**Chapter 3: Attention**

**Learning Objectives**

* Describe the cocktail party effect and how it can be explained by early selection, attenuation, and late selection filter models of attention.
* Explain under what circumstances a task can become automatic and undemanding on limited attentional resources.
* Understand the brain regions involved and the psychological functions of the networks for orienting, alerting, and executive attention.
* Explain why driving while talking on even a hands-free cell phone can contribute to accidents. Detail the specific role of the central bottleneck and inattentional blindness.

**Chapter 3: Attention**

**Brief Summary**

Attention is the process by which we evaluate the stream of internal and external events that dominate our consciousness and select out particular stimuli upon which to focus our cognitive resources. Attention has many real world applications from following a conversation to multitasking or performing several tasks at the same time. Two broad classes of theories are proposed to study attention. Each of these theories examines the role played by bottlenecks in information processing. Filter theories examine the specific location of bottlenecks during selective attention, whereas capacity theories examine how the allocation of cognitive resources is affected by bottlenecks in multitasking. A third class of theories, multiple-resource theories, integrates filter and capacity theories to explain how multitasking is dependent on the specific kinds of resources required for each of the tasks (i.e., perceptual vs. cognitive).

Different forms of attention recruit the activation of different networks of brain regions. Orienting or aligning attention with a signal in the visual field involves the superior parietal lobe and the junction of the temporal and parietal lobe in the posterior region of the brain. Alerting or maintaining a state of readiness to incoming stimuli involves the parietal lobe, the thalamus, and a region in the frontal lobe of the right hemisphere. Executive attention refers to a network that monitors for conflicts among thoughts, feelings, and responses and resolves such conflicts through inhibition. Executive attention relies primarily on the anterior cingulate gyrus. The perception of a single object requires the integration of information distributed in multiple brain regions. Feature integration theory posits that controlled attentional processing enables the binding of features together into the conscious perception of a whole object.

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**Detailed Summary**

1. Attention refers to the selection of certain stimuli for processing to the exclusion of others. It also refers to the concentration of mental resources on a particular process. Two broad classes of theories have developed to explain attention. Filter theories address the selective nature of attention, whereas capacity theories address the allocation of resources to specific mental processes. Filter theories postulate a bottleneck in the flow of information from initial sensory processing to registration in conscious awareness. Capacity theories recognize that one or more bottlenecks exist but add the assumption that mental processes compete for limited resources as well.

2. Early selection theory places a bottleneck or filter immediately after sensory memory. Pattern recognition of attended material proceeds, while unattended material fades rapidly from sensory memory because it fails to pass the selective filter. Attenuation theory also places the bottleneck after sensory registration, but it assumes that the filter merely lessens or attenuates the signal strength of unattended material. If the threshold for pattern recognition for a given stimulus, such as one’s name, is sufficiently low, then even weak, unattended signals might undergo pattern recognition. Late selection theory places the filter after all pattern recognition of attended and unattended stimuli has taken place. This view holds that all stimuli are fully analyzed for their meaning, yet the filter excludes all but the attended stimuli from entering conscious awareness and memory systems.

3. Single-capacity theory assumes that mental processes compete for a general pool of attentional resources. Two tasks can also interfere with each other if they both demand a high level of general resources. The general pool is always limited, although the exact amount of available capacity fluctuates with arousal and other factors. The percentage of available capacity used by a process defines the degree of mental effort involved. Multiple-capacity theory assumes that pools of resources can be defined in terms of several independent dimensions. Auditory versus visual resources is one such dimension, while verbal versus spatial resources is another. If two tasks both demand, say, verbal capacity, then performance suffers. If one draws on verbal capacity while the other taps spatial capacity, then dual-task performance can proceed without interference. Multiple-capacity theory, therefore, integrates the insights of filter theories and single-capacity theory to provide a comprehensive and detailed description of attention.

4. Automatic processes require little, if any, mental effort. Moreover, they occur without intentional control; even when an individual attempts to stop an automatic process from operation, it unfolds anyway, as demonstrated by the Stroop effect. Finally, automatic processes operate outside the scope of conscious awareness. Processes develop automaticity either through genetic programming or as the result of extensive practice. Learning proficiency at a skill often entails developing automaticity of underlying processes through practice. Controlled processes contrast with automatic processes on each point. They demand extensive mental effort, they require intentional control to operate, and they enter conscious awareness.

5. The central bottleneck refers to the necessity of selecting responses in dual-task situations in series rather than in parallel and implies that response time to a second task is slowed by response selection in the first task. Although other perceptual and cognitive operations may occur in parallel, decisions to make a specific response must be made one at a time. A response selection bottleneck is compatible with all the filter and capacity theories of attention, and it places an important constraint on automatic processing. The bottleneck implies that selecting the response to a second task must be delayed until response selection for the first task is completed. Although the actual motor execution of the first task response can be done in parallel with selecting the response to the second task, there is a bottleneck at the stage of deciding which response to make.

6. The neural basis of visual attention is beginning to be understood. Orienting aligns attention with a signal in the visual field, either overtly through eye movements or covertly without any eye movement. The orienting network involves the superior parietal lobe and the junction of the temporal and parietal lobe in the posterior region of the brain; it further involves a frontal region associated with the visual fields of the eyes and the superior colliculus in the midbrain related to movements of the eyes. Alerting increases sensitivity to incoming stimuli and maintains this state of readiness. It involves the parietal lobe, the thalamus, and a region in the frontal lobe of the right hemisphere. In a sense, the alerting network energizes the brain to pay attention, just in case. Executive attention refers to a network that monitors for conflicts among thoughts, feelings, and responses, and resolves such conflicts by inhibiting inappropriate mental representations and activating appropriate ones. Its function is to control our thoughts and behaviors in adaptive ways. The network for executive attention involves the anterior region of the cingulate gyrus, as well as basal ganglia lying below the cingulate and the lateral prefrontal neocortex lying above it.

7. According to feature integration theory, attention is necessary for visual pattern recognition. Feature detectors operate preattentively or automatically, allowing the identification of shape, color, and other single properties. The identification of a conjunction of two properties, such as color and shape, requires attention. Therefore, attention is the glue that binds together features into a whole object. Evidence shows that with the absence of attention, conscious perception of an object fails to occur, even when the object is fixated directly by the eyes. Inattentional blindness is an example of this failure to perceive in the absence of attention.

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**Topical Outline**

Filter Theories

* Attention can be selective in order to focus on a particular stimulus or divided in which two or more stimuli share cognitive resources. Filter theories attempt to explain how selective attention works.
* The dichotic listening task is the laboratory procedure used to study selective attention. It involves the simultaneous presentation of different auditory messages through headphones to a participant, one to each ear, who is instructed to shadow one of the messages while ignoring the other.

Early Selection

* A model of selective attention postulating an attentional filter that operates after sensory processing, but prior to meaningful semantic processing.
* Attenuation refers to an attentional filter that lowers the strength of the sensory signal on the unattended channel.

Late Selection

* A model of selective attention postulating an attentional filter that operates after meaningful semantic processing.

Capacity Theories

* Attention is limited in overall capacity and our ability to carry out simultaneous tasks depends, in part, on how much capacity the tasks require.

Mental Effort

* The proportion of available attentional capacity that is momentarily allocated to a cognitive process. Mental effort increases as the proportion of available attentional capacity increases.

Multiple Resources

* The ability to perform two tasks concurrently depends not just on the respective demands of these tasks on capacity, but also on the specific kinds of resources required (e.g., perceptual vs. cognitive).

Filter Theories and Capacity Theories: Conclusion

* Filter theories evolved to explain the selective nature of attention, whereas capacity theories assumed structural bottlenecks in the flow of information processing.

Automatic Processes

* Extensive practice gradually minimizes the attention needed to allocate towards performing a skill until it becomes automatic.
  + - The Stroop Task is used to study automaticity in word recognition.

Criteria of Automaticity

* Automatic processes are unintentional, unconscious, and undemanding of attention.
* Controlled processes are intentional, conscious, and demanding of attention.

Practice and Automaticity

* Automatic search is observed with consistent mapping and controlled search is observed with varied mapping.
* Humans innately and automatically process the frequency of occurrence of environmental features and events.
  + Processing the frequency of occurrence of stimulus features allows infants and young children to absorb the statistical structure of the world around them.
  + Infants make use of the statistical distribution of sounds that make up words to learn the appropriate boundaries among the sounds.

The Central Bottleneck

* The necessity of selecting responses in dual-task situations in series rather than in parallel and suggests that response time to a second task is slowed by response selection in the first task.

Visual Attention

* Visual attention is mediated by three specific neural networks that serve the functions of orienting, alerting, and executive attention.

Neural Networks of Attention

* Orienting aligns attention with a signal in the visual field, either overtly through eye movements or covertly without any eye movement.
  + The brain regions involved in the orienting network include the superior parietal lobe and the junction of the temporal and parietal lobe in the posterior region of the brain. It also involves the frontal region associated with the visual fields of the eyes and the superior colliculus in the midbrain related to movements of the eyes.
* Alerting increases sensitivity to incoming stimuli and maintains this state of readiness.
  + The brain regions involved in the alerting network include the parietal lobe, the thalamus, and a region in the frontal lobe of the right hemisphere.
* The executive attention network monitors for conflicts among thoughts, feelings, and responses, and resolves such conflicts by inhibiting inappropriate mental representations and activating appropriate ones.
  + The brain regions involved in the executive attention network include the anterior cingulate gyrus and the basal ganglia.

Perceptual Binding

* Feature integration theory posits that automatic preattentive processing of features must be followed by controlled attentional processing to bind the features into a whole object.
* Inattentional blindness and attentional blink are failures to perceive an object that is not attended.

Subliminal Perception

* Unconscious perception without attention.
* Subliminally presented information has been found to alter our future emotional responses to material even though it cannot be specifically remembered.

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**Key Terms**

attention

selective attention

divided attention

shadowing

early selection

attenuation

priming

mental effort

Stroop effect

automatic processes

controlled processes

central bottleneck

orienting

spatial neglect

alerting

executive attention

anterior cingulate gyrus

feature integration theory

binding problem

inattentional blindness

subliminal perception

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**Discussion Questions**

Discussion Question #1

Supertaskers are individuals who can multitask without any observed decrement in performance on one of the concurrent tasks. Discuss how supertasking is accounted for within the multiple resources framework.

Discussion Question #2

Explain how mental effort is related to automatic and controlled processing. Can many hours of practice in a dual task result in the development of greater automaticity in the performance of this task?

Discussion Question #3

Describe the attentional processes that would function when an individual attempts to quit smoking. How might such an endeavor affect mental resources? Which of the three neural networks of attention would be most important in successfully quitting smoking?

Discussion Question #4

How are perceptual binding and attention related to consciousness? Can consciousness be affected by the pool of available attentional resources or is it independent of such resources?

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**Questions for Thought**

Driving while talking on a cell phone, even one that is hands free, can cause errors in decision making and delays in response time. Explain how the central bottleneck contributes to those breakdowns in driving performance. How does inattentional blindness add to the problem? In your view, why do so many people believe themselves to be immune from these effects, even though others might be impaired by cell phone use during driving?

In a well-known experiment, participants count how often a team in white shirts passes a basketball amidst another team in black shirts whose players also pass a ball. A gorilla can unexpectedly walk through the game unnoticed by many. Explain how the early selection model of attention would explain this result, given that participants focus on the team in white. Would a polar bear be easier to see than a gorilla? Why, from the perspective of early selection theory? Would single-capacity theory lead one to expect a difference in detecting a polar bear versus a gorilla?

Provide examples from everyday activities in which the networks for orienting versus alerting versus executive attention must be engaged.

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**Web Resources**

[**Selective Attention (Auditory Demonstration)**](http://www.gocognitive.net/demo/selective-attention-auditory-demonstration)

An interactive demonstration of auditory selective attention.

[**Attentional Blink Experiment**](http://psych.hanover.edu./JavaTest/Cognition/Cognition/attentionalblink_instructions.html)

An interactive demonstration of attentional blink.

[**Word Superiority Experiment**](http://psych.hanover.edu./JavaTest/CLE/Cognition/Cognition/wordsuperiority_instructions.html)

An interactive demonstration of the word superiority effect.

[**Demos**](http://ruccs.rutgers.edu/val/index.php/demos)

A series of interactive demonstrations involving visual attention.

[**Visual Cognition Demonstrations**](http://pantheon.yale.edu/~bs265/bjs-demos.html)

A series of interactive demonstrations from the Yale Perception and Cognition laboratory featuring inattentional blindness and change blindness tasks

[**Human Multi-task Performance and Attention Limits**](http://www.dualtask.org/)

A website featuring various interactive demonstrations on human multi-task performance and attentional processes.

[**Interactive Stroop Effect Experiment**](http://faculty.washington.edu/chudler/java/ready.html)

An interactive demonstration of the Stroop Effect.

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**SAGE Journal Articles**

Bratzke, D., Rolke, B., Ulrich, R., & Peters, M. (2007). [Central slowing during the night](http://pss.sagepub.com/cgi/reprint/18/5/456?ijkey=9Pg1f7CUjjH86&keytype=ref&siteid=sppss)*.* Psychological Science, 18, 456-461.

1. What evidence do the authors provide for their *central slowing hypothesis*?
2. What is the PRP paradigm? How is the speed of central processing determined by the PRP paradigm?
3. According to the authors, what time of day was the PRP effect most pronounced? What are the practical implications of these findings?

Hochman, J-R. & Papeo, L. (2014). [The invariance problem in infancy: A pupillometry study](http://pss.sagepub.com/cgi/reprint/25/11/2038?ijkey=XXSsnnRkVKYYk&keytype=ref&siteid=sppss). Psychological Science, 25, 2038-2046.

1. What is the invariance problem in speech perception? How is resolving the invariance problem a signature of mature speech perception?
2. How do the authors plan to use pupillometry to study speech perception in infants? What evidence exists demonstrating the successful use of pupillometry in studies involving infants?
3. In what way did the authors’ results indicate a developmental change in speech perception in infants? What was the nature of this change?
4. How do the results of this article relate to Hasher and Zacks (1979, 1984) proposal that humans have an innate capacity to automatically process frequency information?

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**Recommended Readings**

Broadbent, D. E. (1958). *Perception and communication*. New York: Pergamon.

Kahneman, D. (1973). *Attention and effort*. Englewood Cliffs, NJ: Prentice Hall.

Logan, G. (2004). Cumulative progress in formal theories of attention. *Annual Review of Psychology*, 55, 207-234.

Pashler, H., Johnston, J. C., & Ruthruff, E. (2001). Attention and performance. *Annual Review Psychology*, 52, 629-651.

Posner, M. I., & Rothbart, M. K. (2007). *Educating the human brain.* Washington, DC: American Psychological Association.

Strayer, D. L., & Drews, F. A.(2007).Cell-phone-induced driver distraction. *Current Directions in Psychological Science, 16,* 128–131.