Attention

PSYC423: Research in Aging

Essential Properties of Attention

- Human information processing capacity is limited
- Quantity of sensory input exceeds cognitive processing capacity
- Attention selects task-relevant stimuli for higher-order cognitive processing in the service of task-relevant goals
- Attention reflects the management of limited cognitive resources (focus; goal maintenance; task-switching; etc.)
- Attention can be guided by both “top-down” and “bottom-up” constraints (e.g. “Change Blindness” demo)

(In)famous Attention Demonstrations

Video Demonstration #1

- “Special” game of basketball
- Two teams (Black versus White)
- Two basketballs (one for each team)
- Objective of game: Pass the ball as many times as possible

- YOUR TASK: Count the number of times the WHITE team passes the ball

Let’s see how well you can perform this task…

Varieties of Attention

- Selective Attention (Focus)
- Divided Attention (MultiTasking)
- Sustained Attention (Vigilance)

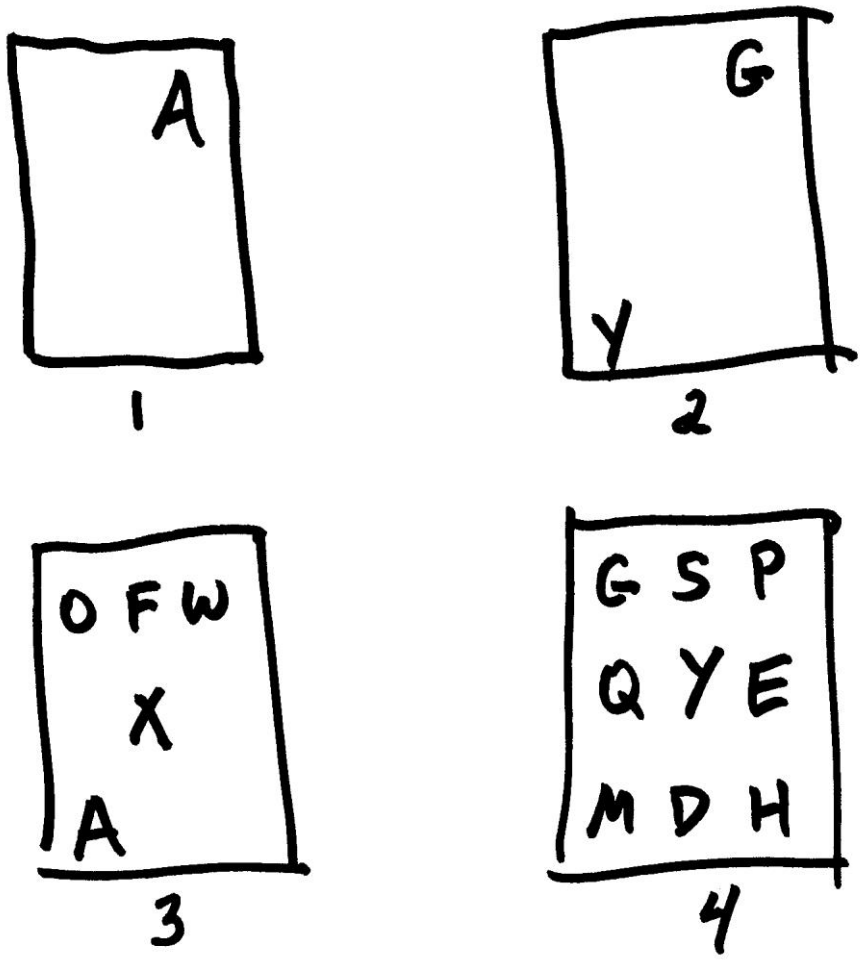
- Span of Visual Attention (Useful Field of View)

I. Selective Attention

Classic Experiment of P. Rabbitt (1965)

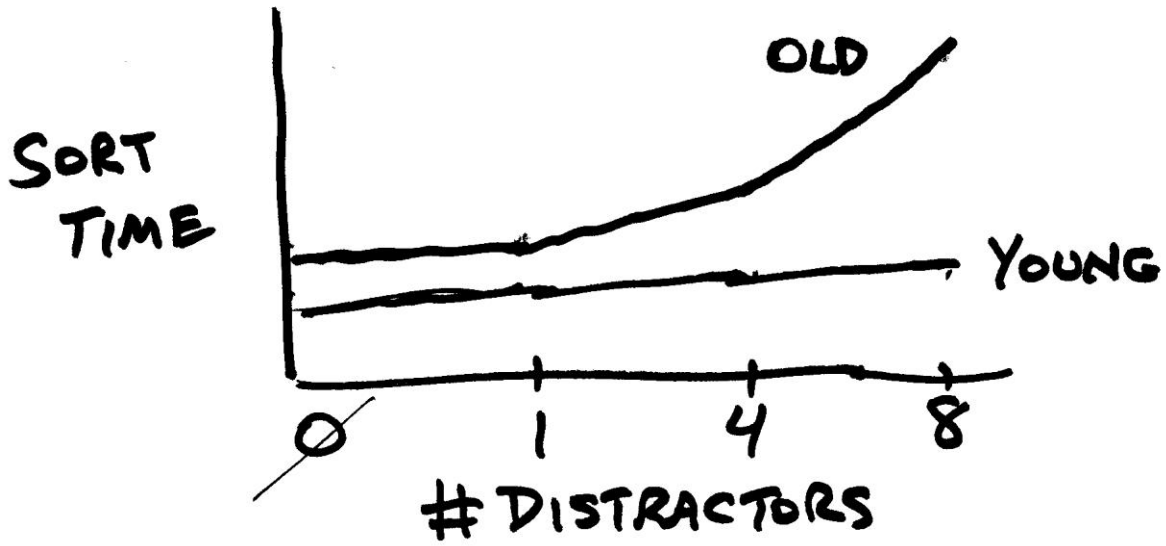
- Card Sorting Task
- 48 Stimulus Cards in a Deck
- Sort Cards into Two Piles: Cards containing letter “A” versus “Y”
- Independent Variable:
  Number of distracting letters on cards {0,1,4 or 8}
- Dependent Variable:
  Time required to finish sorting the deck of cards

Sample Stimuli from Rabbitt's Card Sorting Experiment (Sort Deck of Cards into the "A" versus "Y" Piles)



Deck 1 = No distracters
Deck 2 = 1 distracter
Deck 3 = 4 distracters
Deck 4 = 8 distracters

Rabbitt's Results:



Older adults demonstrate an "inability to ignore task irrelevant stimuli"

This is a failure of "selective attention"

Why is this happening?

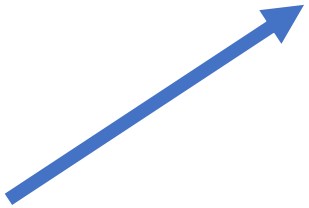
(see next slide)

Why does SELECTIVE ATTENTION become less efficient as we age?

The search for mechanisms as identified two major explanations:

(1) General cognitive slowing

(2) Loss of inhibitory cognitive control (Frontal lobe function)



Consistent with the "hypofrontality" hypothesis introduced in our coverage of the aging brain

Impairments of Selective Attention
Mechanism 1: Inhibitory Control

Loss of Inhibitory Control

- Stroop Interference Effects
- Diminished Negative Priming Effects

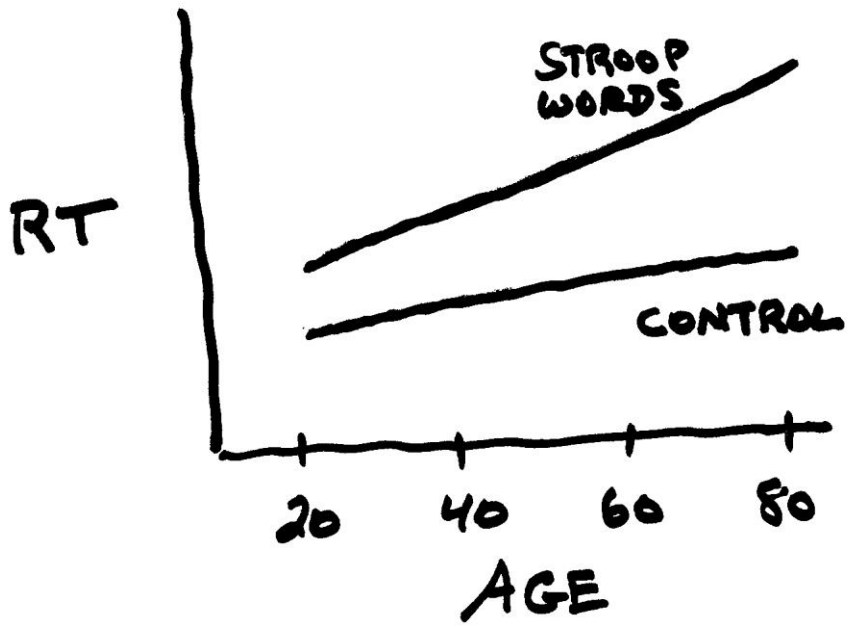
Stroop Interference Effect

Stroop interference occurs when the processing of a specific stimulus feature impedes the simultaneous processing of a second feature of that same stimulus.

The extent of this interference can be used to assess the ability to assert inhibitory control of cognitive processes.

Stroop Color Word Test:
Name the color of the **"ink"** used to print each word
[Need to inhibit automatized word reading response]

Older adults demonstrate exaggerated Stroop interference effects



Low Interference Control Stimuli

BLUE
GREEN
RED
YELLOW

<u>Diminished inhibitory control</u>
accompanies normal adult aging

Negative Priming in Simple Visual Search

- Hasher and her students used the “negative priming” paradigm to demonstrate diminished strength of inhibitory control in healthy older adults

- The Hasher et al. studies are especially convincing because they predict situations in which older participants perform significantly better than their younger counterparts

Negative priming of selective attention occurs when the distracter stimulus in the first block of experimental trials becomes the target stimulus in a subsequent block of experimental trials.

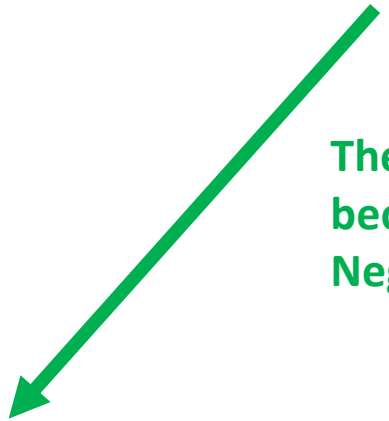
That is:
Cognitive inhibition of the distracter stimulus that is developed during the initial phase of a visual search experiment can carry-over to disrupt search performance in a subsequent phase of the experiment when the role of the stimulus changes from being the distracter to being the target.

Experiment Block 1: Priming Phase

Two Groups: Negative priming group; control group

Visual Search Stimuli:

Control group:	Target = T	Distractor = A	(e.g., AAATAAAAA)
Neg Priming group:	Target = T	Distracter = V	(e.g., VVVVVVVTV)



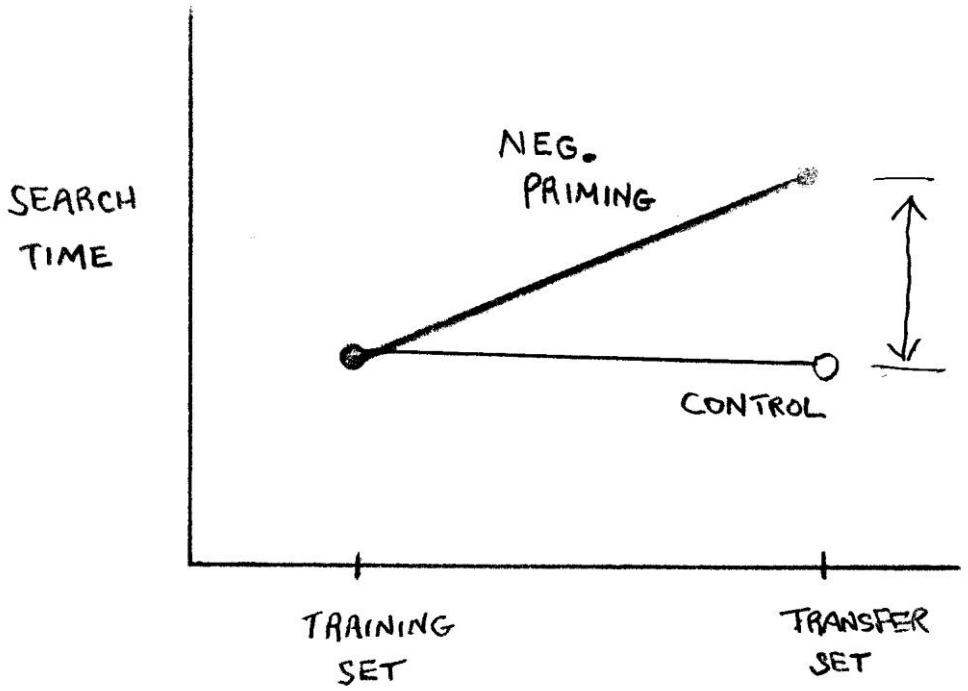
The distracter ("V") during Block-1 becomes the target in Block-2 for the Negative Priming group

Experimental Block 2: Test Phase

Visual Search Stimuli (for BOTH groups):

Target = V Distracter = X (e.g., XXXXVXXXX)

Typical Negative Priming Results (for Young participants)



Block 1 Block 2

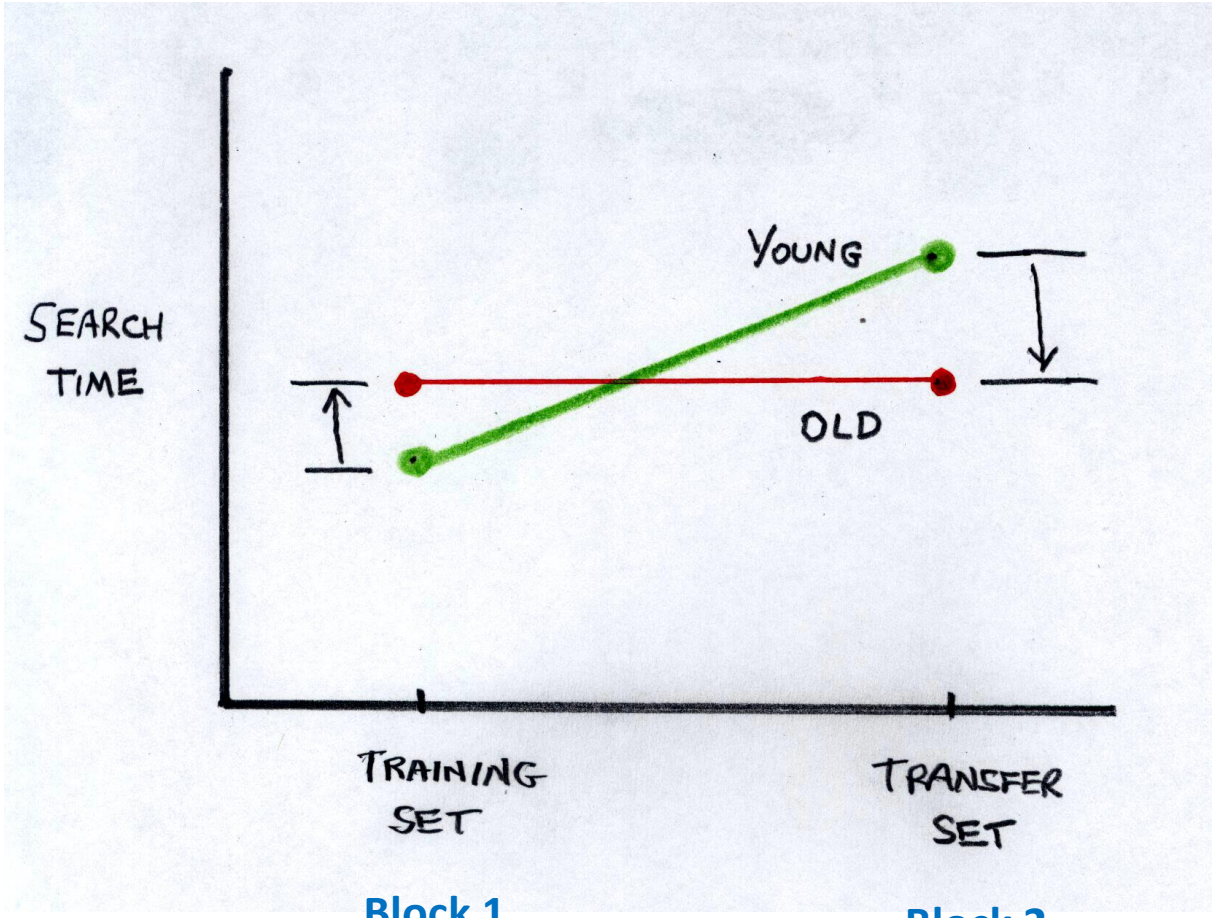
Following development of inhibition for the letter "V" distracter in Block-1, search time for the letter "V" target slows down in Block-2

No such slowdown occurs across experimental blocks for the control group.

This is a "Negative Priming Effect"

If inhibitory control mechanisms weaken with age, what should the results look like when the experiment is repeated with older participants???

Hasher et al. predicted that Older adults would outperform Young adults following the priming procedure



Failure to observe negative priming effects among older participants is consistent with impaired inhibitory control

Impairments of Selective Attention
Mechanism 2: General Slowing

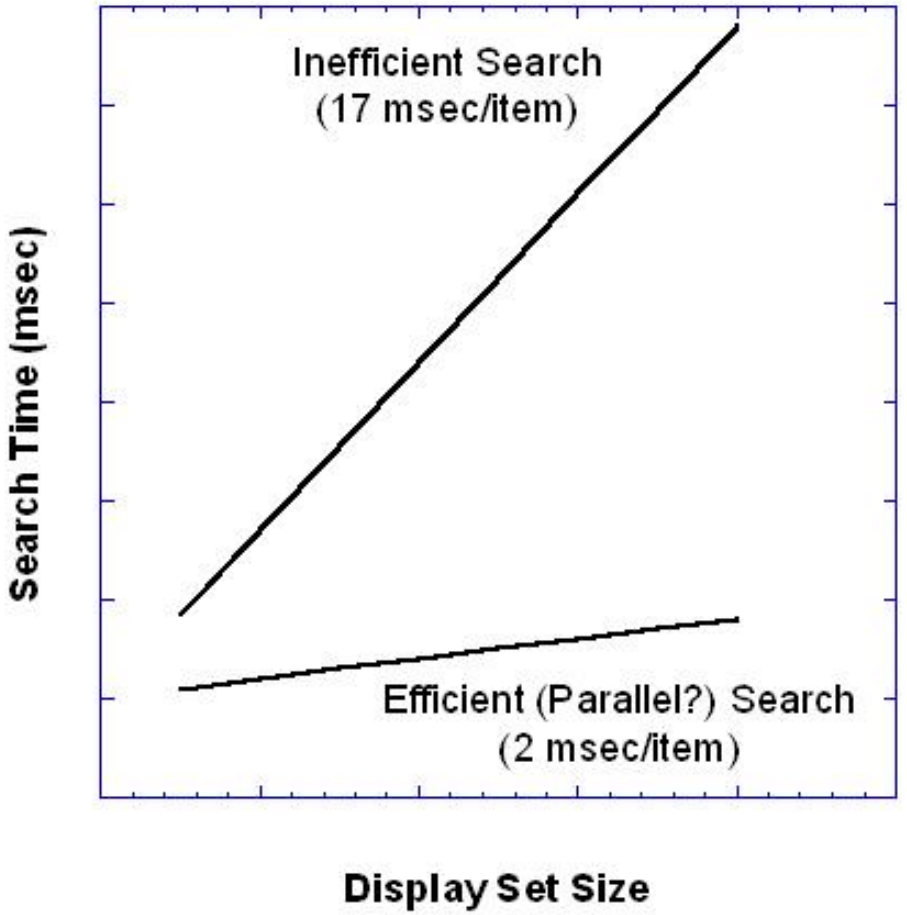
Treisman Visual Search Paradigm

Treisman Visual Search Paradigm

- Identified 2 different types of visual search processes distinguished by the "slope" of the function relating search reaction time to the number of items in the stimulus set being examined

- Fast, efficient, **PARALLEL** search (slope approaching zero)

- Slow, effortful, **SERIAL** search (steep slope approaching 20 msec/item)



Insert Search Demo Here

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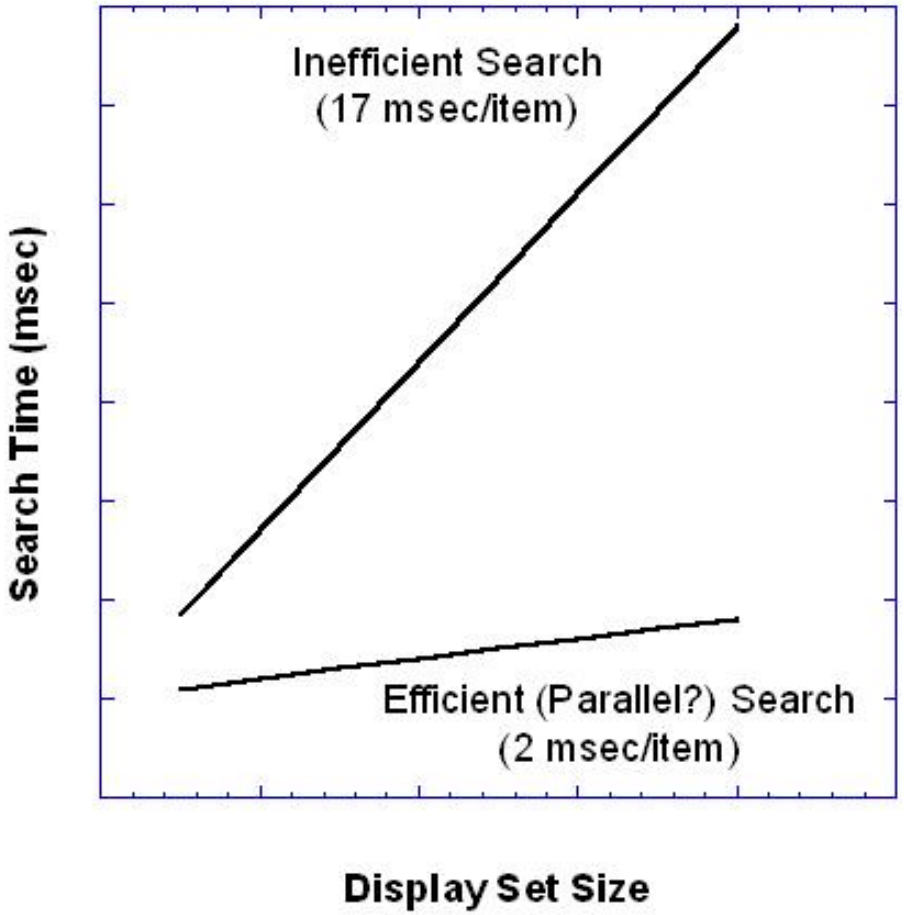


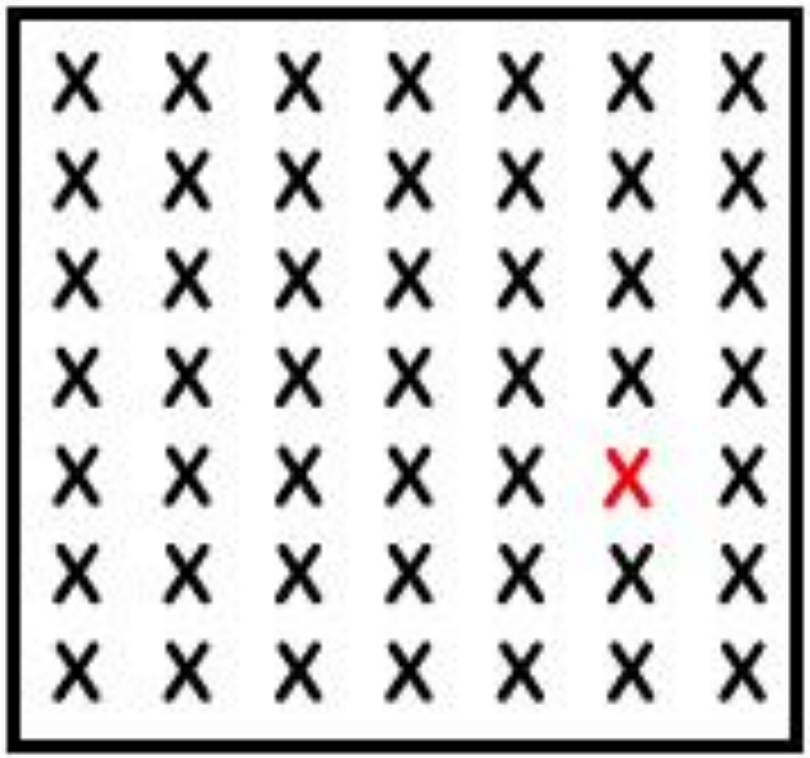
Fast, Efficient, PARALLEL Visual Search

- When the distracters all share a single perceptual property (e.g., color, size, orientation, etc.) and the target is characterized by a different level of this perceptual property, the target will appear to automatically and effortless **"pop out"** of the stimulus set

- It is "as if" the observer can simultaneously evaluate all of the items in the search set simultaneously (i.e., search in "parallel")

- Interestingly, the perceptual dimensions where such "pop out" effects have been observed correspond to the tuning properties of neurons in the visual cortex (Perceptual rather than cognitive level of processing)

Sample “Pop Out” Stimulus



When searching for a “red” target among “black” distractors your search time will be very fast and will not slow down as the number of distractors increases from few to many.

It is believed that such efficiency results from the fact that much of the processing needed to complete this class of visual search can be achieved using low-level perceptual information without much dependence upon higher-level cognitive (attentional) processes.

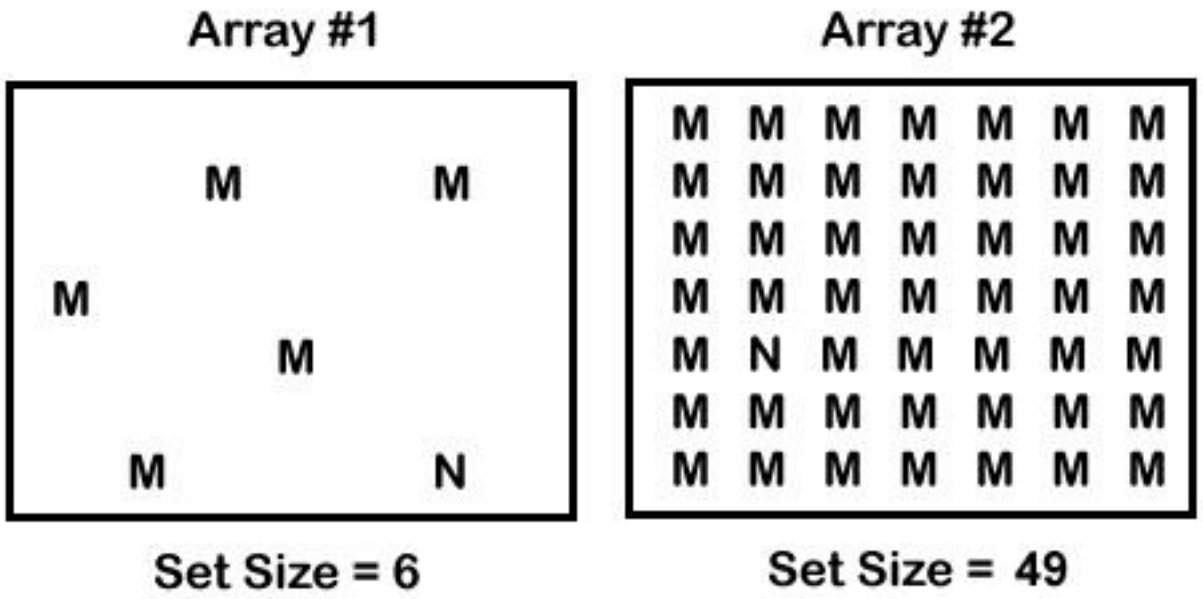
Slow, Effortful, SERIAL Visual Search

- When the target is defined by a combination or two or more perceptual properties then search times will increase incrementally as each additional distracter is added to the stimulus set.

- It is theorized that such **CONJUNCTION** search targets are "cognitive objects" that are represented at higher-levels in the brain and require cognitive resources to "bind" the perceptual properties together (i.e., Treisman's Feature Integration Theory)

- Since cognitive processes require "attention" (which is a limited commodity), conjunction searches proceed one stimulus item at a time until the target is found (i.e., in a serial fashion)

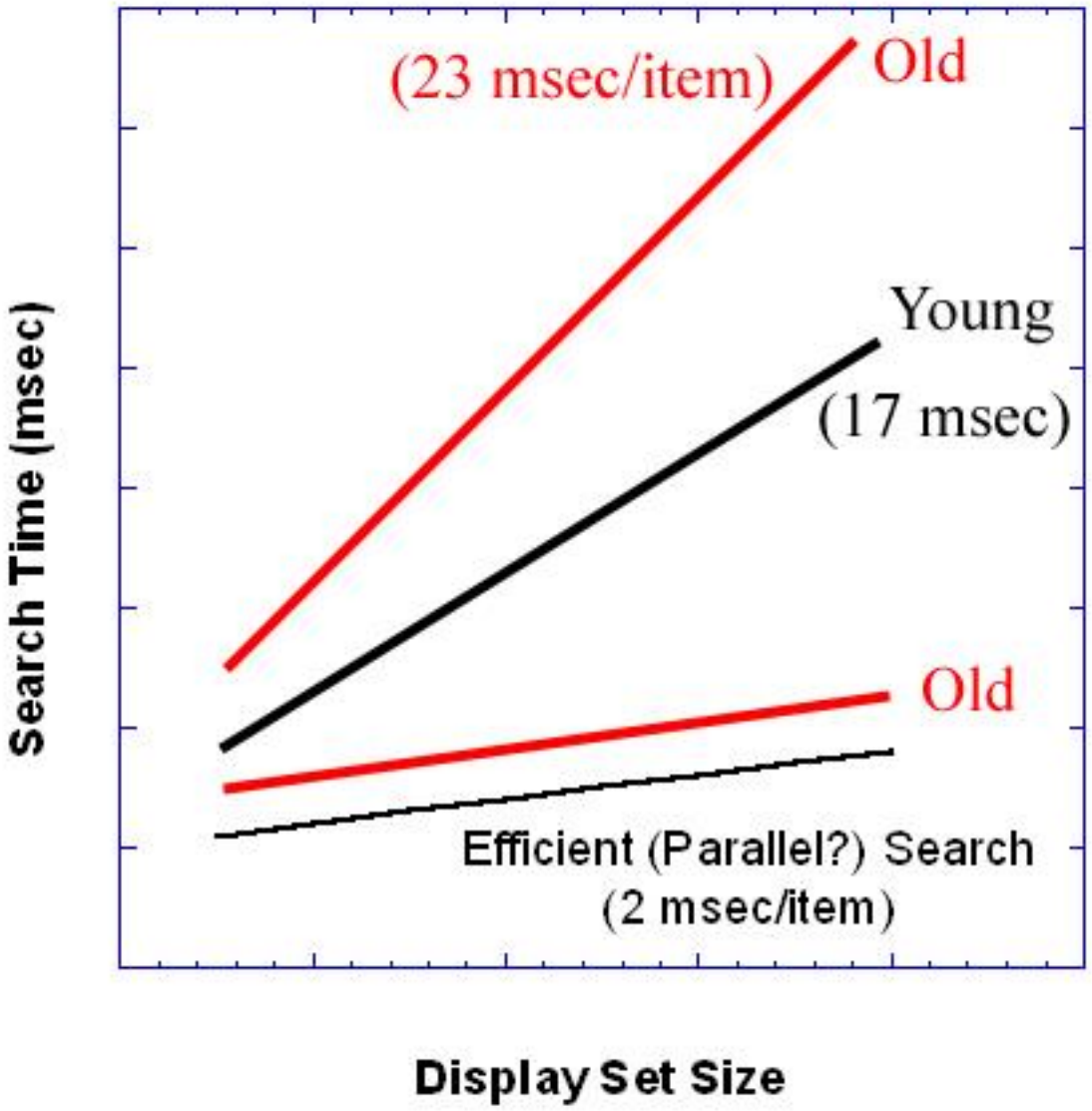
Sample CONJUNCTION SEARCH Stimuli



Searching for the letter "**N**" among an array of letter "**M**" distractors requires attention to bind the perceptual elements (line segments) into cognitive objects (letters of the alphabet).

Because attention is a limited cognitive commodity, such **CONJUNCTION** searches are slow, effortful and SERIAL in nature.

Age-Differences in Treisman Visual Search

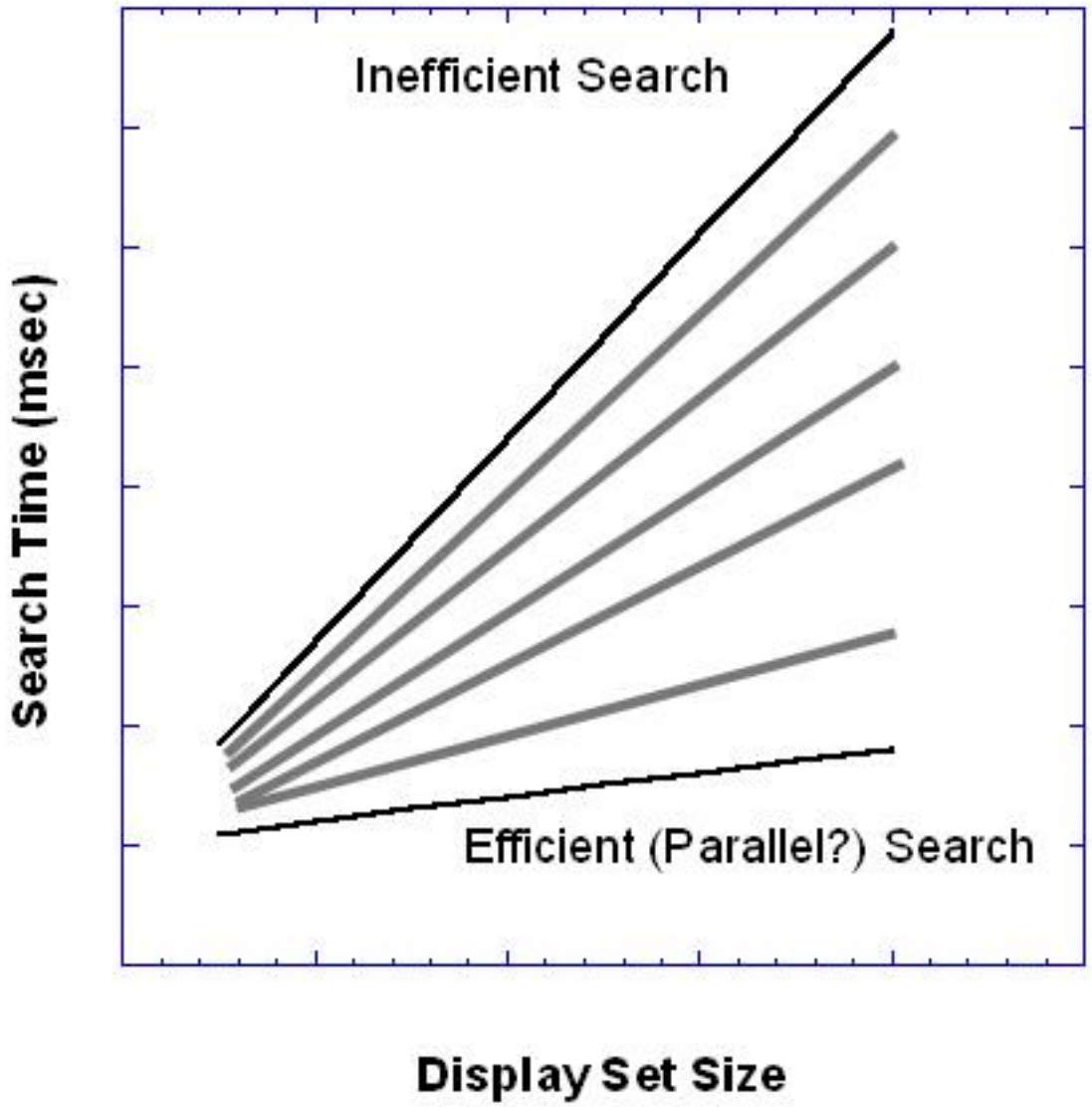


Serial search processes limited by attentional capacity slow significantly with normal adult aging.

The increased slope of the serial search function indicates that speed of selective attention slows by approximately 35%.

Note that fast, parallel search remains relatively spared by advancing age. Thus, impairment of selective attention appears to be related to slowing in higher-order cognitive processes rather than declines in low-level sensory/perceptual constraints.

Failure to Develop Automaticity (Visual Skill) Among Healthy Older Adults



When visual search tasks with consistent target-distractor mappings are practiced for MANY THOUSANDS of trials, the slope of the search time function gradually decreases over time.

This represents a transition from an effortful, top-down cognitive process to an **automatized visual SKILL** requiring minimal attentional resources.

Numerous attempts to produce such automaticity of skilled visual performance in older adults have failed to yield successful results.

Expertise

II. Divided Attention

Divided Attention

- Sharing attention between two or more tasks performed concurrently (Multi-Tasking)
- Research consistently reveals that multiple tasks are not performed in parallel as only one cognitively controlled task can be performed at a time ("The Central Bottleneck")
- Task concurrency is achieved by maintaining multiple task goals in working memory and strategically controlling task-switching operations
- Goal maintenance and task-switching require significant attentional effort
- Task concurrency always exacts a "cost"….Either the speed or the accuracy of one or more tasks will suffer

Dual-Task Paradigm

- **Subsidiary Task Procedure**

  -Primary task and subsidiary task performed concurrently

  -Primary task is prioritized
  (neglect the subsidiary task in favor of the primary task if necessary)

  -How demanding can the primary task become before spare attentional capacity is exhausted and subsidiary task performance becomes degraded

  -Subsidiary task decrements occur before catastrophic effects on the primary task

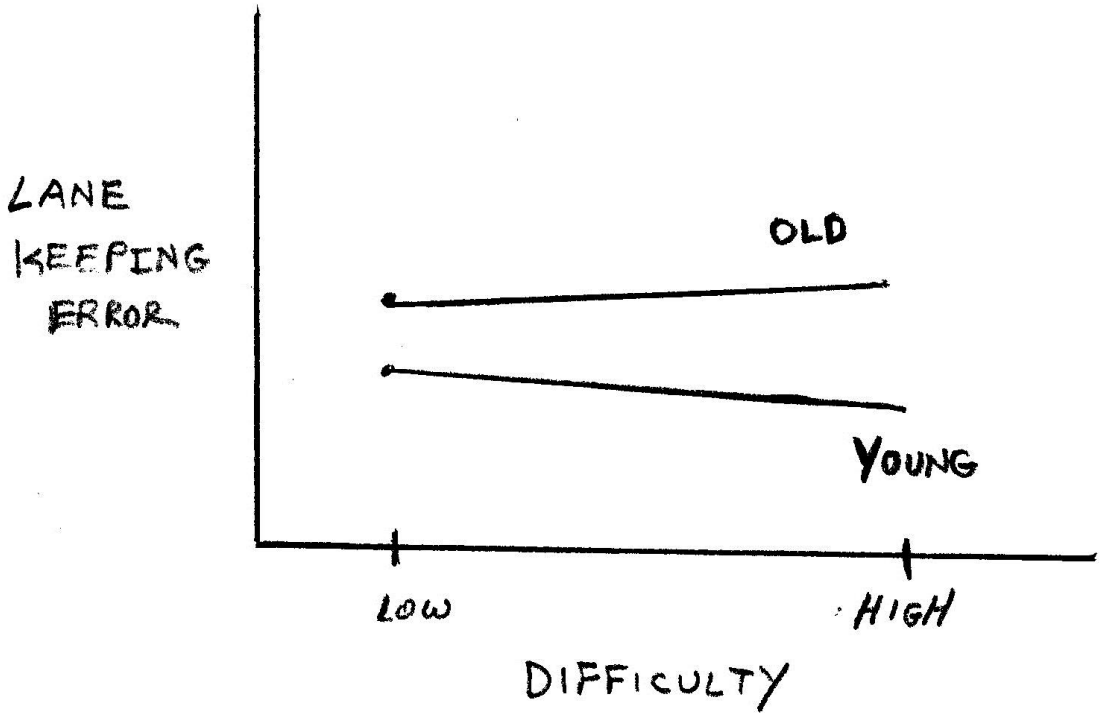
Dual-Task Studies of Aging and Driving

- Speed of Mental Arithmetic in a Driving Simulator
- Reading Text Displays during Simulated Driving
- Visual Search of the Driving Environment while Engaged in Concurrent Cognitive Tasks
- Revealing the "Hidden Costs of Compensation" using a Driving Simulator (Korteling)

Mental Arithmetic in a Driving Simulator

(Schieber & Baldwin)

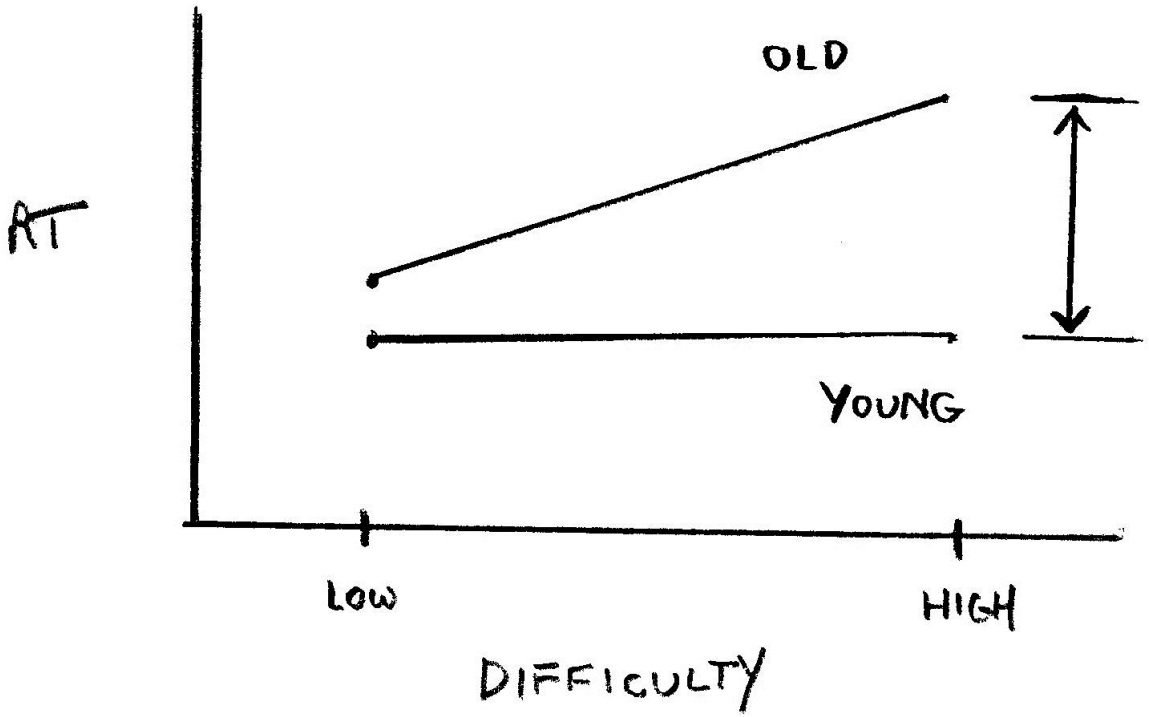
- Young and Older participants operated a driving simulator
- Complexity of the roadway was varied:
  - Low: Predictable, gradual sine wave
  - High: Unpredictable, sum-of-sines
- Concurrent subsidiary task: Harms' Mental Arithmetic Task
  - Presented with 2-digit number over a set of headphones
  - Subtract the smaller digit from the larger digit and say result
- Dependent variables:
  - Driving: lane-keeping error (std dev lane position)
  - Arithmetic: latency of response (RT)



Lane Keeping Error

No decline in lane keeping performance when driving task became more challenging (requiring more attentional effort)

In fact, young actually improved as driving task became more difficult (i.e., neglect when task is too easy)



Mental Arithmetic Latency

Only the old group demonstrated significant increased in latency when the primary task of lane maintenance required more attentional effort

Indicates that older drivers have less "spare capacity" of attention

Reading Automobile Text Displays During Simulated Driving

(Schieber, Holtz, Schlorholtz & McCall, 2008)

Research Questions

- What are the visual attention demands imposed by in-vehicle text display consoles?

- How do these demands vary with aging?

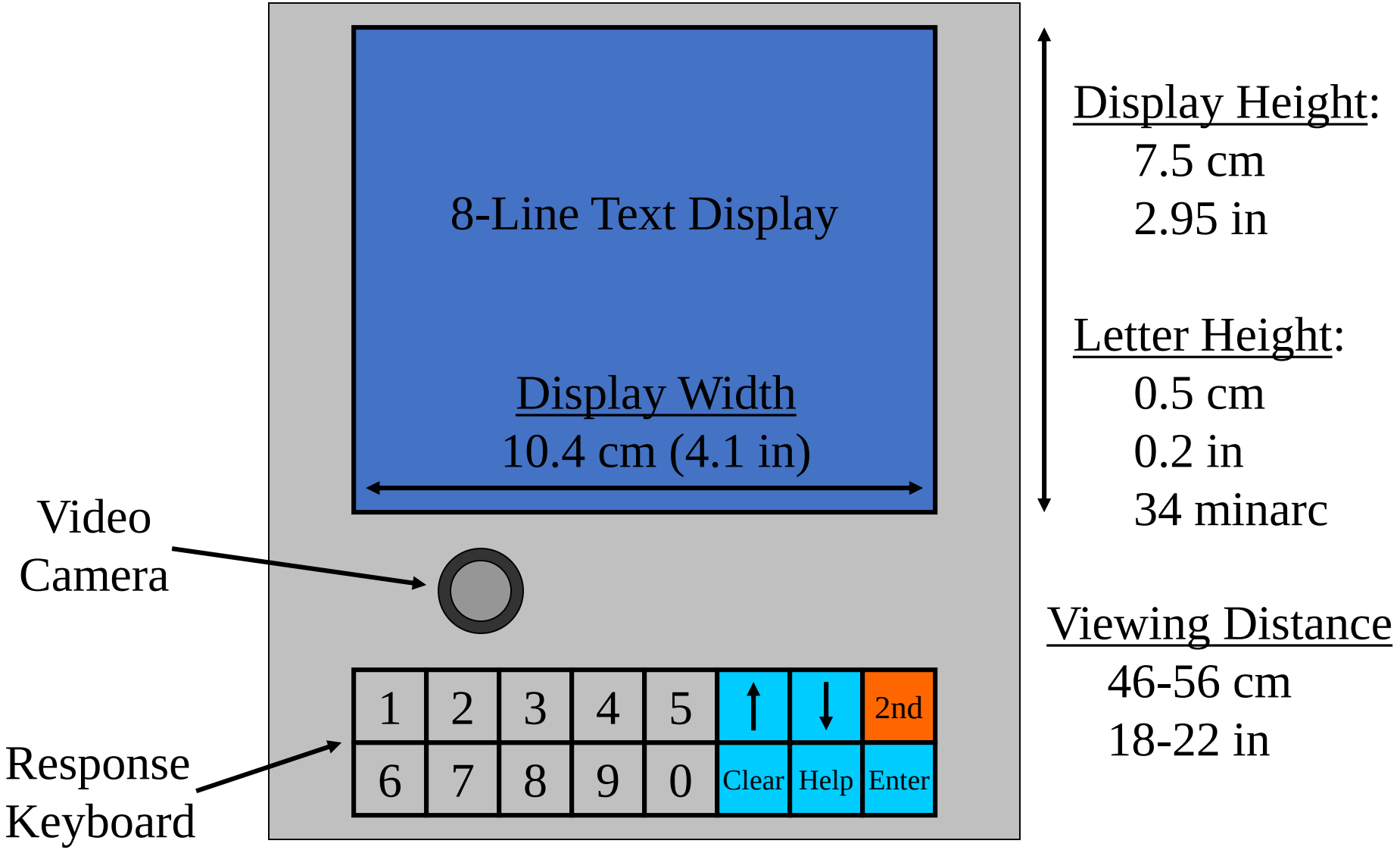
Can roadway gaze inertia previously demonstrated in older drivers be replicated? (re: Schieber, et al., 2000)

Experimental Design
(2) Age by (5) Message-Length

- Age
  Young (n=16; mean age=20; range=19-21)
  Old (n=16; mean age=77; range=65-85)

- Message Length
  Read in-vehicle text messages of variable length
  (5 levels: 1, 2, 3, 4 & 6 lines)

Text Message Console



1st Glance Latency

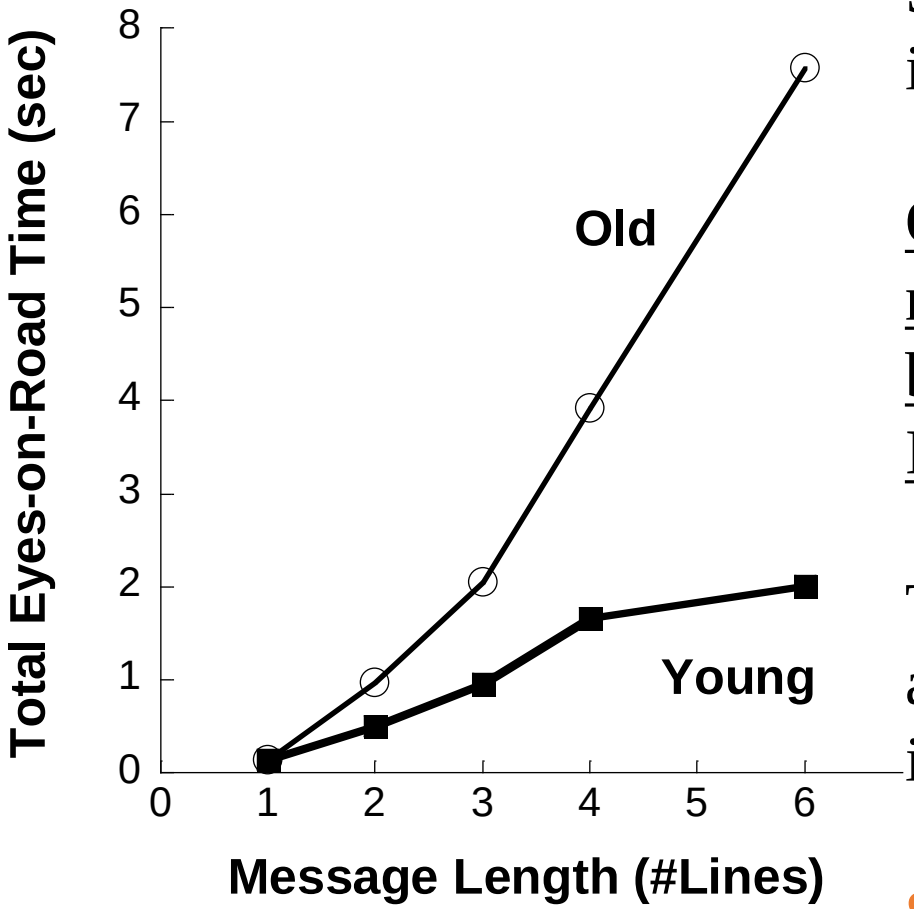
(upon onset of new message & warning tone)

- Significant main effect of AGE

- Regardless of message length, older drivers waited longer before reallocating their gaze from the roadway to the text display

  Old (mean = 1.12 sec)
  Young (mean = 0.54 sec)

Total Eyes-on-Road Time



Significant Age by Message Length interaction (0.001)

Older drivers needed to inspect the roadway for greater periods of time between successive glances to the IVIS display.

This effect appears to completely account for the age-related increase in total elapsed time observed earlier.

SA decay effect???
Attention switching problem?

IPSCAN2 Summary

- Large increase in the overall time needed by older drivers to read messages requiring more than a single glance.
- Age-related increase in total elapsed time was not due to the need for longer glances or more glances.
- Elevations of inter-glance time (eyes-on-road time) account for virtually all of the age-related slowing.

IPSCAN2 Summary (cont.)

- Why the need for greater eyes-on-road time?

  (1) Need to re-establish Situation Awareness?
  (2) Attention switching deficit?

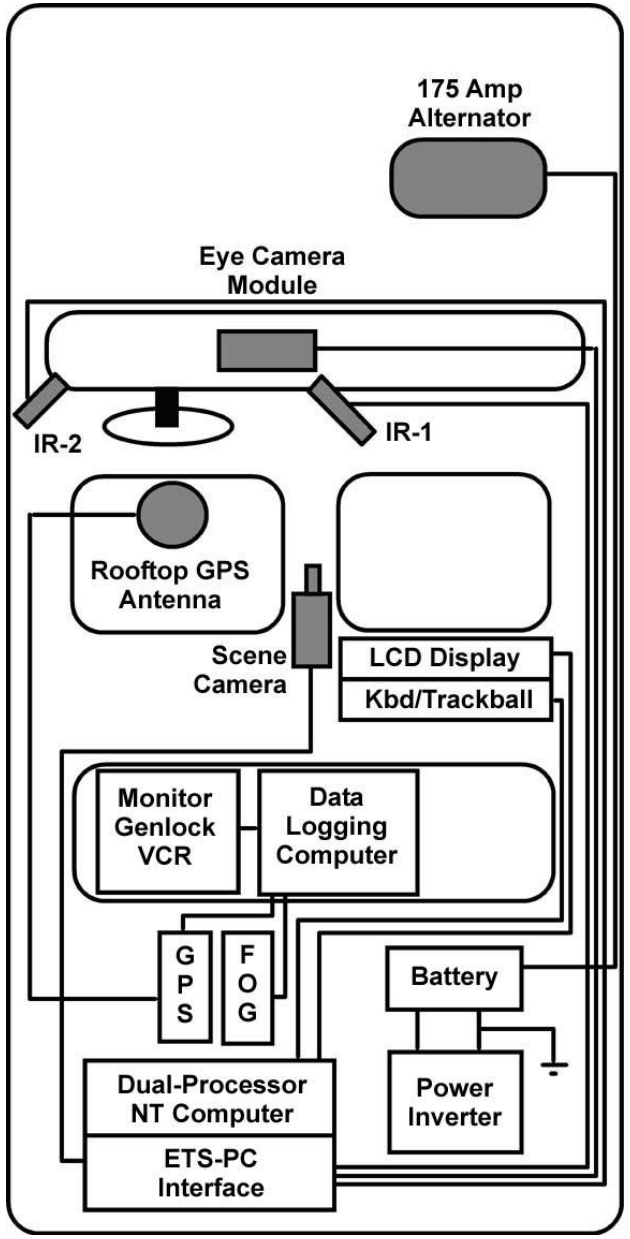
  (e.g., Korteling, 1991; Ball, et al., 1993; Verwey, 2002)

- Age-related increase in 1st Glance Latency consistent with attention switching mechanism ("reallocation" or "disengagement" problem)

Effects of Cognitive Load Imposed by Subsidiary Tasks upon the Complexity of Driver Eye Scanning Behavior

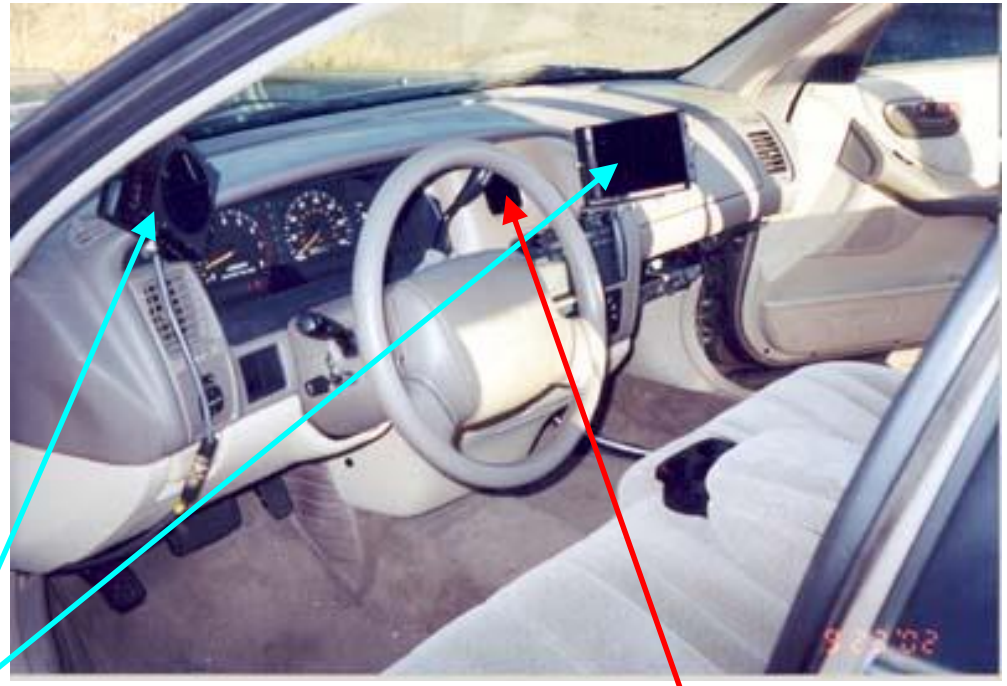
(Schieber & Gilland, 2008)

USD Instrumented Research Vehicle



ASL ETS-PC Eye Tracker

ASL ETS-PC
Driver Eye Tracking System



Infrared Illuminators
(source of corneal reflections)

Hidden Eye Tracker Optics

The Experiment

- Eye movements recorded during 10 min drives on rural 2-lane highway (55 MPH)
- 3 driving conditions:
  - Baseline
  - Memory Load Task
  - Visual-spatial Load Task
- 2 Age Groups:
  - Young (mean age = 27)
  - Old (mean age = 75)

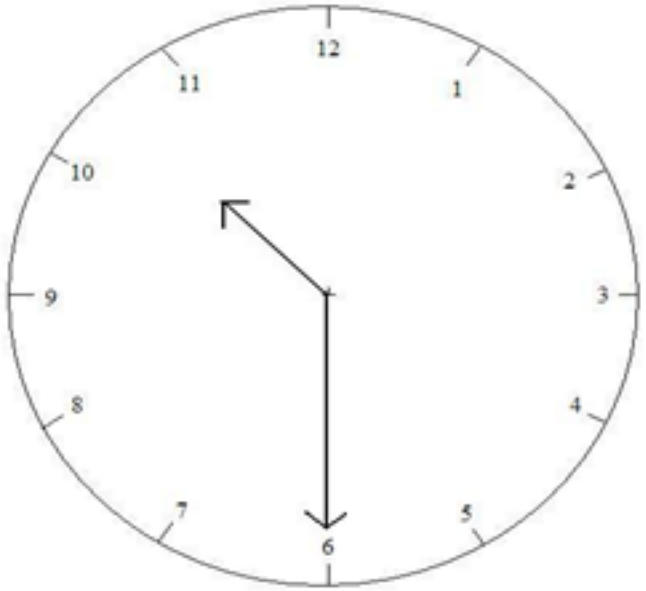
Memory Load Subsidiary Task:

- 1-Back Task
- Quasi-random string of numerical digits
- Auditory presentation (subjective level adj.)
- Interstimulus interval = 4 sec
- Answer Yes/No question for each stimulus:
  Same as the previous stimulus?

Visual-Spatial Subsidiary Load Task: (The Clock Task)

- Audio presentation of time-of-day stimulus (ISI = 8 sec)
- Form visual image of the time on the face of an imaginary analog clock
- Answer Visual-Spatial Question:

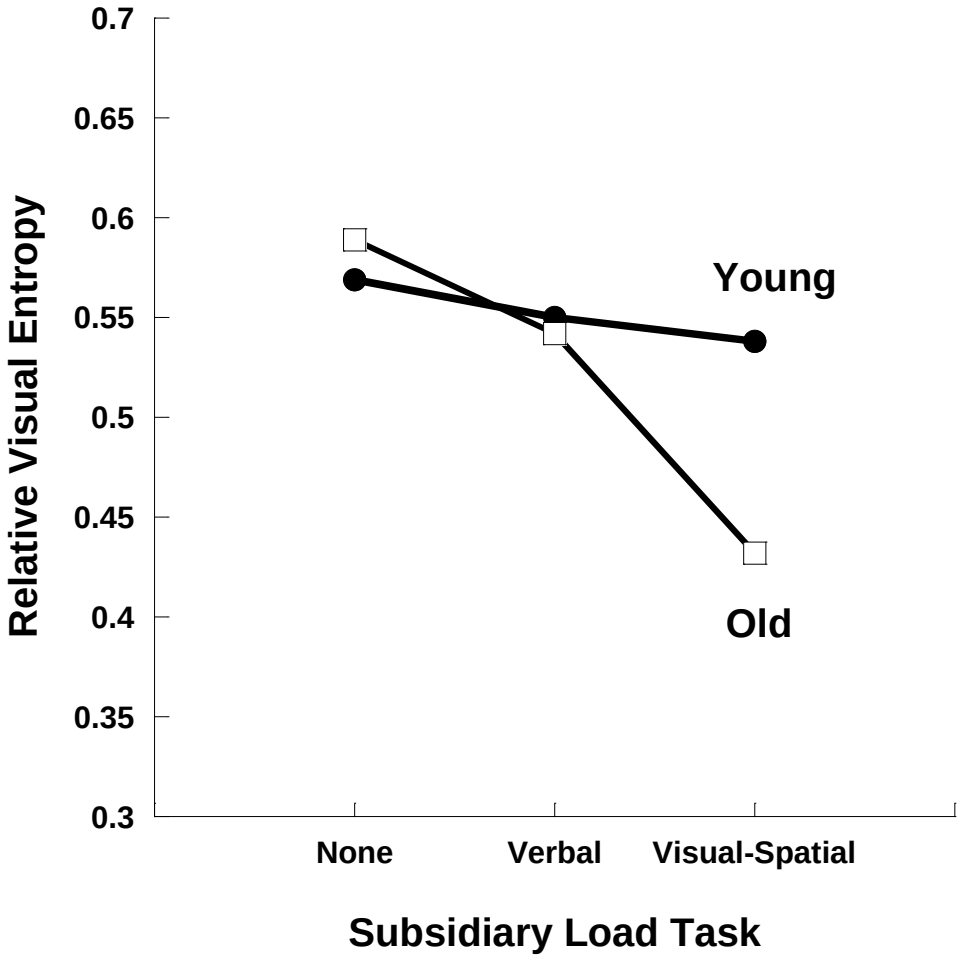
  Is the smallest angle formed by the hands of the clock greater or less than **90-deg**?



"10:30"
Correct answer = "More"

"9:54"
Correct answer = "Less"

Insert video clip here



Significant Age x Task Load Interaction

Complexity of visual scanning for young drivers not influenced by cognitive loading task

Older drivers not affected by the memory loading task.

Imposition of the Clock Task resulted in a remarkable reduction in the complexity of visual scanning for the older drivers.

Visual-spatial processing is easily overloaded in older drivers because of diminished spare attentional capacity.

(Tunnel vision under high task load)
(Reduced useful field of view?)

Korteling Dual-Task Driving Study

("Hidden Cost of Compensation")

- Young and older adults performed a **car following task** in a simulator
- Baseline performance established during initial session
  Lateral Variability (stability of lane keeping)
  Longitudinal Variability (maintaining distance from lead vehicle)
- Reversal of accelerator function in second phase of study
  Results:
  No age differences in longitudinal variability
  Older drivers demonstrated increased lateral variability
- Older drivers successfully compensated for the accelerator reversal but the attentional effort was so great that they neglected the lane keeping subtask

Rob Peter to Pay Paul

III. Sustained Attention (Vigilance)

Vigilance

- The ability to maintain the allocation of attention to one or more tasks over an extended period of time
- The ability to “stay on task”
- Usually assessed using an extensive set of stimuli presented sequentially over a long time period:

For example:

Detect any rare occurrence of ZERO in a stream of digits

or

Detect temporal-spatial anomalies on a **Macworth Clock**

Vigilance and Aging

- Studies of sustained attention typically demonstrate a "vigilance decrement"….Performance gradually declines as a function of time on task

- **STUDIES OF OLDER ADULTS HAVE REVEALED LITTLE OR NO AGE-DIFFERENCE IN THE MAGNITUDE OR SLOPE OF THE VIGILANCE DECREMENT**

- Sustained attention is resistant to the effects of aging provided that the visual system is not overtaxed by rapid stimulus presentation rate, spatial uncertainty or stimulus degradation