¹ Attention, Effort, and

Resource Allocation

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² 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)

³ 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

⁴ 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.

⁵ Automatic Vs. Controlled Processing Distinction

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

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⁹ 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)

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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

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²⁰ 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

²¹ 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 <u>perceptual/physical</u> characteristics of the input

²² Broadbent's Filter Theory

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²⁴ 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

²⁵ Early Vs. Late Selection

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

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27 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

28 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
I	Kahneman (1973)
	 Supplements previous bottom-up analysis with a consideration of top-down influences
	Emphasizes concept of processing resources
	Attention and mental errort are strongly correlated Arousal can work to increase processing resources
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31 🔲 l	Inderstanding 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 recourses may have little offect on performance.
	Most processes have both resource- and data-limited components
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35 🔲	Focused Visual Attention
	The Attentional "Spotlight" model
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• 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)
	 Awh and Pashler (2000). (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 Posner and Cohen (1984) 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 Models of Visual Search regid 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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51 ⁵² Sey 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' 53 54 55 56 57 58 59 60 61 62 🔲 63 Dosner'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 ⁶⁴ Processing Components of Attention (Posner & Rothbart) Alerting (NE) · Orienting (ACh) · Executive (DA) 65 66 🔲 67 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
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	 Sensitivity (d') to auditory and visual signals as a function of concurrent imagery modality (auditory vs. visual). Adapted from Segal and Fusella (1970).
69	Multiple-resource Theories
	• Wickens (1984). A proposed dimensional structure of human processing resources. From "Processing resources in attention" by Wickens, C.D. in Varieties of Attention edited by R. Parasuraman and D.R. Davies © 1984 by Academic Press. Reproduced by permission of Elsevier.
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71	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
72	– Deliberate control by a conscious, supervisory attentional system Summary: Important Concepts
72	 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