Review questions

- What are the two major characteristics of sensation?

  - Adaptation
    - Adaptation
  - Better at telling the difference
    - Better at telling the difference

- What are the three major characteristics of perception?

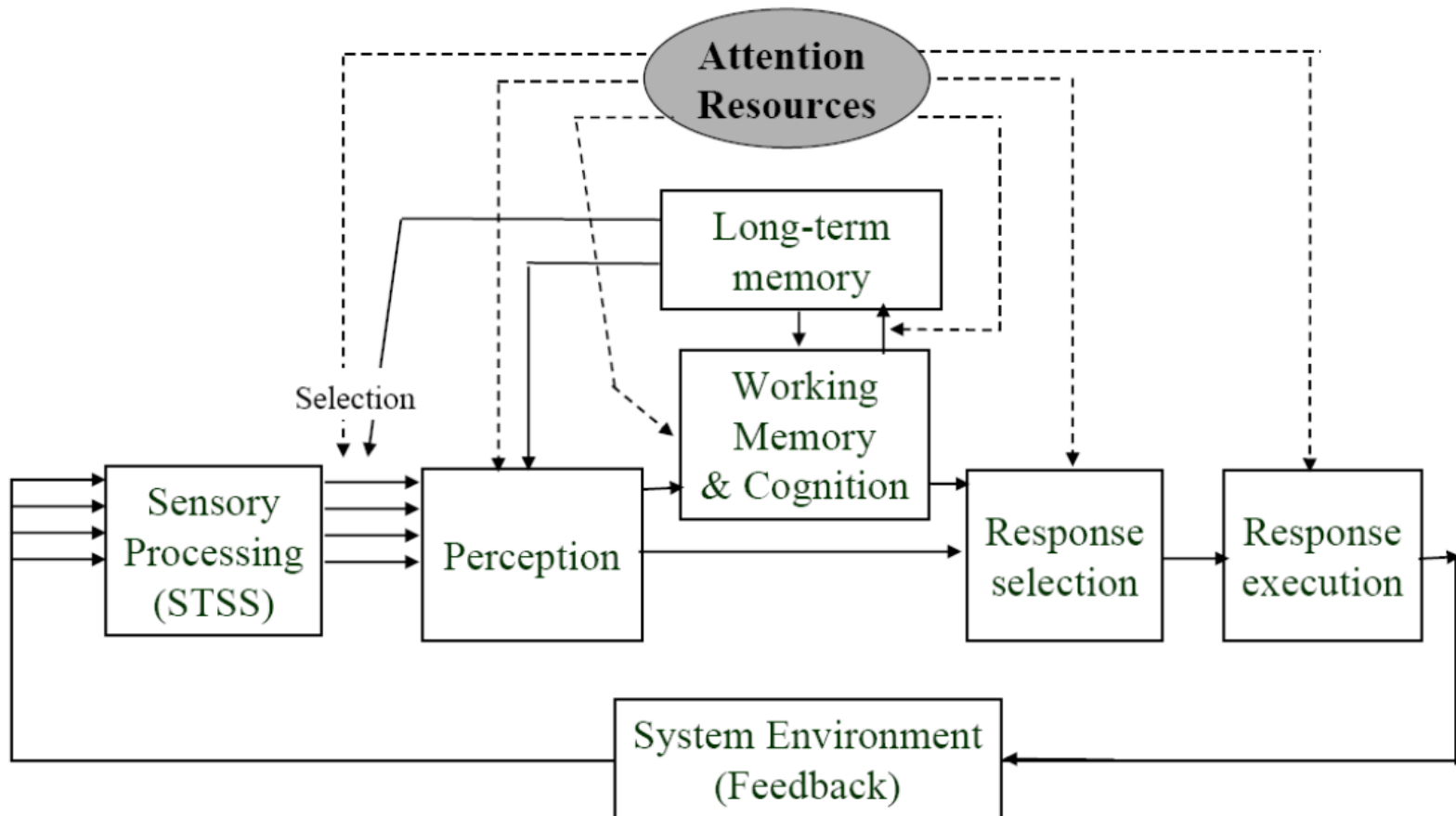**Check previous lecture slides to find the answers.**

SYDE 543 (Fall 2016)
Cognitive Ergonomics

Attention I

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Systems Design Engineering

UNIVERSITY OF
**WATERLOO**

Overview of today's lecture

- Characteristics of attention

- SEEV model of visual attention

- Visual search and display design considerations

Characteristics of attention

- Selective attention

- Focused attention

- Divided attention

- Sustained attention

Selective attention

- Large amount of sensory input
- Limited attention resources
- Can only process some selected

- Spotlight metaphor
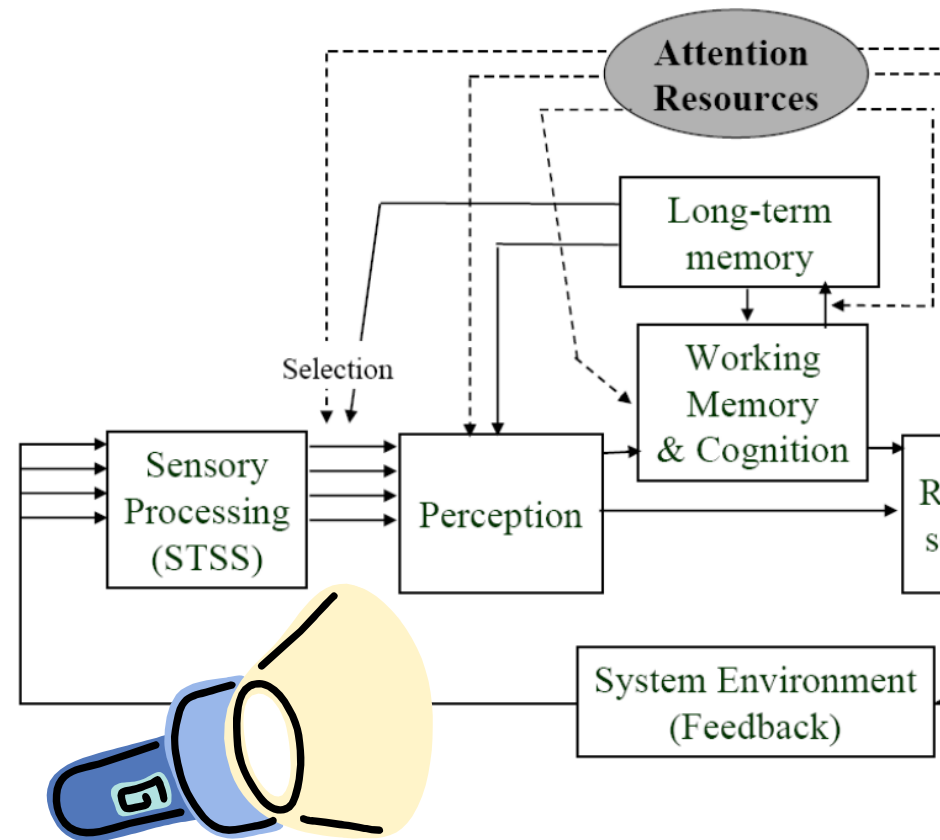
Visual attention shift ≠ eye movement

- <u>Overt</u> attention shift: with eye movements and any physical orienting of the body.

- <u>Covert</u> attention shift: without eye movement.

E   A ✛ B   D

Selective attention (auditory)

Focused attention

- The other side of selective attention

- Ignore sensory info not selected

- Suppress distracters

- Can be difficult when distraction is attention-capturing

Focused attention (without distractions)

Focused attention (with distractions)

Divided attention

- Attend multiple objects at the same time
- Can we attend multiple tasks at the same time?
- What kind of tasks can be done at the same time?
- Multitasking (details in the next lecture)

http://www.premierlife.ca/on-campus/road-train-cars-drive-by-themselves/attachment/texting-while-driving-1b190c5d30a532ae_large/

Sustained attention

- Maintain vigilance, focused on the task for prolonged time
  - System monitoring (e.g., radar, power plant control room)
  - Long distance driving
  - Night guard security
  - Airport security check
  - Swimming pool lifeguard
  - …

- More details in the mental workload and stress lecture later

NOT four kinds of resources,
but four ways to use your attention resources

- Selective attention

- Focused attention

- Divided attention

- Sustained attention

- More about attention resources next lecture

SEEV model of visual attention

- Model explains factors that affect
  - Where the eye is looking (AOI, area of interest, a physical location where specific task-related information can be found)
  - How long time is spent looking at each AOI
  - The probability to notice unusual events

- Bottom-up factors
  - **S**alience
  - **E**ffort (with respect to moving attention and the eyes)
- Top-down factors
  - **E**xpectancy
  - **V**alue

Salience

- The extent to which the AOI stands out from the background (or from other AOIs) by virtues such as its size, color, intensity, contrast, novelty, or flashing/changing.

- E.g., tag cloud (word cloud, weighted list)

Salience is a relative concept.

Effort

- Cost of moving attention from one AOI to another.
  - No eye movement (covert attention shift)
  - Eye movement
  - Head movement
  - Body movement

FIGURE 13-18
The control room of the Three-Mile Island nuclear power plant. *(Photograph courtesy of Dr. Thomas B. Malone, Essex Corporation.)*

- Estimated likelihood of events happening at an AOI

- Related to personal knowledge, experience, and understanding of the system dynamics

- Can be improved by training

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Value

- The usefulness/importance of the information from an AOI.

- E.g., driving

  - Road and other cars information value

  - Traffic sign and signal value

  - GPS information value

  - Text message information value

SEEV model of visual attention

- Qualitatively, identify important factors
- Limitations
  - Quantitatively, the exact numbers of S, E, E, and V are difficult to estimate.
  - Existing studies used a lot of subjective estimation.
  - Consensus and database for consistent numerical SEEV values are needed
- (Advanced topic) Computational methods to determine
  - Where the eye looks   2009-Wickens et al-NT-SEEV
  - How long time is spent looking at each AOI
  - The probability to notice unexpected events

- Is there a change in the picture? Look carefully.

Limitations of attention

- https://www.youtube.com/watch?v=FWSxSQsspiQ

Limitations of attention

- https://www.youtube.com/watch?v=1nL5ulsWMYc

Limitations of attention

- https://www.youtube.com/watch?v=vJG698U2Mvo

Change blindness

Changes in the physical world, although salient and visible by the eye (or audible by the ear, etc), are not detected.

- Blink change (related to focused attention and STSS)
- Door experiment (related to focused attention and STSS)
- Gradual change (related to focused attention and differential threshold)
- Gorilla (related to focused attention)

Major causes:

- Selective and focused attention
- Attentional narrowing or tunneling
  - Attention focused on AOIs with expected high values/importance
  - Unexpected events from unexpected AOIs could be missed

Visual search and design considerations

- Limited attention, large visual info -> need to search
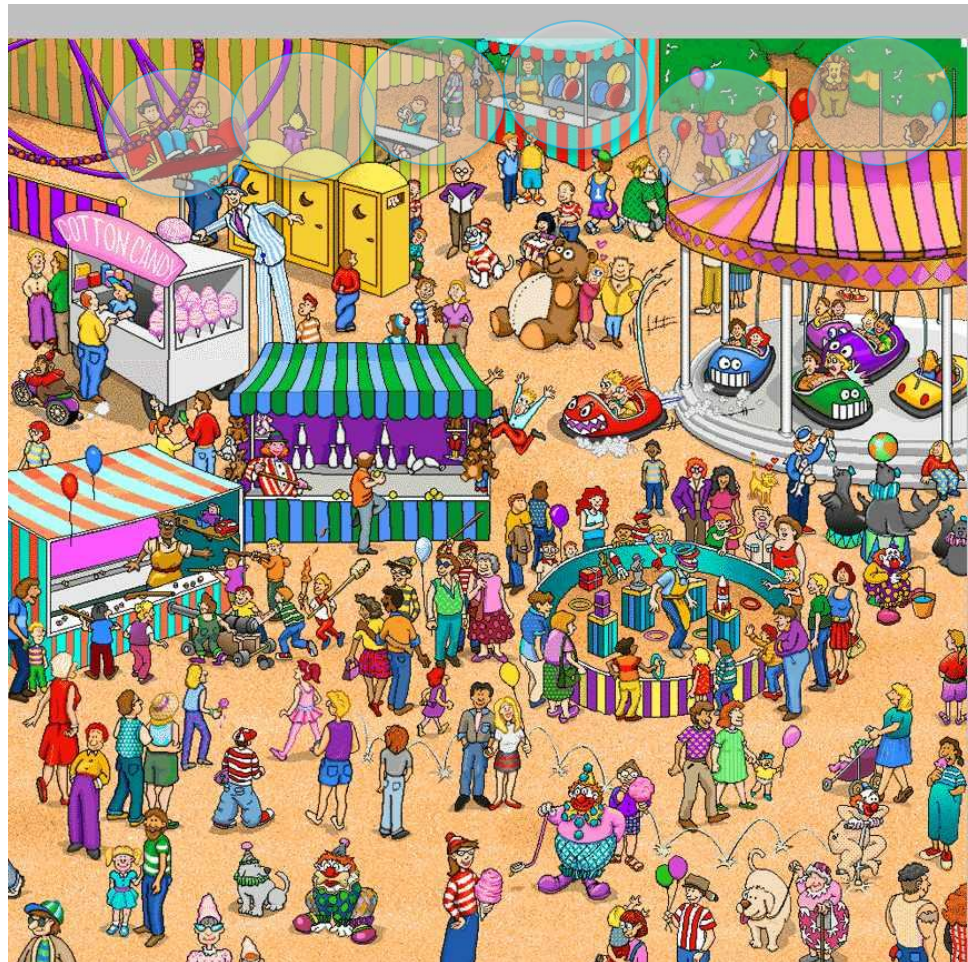

Where's Waldo?

- **Useful field of view (UFOV)**: the visual angle within which a target can be detected if it is present, or a non-target identified if it is not.

- Systematic search will "blanket" the field.

- Serial search
  - Fixed order
  - Random order

- Parallel search
  - When the target stands out from others

Parallel search. Find letter L

T   T   T   T   T   T

  T   T   T   T   T   T

       T   T   T   T

   T   T   T   T   T   T

T   T   T   T   T   T   T   T

       T   T   T   T   T

  T T   T   T   T   T   T   T   T

   T   T   T   T   T   T

       T   T   L   T   T

T   T   T   T   T   T

Salient target (color coding)
Parallel processing, target popout
Search time decreased

Clutter

- Refers to the characteristics of display items that hinder selective and focused attention in visual search.
    - Numerosity clutter (large number of distracters)
    - Density clutter (dense distribution of distracters)
    - Disorganizational clutter (random location of distracters)
    - Heterogeneous clutter (different features like color, shape, or size of distracters)

Why clutter disrupts visual search?

- Distracters near the target may be processed automatically (preattentively, requiring few attention resources)

- Automatic process (less or no need for attention):
  - E.g., reading and listening to your native language

- Controlled process (requires attention):
  - E.g., reading and listening to a new second language

Test 1

- Read aloud the <u>color</u> of each word as quickly as possible.

Red	Yellow	Blue	Green
Blue	Red	Green	Yellow
Yellow	Green	Red	Blue

Test 2

- Read aloud the <u>color</u> of each word as quickly as possible.

Red   Blue   Green   Yellow

Yellow   Red   Blue   Green

Blue   Yellow   Green   Red

Stroop Effect: What's Happening?

- The words are processed automatically.
- When there is conflict between word and name of color
  - Perceptual competition
  - Extra attentional effort is required to suppress the meaning of words (focused attention).
  - May accidentally select the incorrect response
  - Slower response

Stroop Effect Takeaways

- Redundancy gain (Red vs. OOO):
  - increase in performance when object features map to the same (compatible) responses

- Response conflicts (Red vs. OOO):
  - decrease in performance when object features map to different (incompatible) responses

- Design implication
  - Use redundancy gain
  - Avoid response conflict

Design trade-off

- Put multiple displays closer to each other
  - reduce visual search effort

- Put multiple displays farther away from each other
  - Avoid clutter

- Head-up display (HUD)
- Augmented reality display

Overlapping views & Head-up display (HUD)

- Pros: can reduce visual search effort, faster visual search; may support divided attention and parallel processing
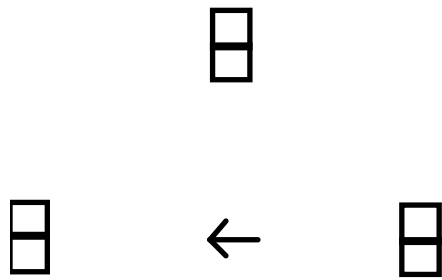- Cons: can clutter the display, making items less easy to detect or process; may block images

Proximity Compatibility Principle

- If two tasks are different in terms of goals and requirements (low task proximity), the displays for the tasks should be separated or placed farther away from each other (low display proximity).

- If two tasks are similar in terms of goals and requirements (high task proximity), the displays for the tasks should be integrated or placed close to each other (high display proximity).
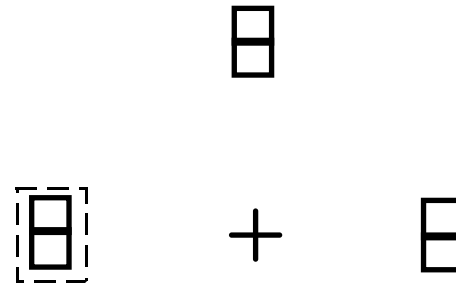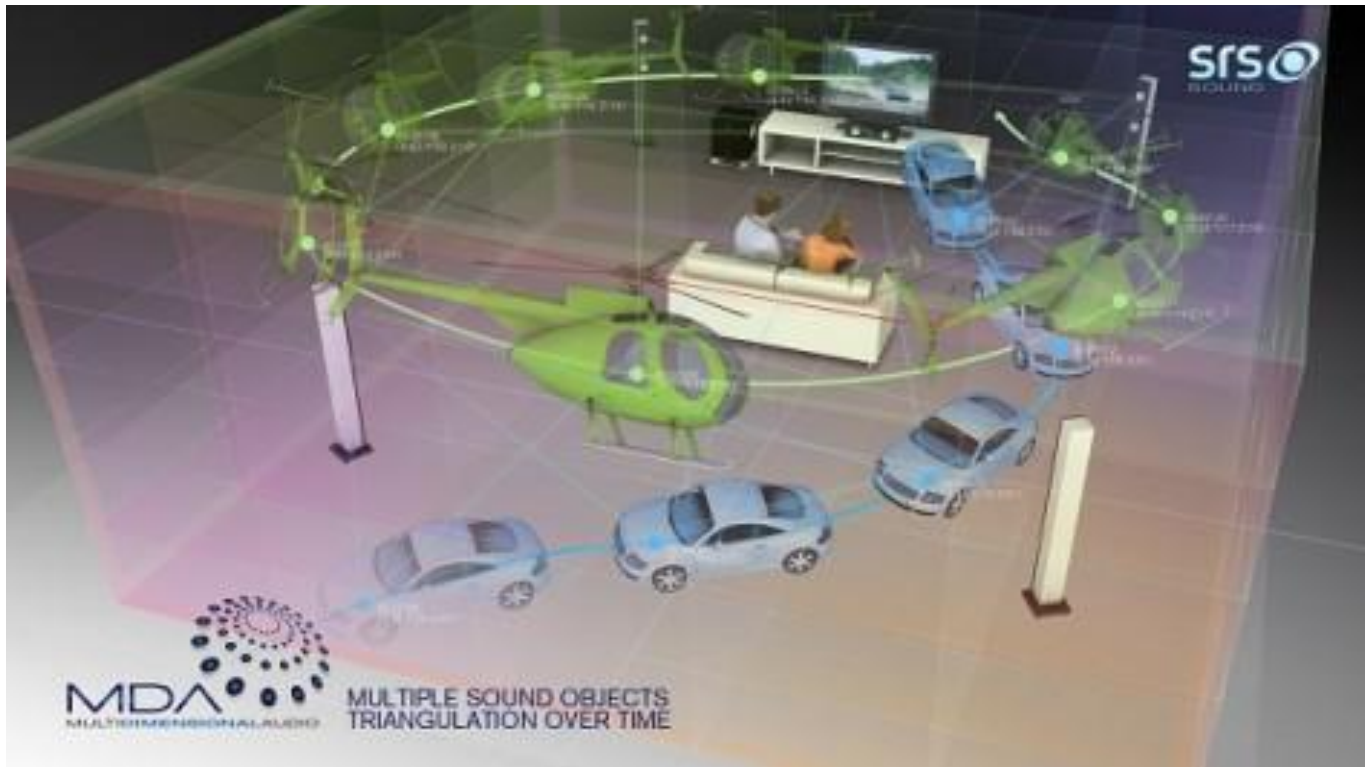
- Central visual cue

- Peripheral visual cue

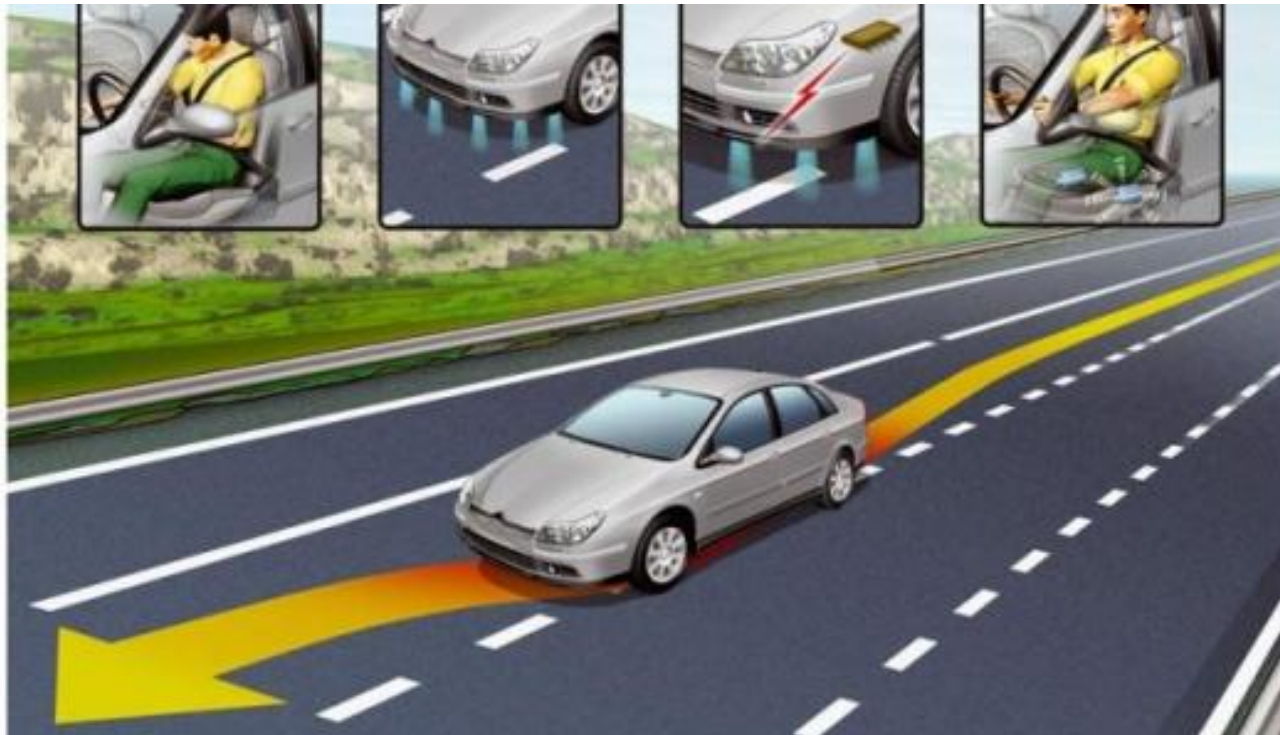# Directing and guiding attention

- Central visual cue

- Peripheral visual cue

- 3D audio direction cue

- Central visual cue

- Peripheral visual cue

- 3D audio direction cue

- Tactile cue

Summary of today's lecture

- Characteristics of attention

- SEEV model of visual attention

- Visual search and display design considerations

Homework 1

- Posted on LEARN

End of lecture