Sensory and perceptual contributions to memory performance

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Age and memory

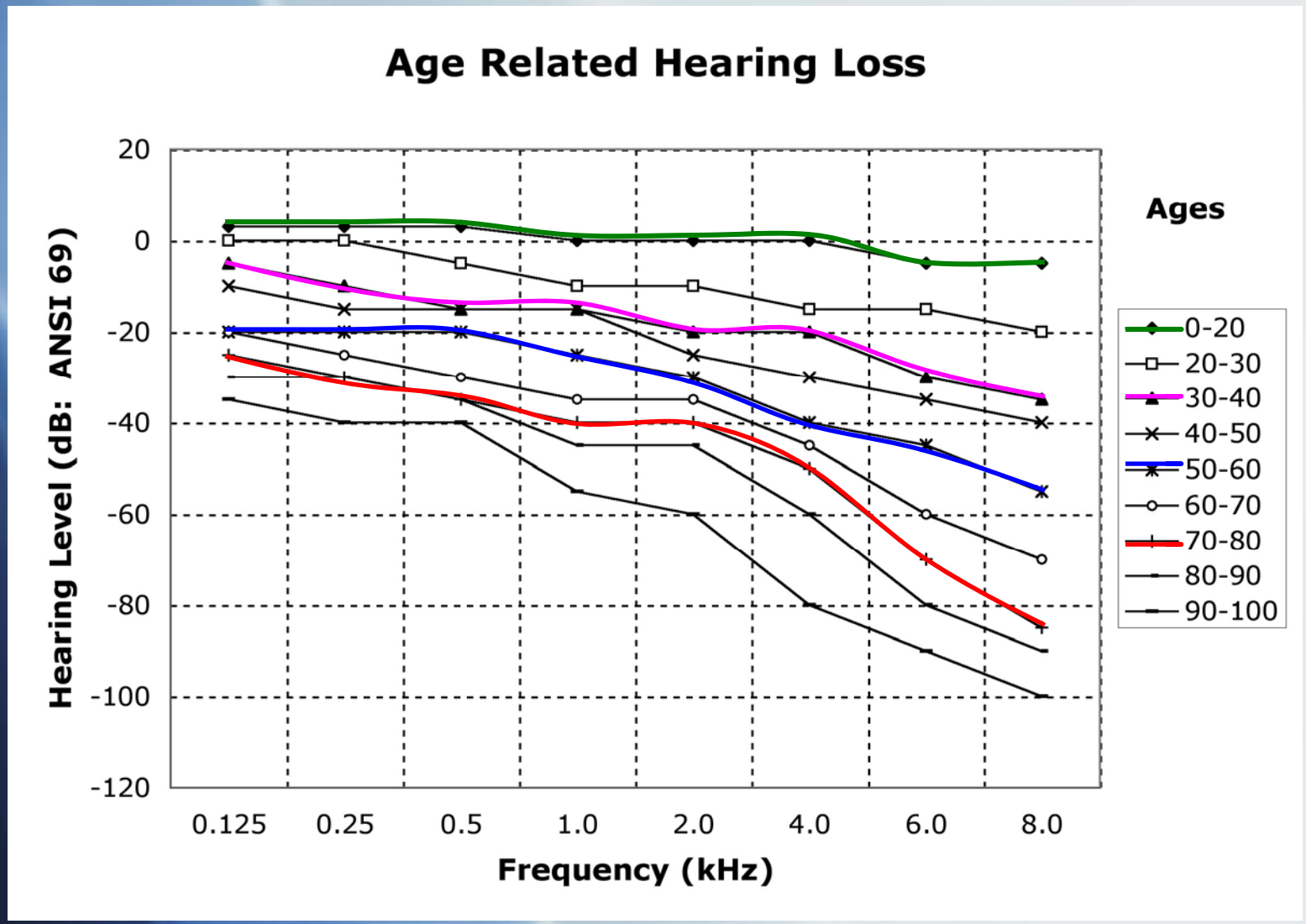
- Research shows reductions in many types of memory as a function of age:
  - Serial recall
  - Free recall
  - Remembering names
  - Remembering appointments
  - Etc.

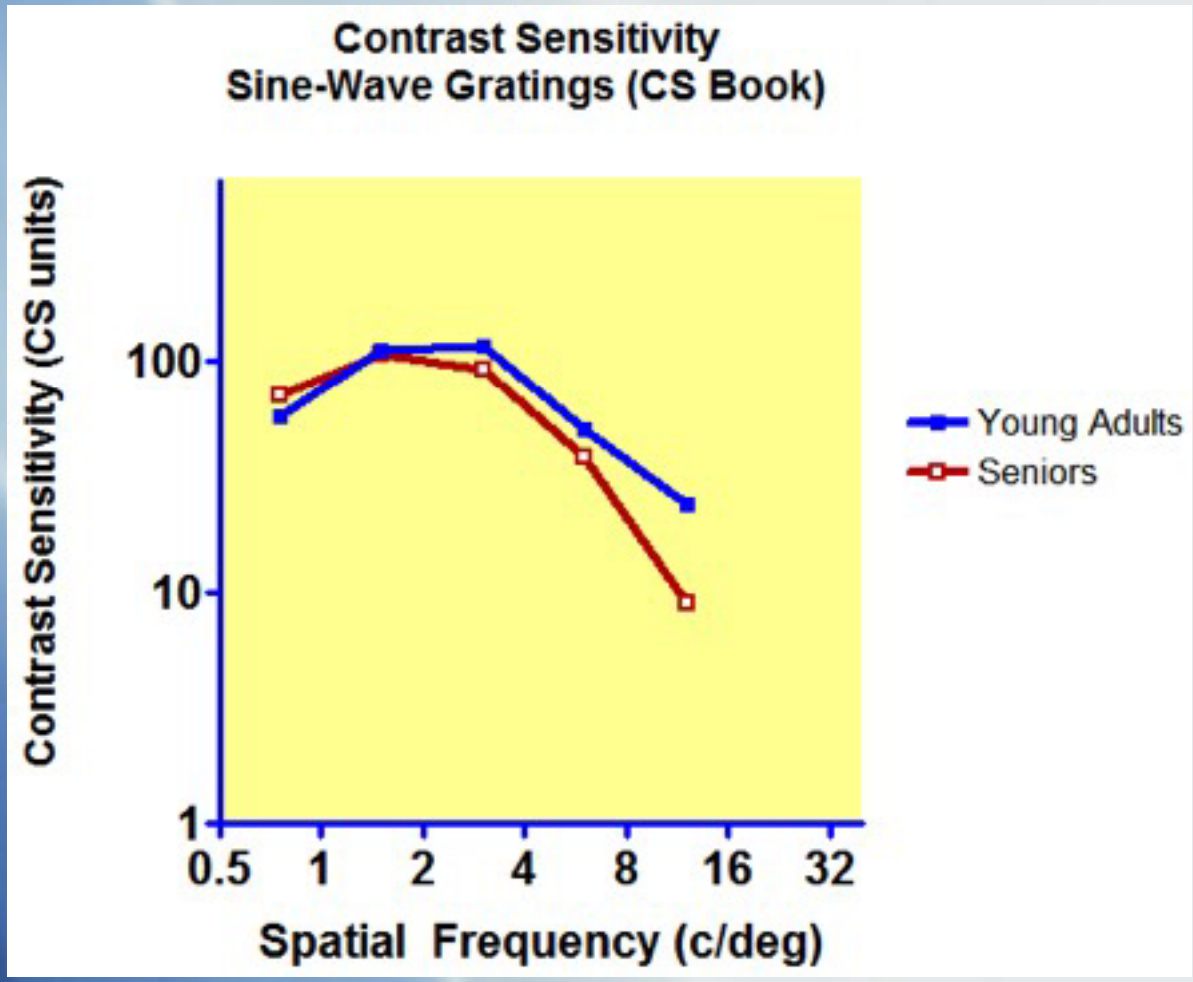
Cognitive explanations

- Reduced working memory capacity (Baddeley, 1986).
- Slowed speed of processing (Salthouse, 1994; 1996).
- Lack of inhibitory control (Hasher & Zacks, 1988; Zacks & Hasher, 1994).

Sensory Acuity

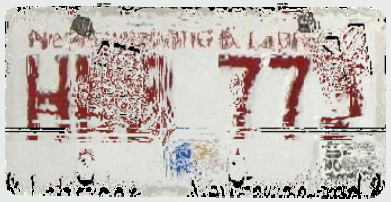
- Sensory acuity also declines as a function of age


Age Related Hearing Loss
Hearing Level (dB: ANSI 69)
20
0
-20
-40
-60
-80
-100
-120
0.125
0.25
0.5
1.0
2.0
4.0
6.0
8.0
Frequency (kHz)
Ages
0-20
20-30
30-40
40-50
50-60
60-70
70-80
80-90
90-100


Contrast Sensitivity
Sine-Wave Gratings (CS Book)
Contrast Sensitivity (CS units)
100
10
1
0.5
1
2
4
8
16
32
Spatial Frequency (c/deg)
Young Adults
Seniors

Younger

Older



Sensory explanations

- A growing body of evidence points to the possibility that reduced cognitive functioning is related to, and could be substantially affected by, reductions in lower-level *perceptual* processing
  - e.g., Baltes & Lindenberger, 1997; Schneider & Pichora-Fuller, 2000; Surprenant, in press.

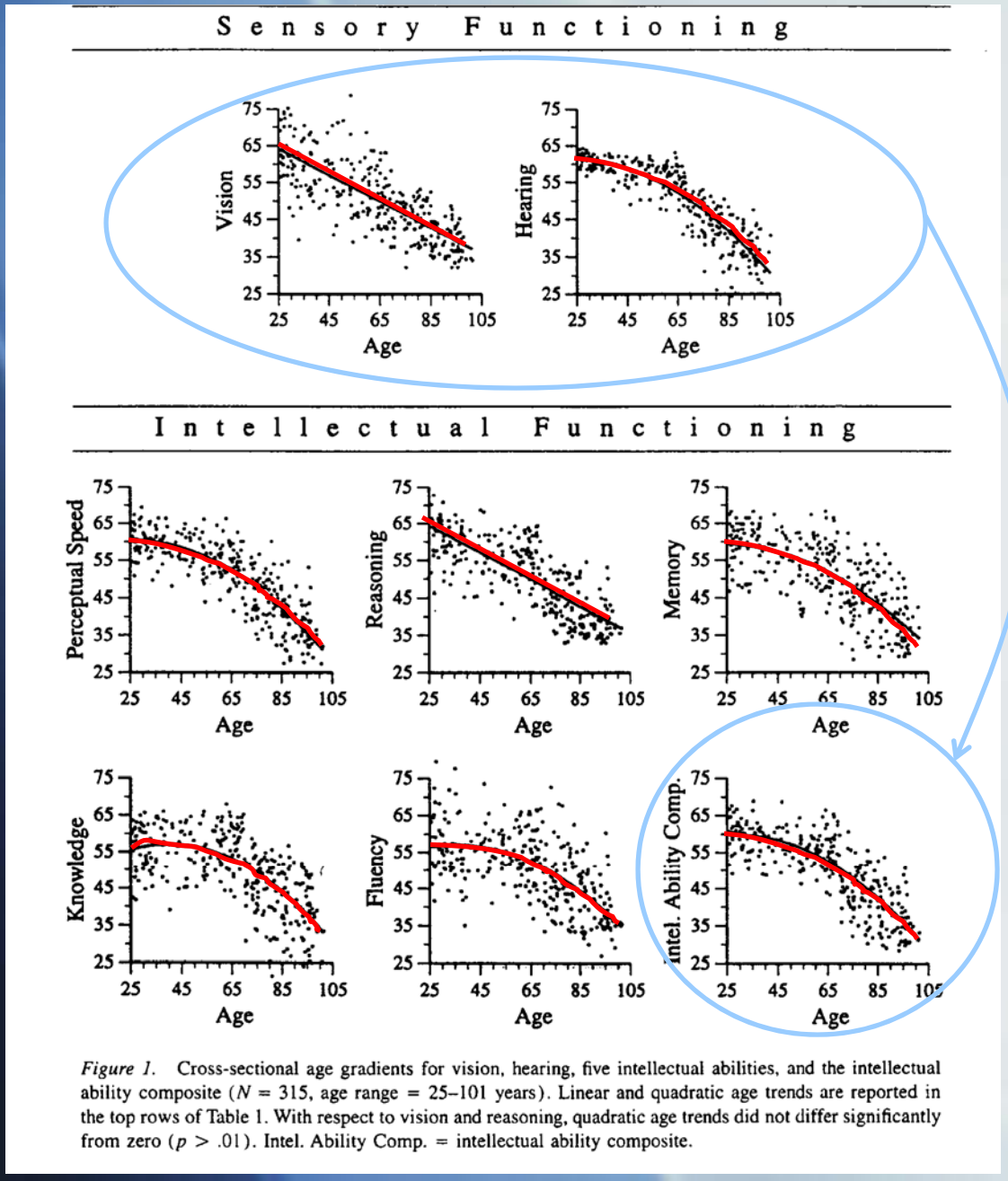


Figure 1. Cross-sectional age gradients for vision, hearing, five intellectual abilities, and the intellectual ability composite (N = 315, age range = 25–101 years). Linear and quadratic age trends are reported in the top rows of Table 1. With respect to vision and reasoning, quadratic age trends did not differ significantly from zero ($p > .01$). Intel. Ability Comp. = intellectual ability composite.

Baltes & Lindenberger (1994): Vision and hearing accounted for 49.2% of the total and 93.1% of the age-related variance.

Perceptual degradation hypothesis

- Perceptual deficits that accompany normal aging can affect higher-level cognitive performance
  - Reduce resources normally devoted to higher-level processing such as rehearsal or elaboration
  - Slow speed of processing because impoverished input takes more time to identify and interpret
  - Reduce ability to inhibit irrelevant information

Sensory acuity and aging

- Researchers studying cognitive aging often fail to test even basic sensory functioning
  - Schneider & Pichora-Fuller (2000) reviewed 288 published articles on cognitive aging and found that over 80% of them did not measure hearing or visual acuity at all

Caveat

- Even though there is this relationship with sensory/perceptual abilities and cognition, clearly, this will not account for all of the differences. Multiple sources probably contribute to reduced memory performance in older adults.

Question:

- How much of the age-related declines in memory can be attributed to the quality of the input?

Experiment 1

- Relate ease of encoding to memory performance.

Experiment 1

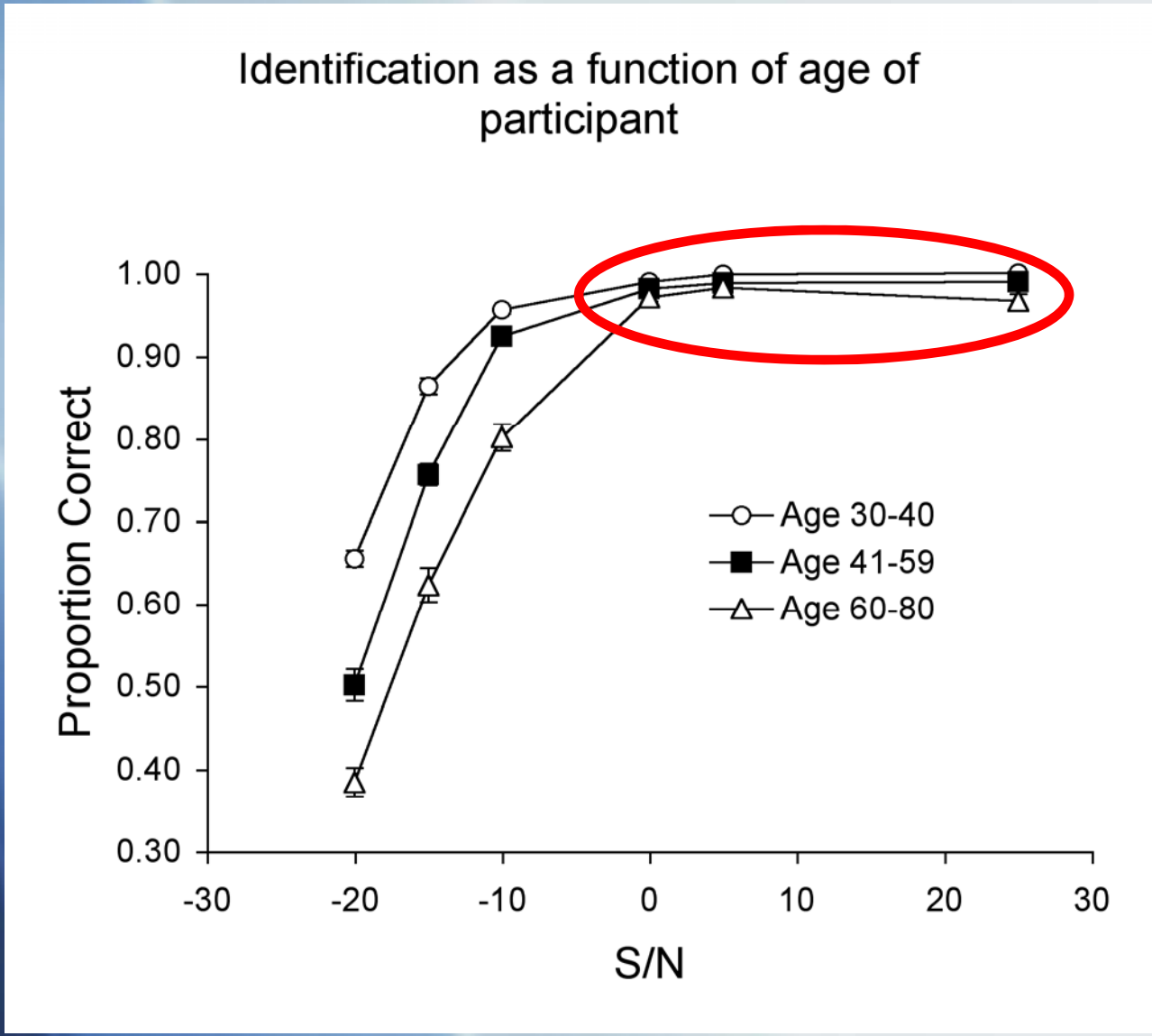
- Measured:
  - perceptual identification of spoken syllables in various amounts of noise
  - memory for those same spoken syllables
- Directly relate measures of ease of identification to memory for the same materials.

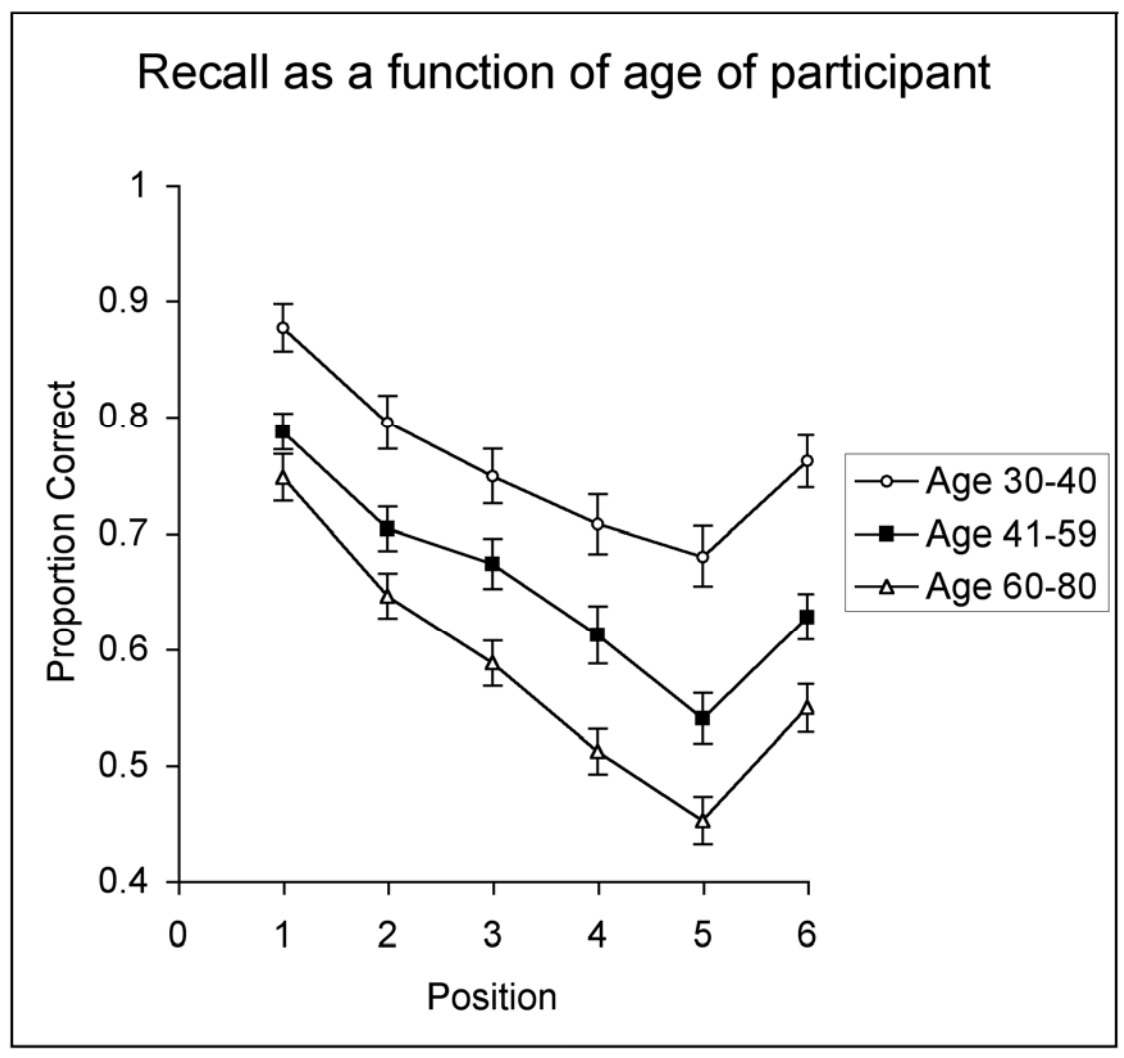
Participants

- Forty adults between the ages of 30-75
- Ten of the subjects were between ages 30-39; twelve between 40-49; seven between 50-59; eleven were 60-75.
- Thirty-two women; eight men.
- Self-reported good health.
- All had hearing within the range considered to be clinically normal up to 3 kHz (in the presentation ear).

Tasks

- Identification — six stop consonants (followed by /a/) were presented in various levels of noise (25, 5, 0, -15, and -20 dB S/N) for identification.
- Serial Recall — lists of the stop consonants identified above were presented in random order for serial recall. Three levels of noise (25, 5, and 0 dB S/N) were used.


Identification as a function of age of participant
Proportion Correct
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
-30
-20
-10
0
10
20
30
S/N
Age 30-40
Age 41-59
Age 60-80


Recall as a function of age of participant
Proportion Correct
1
0.9
0.8
0.7
0.6
0.5
0.4
0
1
2
3
4
5
6
Position
Age 30-40
Age 41-59
Age 60-80

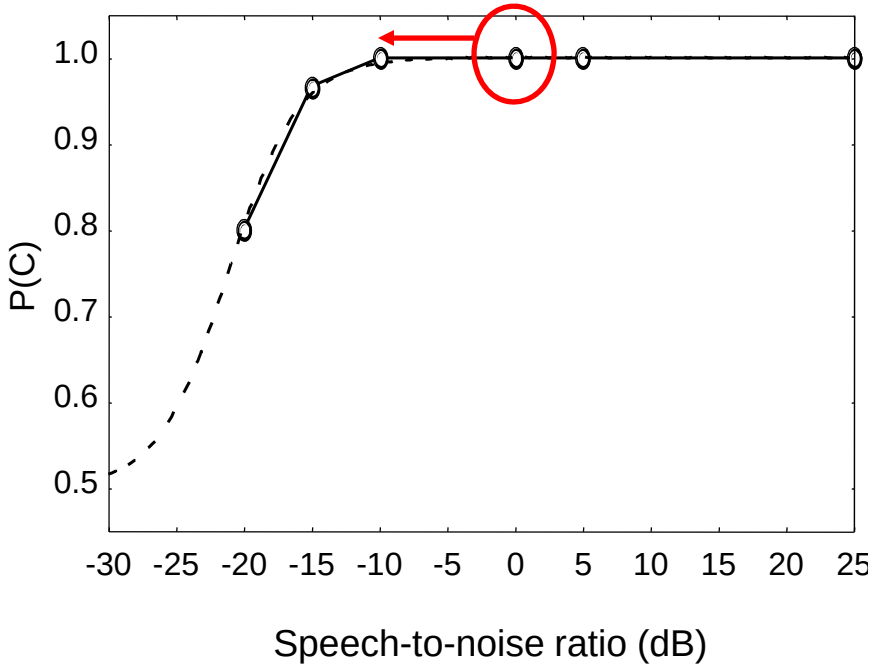
Older adults do worse on the memory task than younger adults

- Replicated previous experiments.
- However, we have individual identification functions so we may be able to account for individual differences in memory based on identification rather than age, *per se*.

Individual Identification Functions

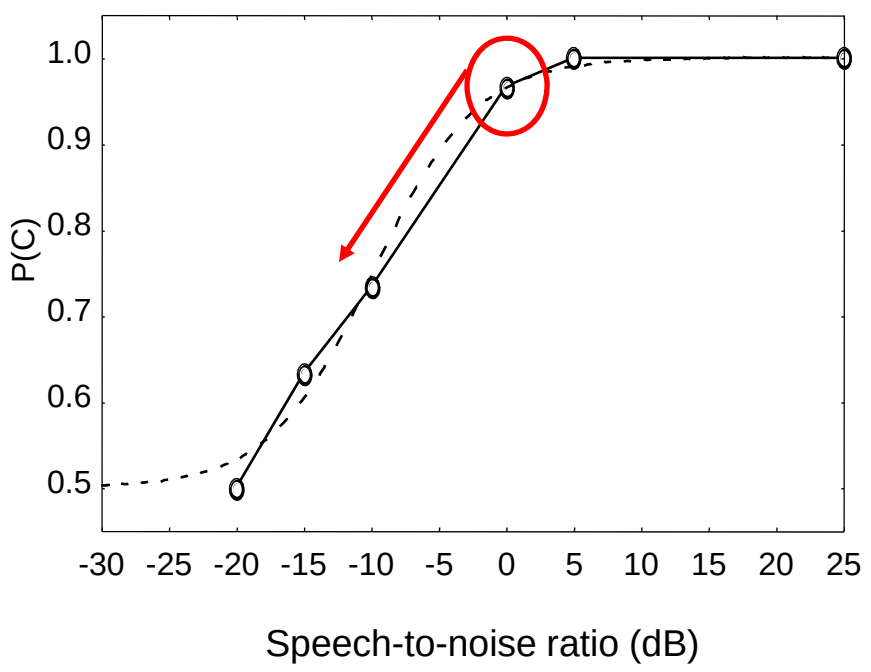
Subject 27

70% threshold = -22.2 dB



Subject 38

70% threshold = -11.7 dB



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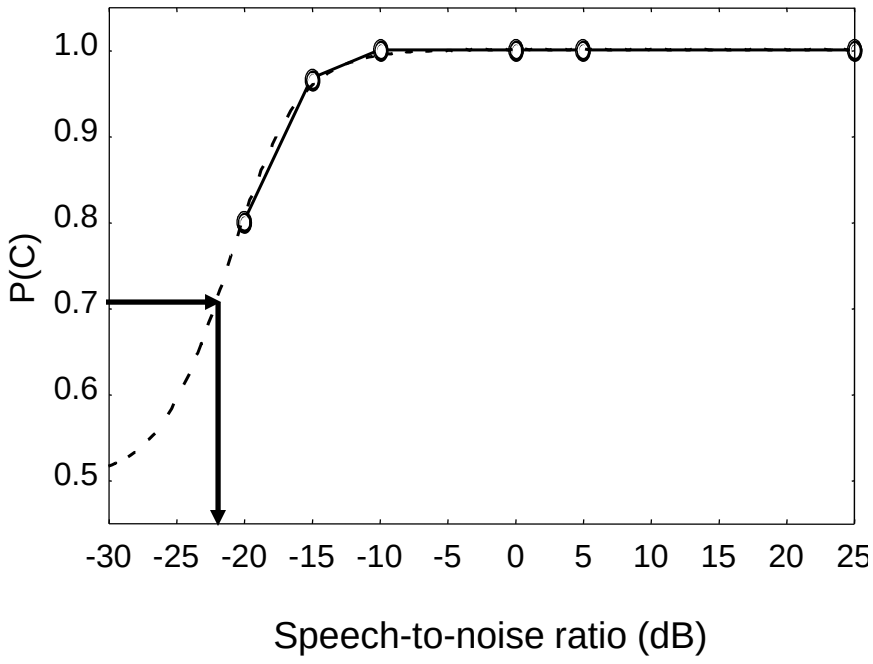

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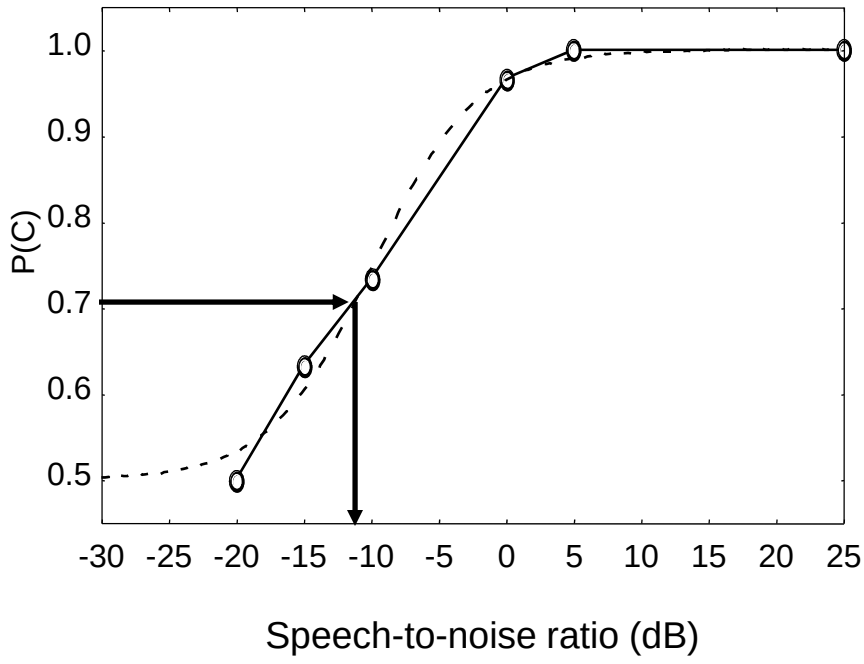
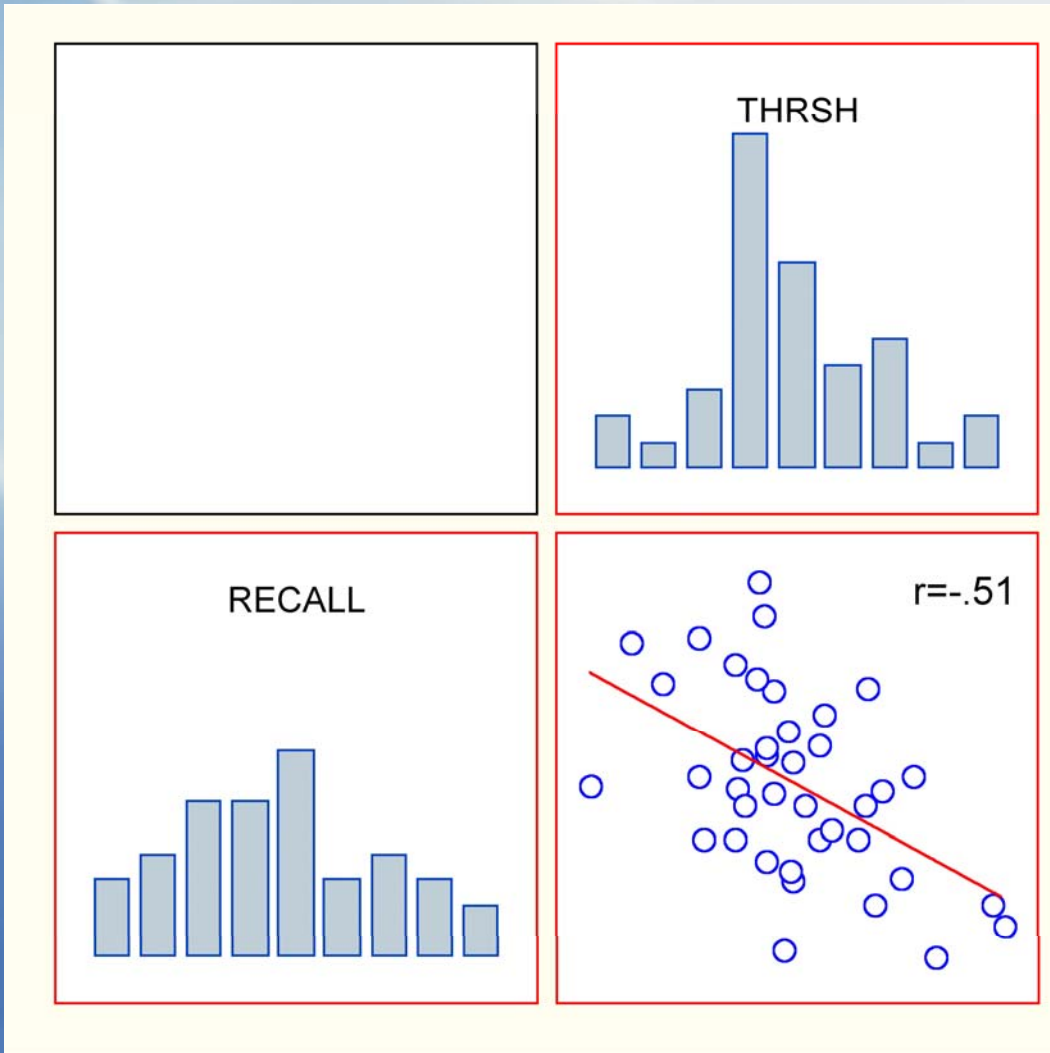


Correlations



Interim conclusions

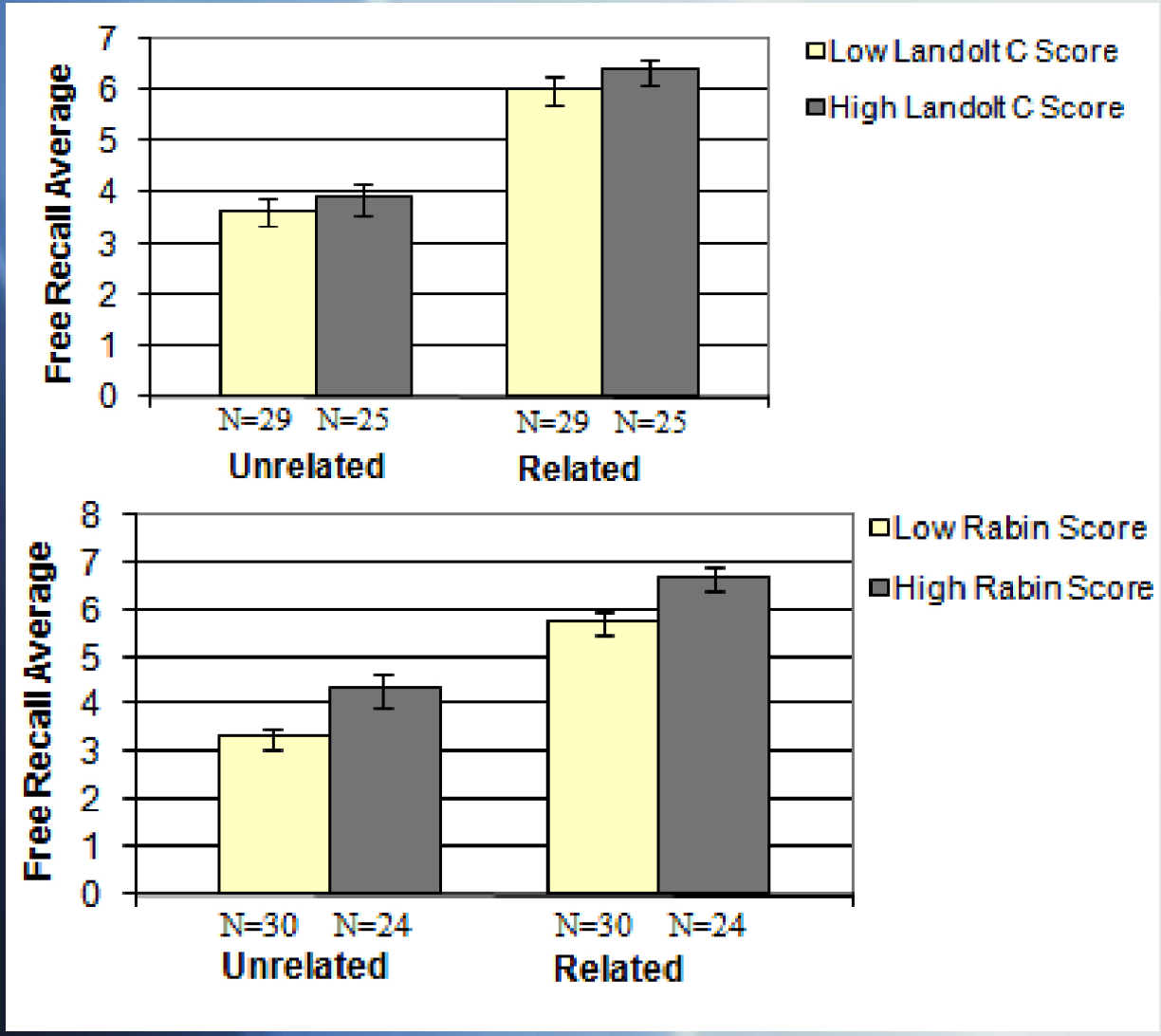
- Even when identification performance is equivalent, it cannot be assumed that individuals are performing with the same perceptual efficiency.
- By measuring identification at a number of different levels individual differences start to become evident.
- If processing resources are taxed by adding noise, even when identification is essentially perfect, higher level cognitive processes like memory can be substantially affected.

Experiment 2

- How about vision?

Vision and free recall (B. Faux MSc thesis data)

- 56 older adults aged 58-85 (M = 69.59)
- Tested visual acuity (Landolt) and contrast sensitivity (Rabin); split into high and low performance groups.
- 10-item lists of either related (e.g., robin, eagle, canary, hawk…) or unrelated (e.g., ginger, fork, canoe, deputy…).
- Recall in any order



No relationship between visual acuity and recall but the high scorers on contrast sensitivity recalled significantly more words--particularly unrelated (less top-down info could be used)

Discussion

- These experiments demonstrate a close link between perception (as measured by identification performance and contrast sensitivity) and memory (as measured by serial and free recall).
- In addition, we can do a fairly good job of predicting individual errors from identification.

Broader implications

- Cognitive aging researchers need to consider sensory functioning as a factor in age-related memory loss.
- Even small amounts of sensory loss may cause higher-level deficits
- There are data showing that impairments in basic vision are common in older individuals with dementia (particularly AD).

Broader implications

- Carefully consider sensory status when comparing older and younger adults on cognitive measures.
- Noisy environments or degraded stimuli may decrease memory for everyone
  - Classroom environments
  - Speech intelligibility on cell-phones

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