What Is Attention?

- “Every one knows what attention is. It is the taking possession by the mind, in a clear and vivid form of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration of consciousness are of its essence. It implies withdrawal from some things in order to deal with others…” (James, 1890, p. 403)

Attention is...

- An attitude of mind
- Relative proportion of activated traces to all memory traces - active workspace
- Some form of energy or desire involving will or effort
- A filter
- An allocation of resources
- A spotlight, a selective attenuator

Characteristics

- General agreement regarding two characteristics outlined by James:
  - **Bottom up (sensory) attention** driven by environmental events (stimulus-driven; exogenous)
  - **Top down (volitional) attention** to both external and internal stimuli (goal-driven; endogenous)
- May be thought of as automatic vs. controlled, respectively.

Automatic Vs. Controlled Processing Distinction

- **Automatic processes**
  - no capacity limitation; fast
  - do not require attention, effort
  - difficult to modify once learned
- **Controlled processes**
  - limited in capacity; slow
  - require attentional resources, effort
  - can be used flexibly in changing circumstances

Purposes of Attention

- Cope with inherent capacity limitation of brain
- Facilitate stimulus detection
- Facilitate stimulus perception
- Facilitate thinking
• Facilitate memory
• Recruit relevant processors
• Prepare for action

10 Varieties of Attention
• **Focused attention** (processing only one input at a time)
  - Orienting to sensory events
  - Detecting signals for focal (conscious) processing
• **Divided attention** (processing multiple inputs according to nature of inputs and goals)
  • **Maintaining a vigilant state**

11 Varieties of Attention

12 Dimensions of Attention
• Focality (detection vs. selective attention)
• Duration (brief vs. sustained attention)
• Input channel
  - Visual attention
    • Spatial
    • Object-based
  - Auditory attention
    • What, where
• Cognitive effect (facilitation vs. inhibition)

14 Early Visual Attention
• Interface between Attention and STM: **Attentional blink**

15 Early Visual Attention (Cont’d)
• Interface between Attention and STM: **Repetition blindness**

16 Early Visual Attention
• AB and RB can be doubly dissociated (Chun)
  - Making targets different from distractors alleviates AB but not RB
  - Enhancing episodic distinctiveness of the two targets eliminates RB but not AB
• May represent different things
  - AB represents bottleneck in attentional processing
  - RB reflects failure of token individuation

17 Selective Attention
• Selective processing of some information but not others
• Filter vs. capacity models
• Important research paradigms
  - Dichotic listening
    http://www.humnet.ucla.edu/humnet/linguistics/people/schuh/lx001/Dichotic/dichotic.html
  - Shadowing
Cherry (1953)

- Interested in attentional “popout” of relevant information (“cocktail party effect”)
- Two messages, same voice, both ears: subjects could invariably separate messages, but with difficulty; uses physical/source characteristics
- Dichotic listening with shadowing
  - Recalls little if any content from other ear
  - Often doesn’t recall language
  - Can recognize it as speech/nonspeech, and can recognize male-female

Broadbent (1958)

- Influential paper on focused (selective) attention; felt by many to be a critical ‘cornerstone’ paper in cognitive psychology
- Influenced by Cherry’s shadowing results
- Used dichotic listening, and found a strong tendency to report digits ‘by ear’, thus reflecting a tendency to select based on perceptual/physical characteristics of the input

Broadbent’s Filter Theory

Problems With Broadbent’s Filter Model

- Sometimes attention doesn’t follow input source: Gray & Wedderburn (1960)

  - fan
  - out
  - rage
  - tas
  - tic
  - ous

- Can demonstrate that “unattended” information is processed phonologically or semantically: Corteen & Wood (1972)
  - EDR’s to shock-associated words in an unattended channel - city name study

Early Vs. Late Selection

- “Early” theories (Broadbent, Treisman)
  - selection takes place well before extensive (e.g., semantic) analysis takes place
  - contradicted by studies showing semantic effects in unattended ear

- “Late” theories (Deutsch & Deutsch)
  - extensive analysis of stimuli takes place before selection
  - raises issue of benefits of selective attention
  - shadowing delayed by presentation of a synonym in the other ear; recall biased by semantic interpretation (e.g., bank-river, vs. bank-money)

A Hybrid: Perceptual Load Theory

- Everyone has limited attentional capacity
- The amount of attentional capacity allocated to the main task depends on its perceptual load, which is determined by “the number of units in the display and the nature of processing required for each unit” (Lavie & Tsal, 1994, p. 185)
- “Any spare capacity beyond that taken by the high-priority relevant stimuli is automatically allocated to the irrelevant stimuli” (Lavie, 1995, p. 452). Thus, the total available attentional capacity is always allocated to processing
- Early selection occurs when load is high; late selection dominates when load is low

Evidence for Perceptual Load Theory

- Mean target identification time as a function of distractor type (neutral [N] vs. incompatible [Z]) and perceptual load (low vs. high). Based on data in Lavie (1995). Nature of distractor has more effect on time when perceptual load is low.
A Capacity Model
Kahneman (1973)
- Supplements previous bottom-up analysis with a consideration of top-down influences
- Emphasizes concept of processing resources
- Attention and mental effort are strongly correlated
- Arousal can work to increase processing resources

Understanding the Effects of Attention is Important When there are Limitations on Processing
- Resource-limited processes
  - Processes dependent on the availability of resources that can be devoted to task solution
  - Applying more effort or processing resources increases task performance
    - If output not available until task is finished, then devoting more resources decreases RT
    - If output continuously available, then performance level increases
- Data-limited processes
  - Processes dependent upon the quality of data input, rather than upon resource allocation
    - Applying more resources may have little effect on performance
  - Most processes have both resource- and data-limited components

Focused Visual Attention
- The Attentional “Spotlight” model
  - Items within a small portion of the field can be seen clearly
  - Posner’s ‘covert’ shifting of the spotlight
  - Problem: proximity not always facilitative - e.g. Driver & Baylis, 1989 - common movement
- Zoom-lens model (Eriksen & Yeh, 1985)
  - Magnification inversely proportional to FOV
  - ‘Magnification’ can be increased or decreased
  - Grouping processes affect spatial extent of attention
  - Problem: attention can be object-based; objects outside the zoom can be processed or even inhibited

Evidence for Spotlight
- Location-specific facilitation of attention
  - RT’s faster when object appears in cued location
  - Search for target letter and report orientation of “U”; done better when two letters are close together

Focused Visual Attention
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  - Problem: proximity not always facilitative - e.g. Driver & Baylis, 1989 - common movement overrides proximity
- Zoom-lens model (Eriksen & Yeh, 1985)
- Magnification inversely proportional to FOV
- ‘magnification’ can be increased or decreased
- Grouping processes affect spatial extent of attention
- Split attention (Awh & Pashler)
- Problem: attention can be object-based

39 Experiments Demonstrating Split Attention
(a problem for the zoom-lens model)
- (a) Shaded areas indicate the cued locations and the near and far locations are not cued; (b) probability of target detection at valid (left or right) and invalid (near or far) locations.
- Based on information in Awh and Pashler (2000).

40 Object-Based Attention

41 Inhibition in Attention

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44 Inhibition of Return (IOR)
- “A reduced perceptual priority for information in a region that recently enjoyed a higher priority” (Samuel & Kat, 2003, p. 897)
- A bias favouring novel locations and objects
  - IOR due to inhibition of perceptual and/or attentional processes
- Taylor and Klein (1998)
  - IOR due to inhibition of motor processes
- Prime and Ward (2004) ERP study
  - IOR is a perceptual phenomenon not in motor response

45 Models of Visual Search
- Feature integration model
  - rapid initial parallel process not dependent on attention
  - subsequent attention-dependent serial processes in which features are combined to form objects
  - attention provides “glue” binding features together into an object; can only do this one object at a time
  - feature combination affected by stored knowledge
  - without focused attention, features combined randomly, producing ‘illusory conjunctions’

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Key Takeaway Points

• Generally agreed that two processes are involved in visual search (parallel & serial), though recent neuroimaging data suggests otherwise - substantial overlap in brain areas involved
• Different visual features are processed independently
• Speed of visual search depends on set size and similarity of targets to distractors
• Perceptually grouped objects will be selected or rejected together; grouping probably takes place prior to attentional ‘enhancement’

Posner’s components of attention

• Three components involved in visual attention:
  - Disengage attention from a given stimulus
  - Shift attention from one stimulus to another
  - Engage attention on a new stimulus

Processing Components of Attention (Posner & Rothbart)

• Alerting (NE)
• Orienting (ACH)
• Executive (DA)

Dual Task Performance

• Relevant to processing capacity
• Interference methodology a useful tool to determine whether two tasks share resources
• What determines degree of interference?
  - Task similarity
- Task difficulty
- Practice/expertise

- Sensitivity (d') to auditory and visual signals as a function of concurrent imagery modality (auditory vs. visual). Adapted from Segal and Fusella (1970).

Multiple-resource Theories

Norman & Shallice
- Three levels of functioning:
  - Fully automatic processes, controlled by well-learned schemas
  - Partially automatic processing, controlled by contention scheduling
  - Deliberate control by a conscious, supervisory attentional system

Summary: Important Concepts
- Limited-capacity for information-processing (information bottleneck) leads to selective attention
- Attentional acts take time and effort
- Attentional control re: goals and plans
- Automatic vs. Controlled processing
- Attention and consciousness