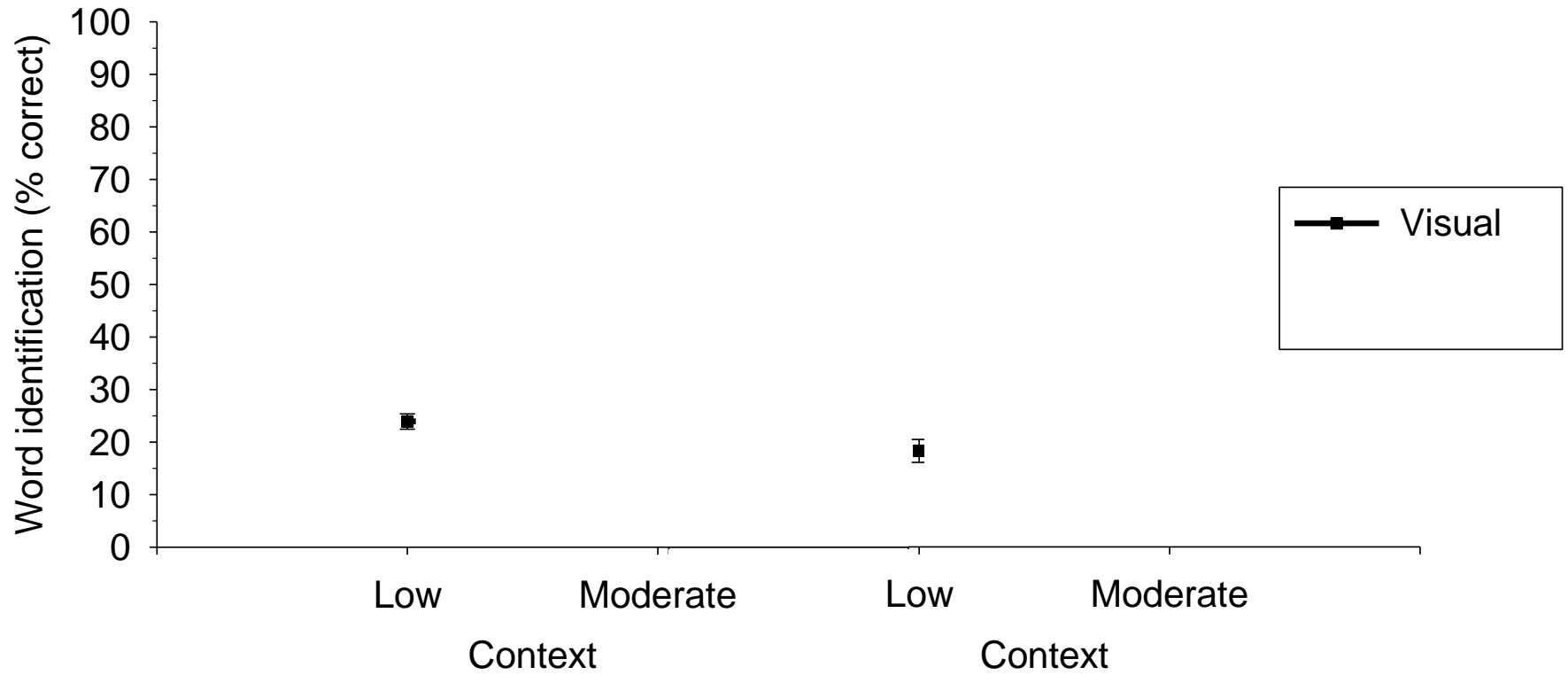
Older adults



# Sentence Word Identification

Younger adults

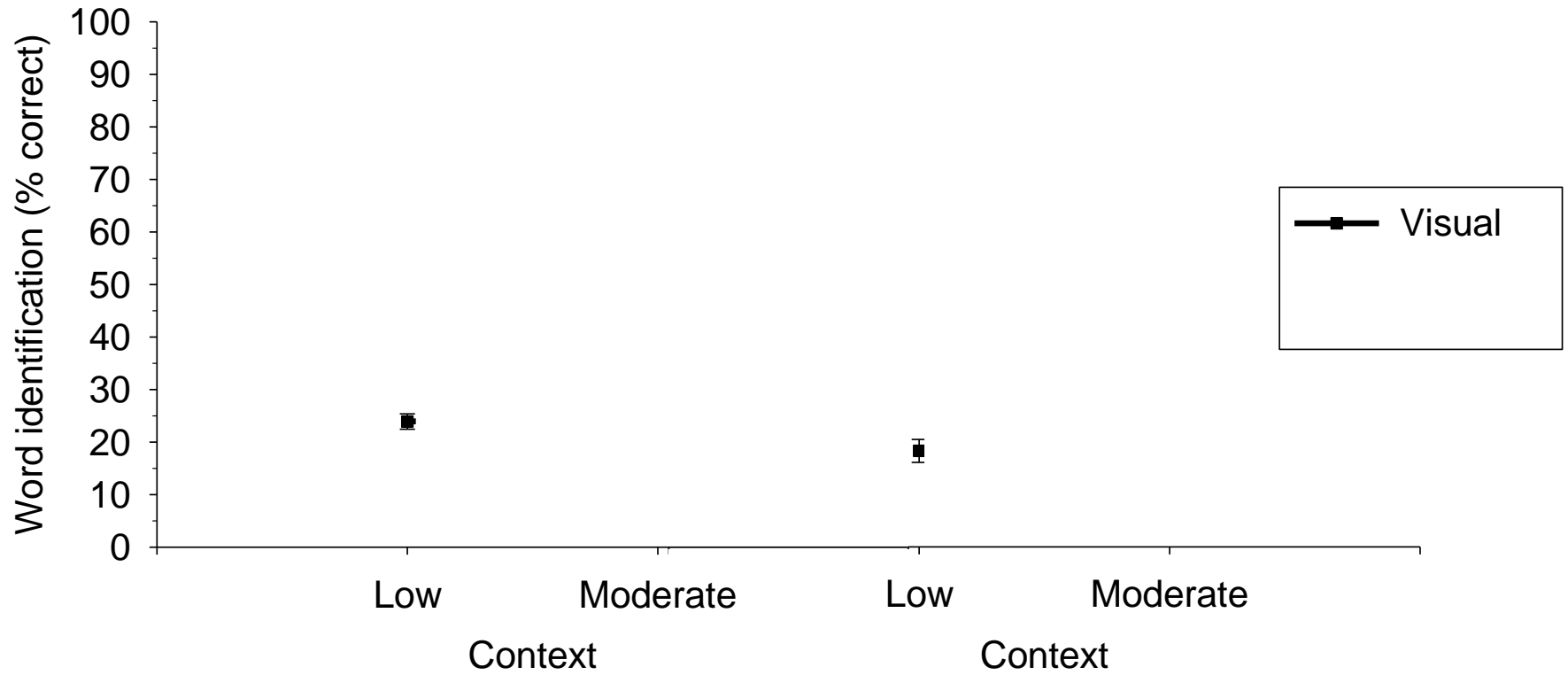
Older adults



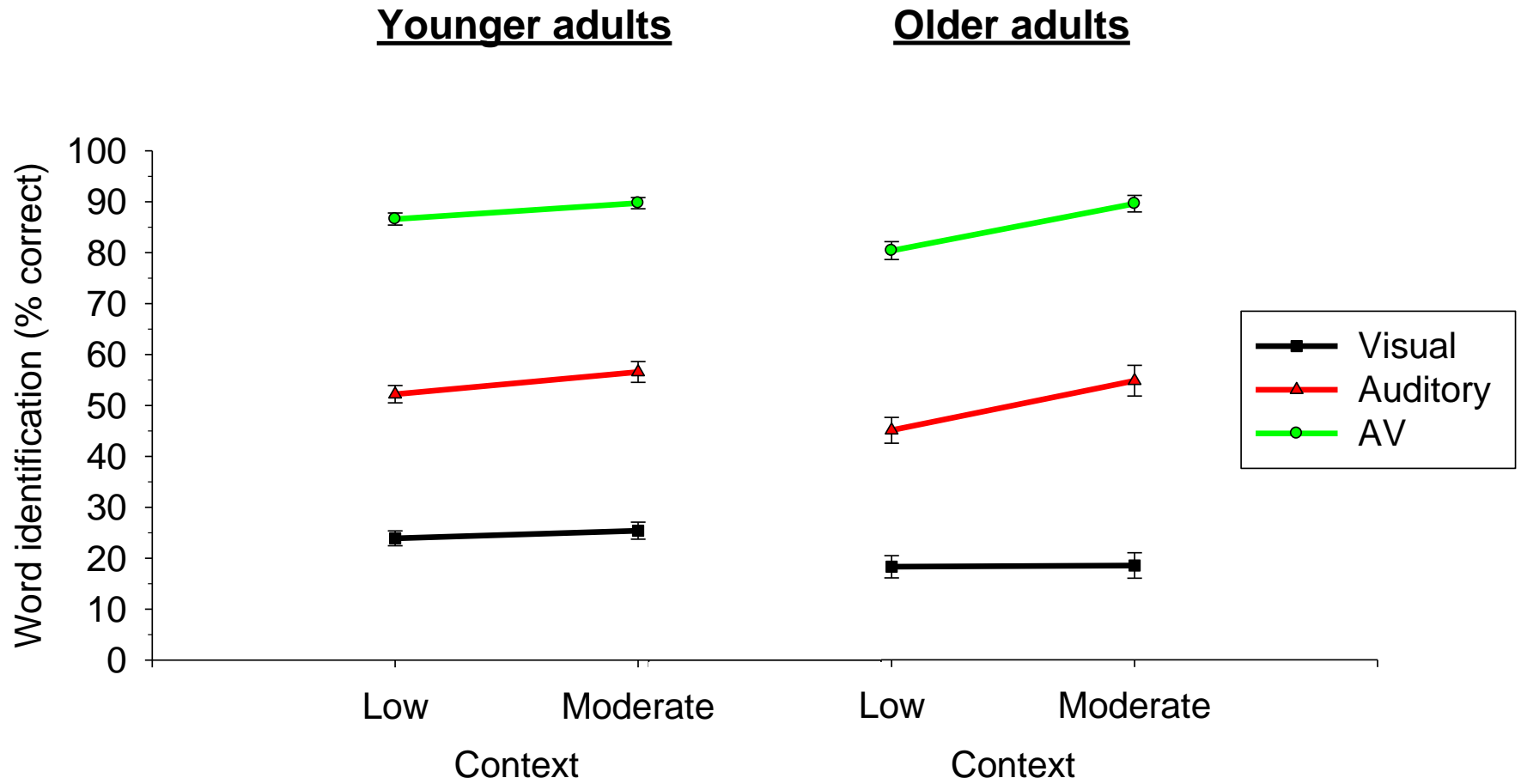
# Sentence Word Identification

Younger adults

Older adults

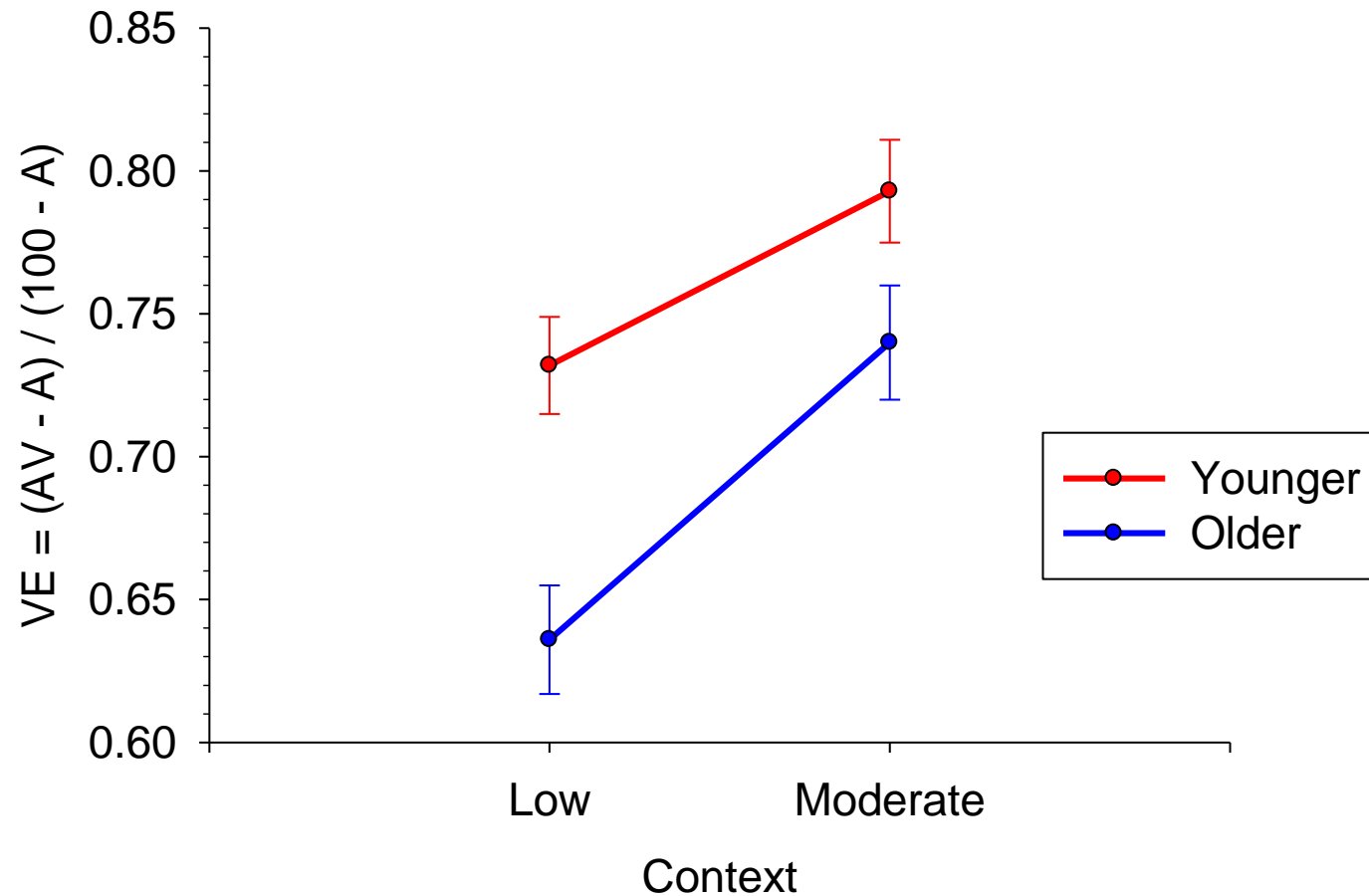


# Sentence Word Identification



remember that these are *identical* uni-modal stimuli contributing to the AV stimuli

# Sentence Perception: Visual Enhancement



# Discussion, thus far

- Sentence word perception increased in a stepwise fashion

Visual < Auditory < AV

- for both younger and older adults
  - older adults benefited from the AV mode, despite poorer uni-modal sensory function
  - visual enhancement present in both groups but larger in the younger adults
- 
- AV modality and semantic context closes the perceptual gap between the ages

Merci!

Thank you!!

(Tusen) takk!!!