IST605: Human Information Processing — Attention Summary

Document Outline

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1. What is Attention For?

Definition and Facets

- **Attention** has multiple meanings in daily speech:
  - **Concentration:** Attending to a lecture
  - **Selection:** Attending to a particular conversation in a crowded room
  - **Capacity limits:** Being able to attend to only so many things at once
  - **Automaticity:** No longer needing to attend to well-practiced skills (conscious monitoring no longer necessary)

Common Theme

- Recognition that people **cannot do an infinite number of different things simultaneously**
- With practice, we improve at doing many things at once
- **Goal of cognitive theories:** Explain types of limitations in information processing and how people learn to deal with them

Why Are There Limits?

Two possibilities:

1. **Environmental complexity:** Cannot process all information as the environment becomes complex
   - Example: Finding a guest at an empty airport is easy; finding them among many people is harder
2. **System noise:** Perceptual and cognitive systems are noisy
   - We do not perceive everything exactly as it appears
   - We do not make decisions perfectly all the time

Ideal Observer Analysis

- **Tool/method:** Investigates how information is processed in perceptual systems
- **Ideal observer:** A theoretical system that performs a task optimally
- **Ideal performance:** The theoretical upper limit; real systems typically achieve sub-ideal performance

- If there is uncertainty, perfect performance is impossible and the ideal observer will make errors

Reasons to Limit Information Processing

(A) Too many possibilities

- Too many signals from the environment to consider all efficiently
- Limiting items reduces the number of combinations to entertain
- Keeps possibilities manageable and prevents overwhelm

(B) Action systems are limited

- We have only two legs and arms; cannot grasp more than two things at once
- Cannot move in more than one direction simultaneously
- When speaking, can only say one word at a time
- Attention transforms parallel-processed information into a form that facilitates action

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2. Functions of Attention

Five Main Functions

1. **Focusing**
    - Limiting the number of items being processed
    - Example: Looking only at people with brown hair when searching for a friend
2. **Perceptual Enhancement**
    - Increasing the gain (strength) of a stimulus in the environment
    - Attention as concentration
    - Analogy: Turning up car radio volume to hear better
    - **Works when:** Signal is clear (turning up volume helps drown out noise)
    - **Fails when:** Signal has static noise (turning up volume amplifies noise too)
3. **Binding**
    - Combining perceptual information about different properties into a percept of a single object
    - Example: In low-level vision, edges are identified separately; binding brings them together to create a coherent object
4. **Sustaining Behaviour**
    - Maintaining an action in the presence of potential distractions
    - Attention may be captured by salient events (loud sounds, flashing lights)
    - Even with distractions, it is possible to concentrate on a single perceptual object to the exclusion of others
5. **Action Selection**
    - Choosing an action to be performed from among a set of possibilities
    - We are limited by actions we can perform

- Some mechanism must select and order actions

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3. Perceptual Attention

Sensory Stores

- **Sensory store:** Records sensory information automatically; information decays after a brief period; very high capacity
- **Iconic memory:** Visual sensory store
- **Echoic memory:** Auditory sensory store
- **Evidence:** Information persists briefly (e.g., looking out a car window—you perceive much, but recall fades quickly as new signals arrive)

Focusing: Selecting Channels

Dichotic listening experiments:

- Different messages played to each ear through headphones
- Participants tested on messages heard

Results:

- When told to attend to one ear: People are aware a voice was present in the other ear but cannot say much beyond that (not even the language)
- Even without instructions: People attend to only one channel at a time
  - Example: Messages {6, 2, 9} to one ear and {4, 7, 3} to the other are recalled as {6, 2, 9, 4, 7, 3}, not alternating {6, 4, 2, 7, 9, 3}

Key observations:

- Focusing does not mean other input is completely suppressed
- Salient stimuli (loud noises, flashing lights) command attention by virtue of extremeness
- **Selective attention:** Ability to recognize significant events outside momentary focus (e.g., hearing your name in a conversation you were not part of)

Fundamental question: What are the limits on selecting the most relevant input and being aware of significant events outside the focus of attention?

Perceptual Enhancement

Two ways attending might make perceptual processing more efficient:

1. **Makes perceptual input stronger:** Amplifies both signal and external noise
2. **Decreases internal noise:** Reduces errors in neuron functioning, making internal representation and processing more efficient

Evidence: Attention makes perceptual input stronger; processing is helped by reducing external noise (which is not amplified along with the signal)

- Examples: Increasing contrast between objects and backgrounds; shutting a car window to filter external noise while turning on the radio

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4. Attentional Limits

Location of Attentional Limits

Sensory stores: Provide vast storage capacity
Dichotic listening: Suggests eventual processing of sensed signals is limited

Bottleneck Theories of Attention

Basic assumption: All inputs are processed completely up to a certain stage; only attended channels are processed more fully after that

Broadbent's Filter/Bottleneck Model:

- **Central processing system:** Receives inputs from sensory channels; compares them with memory to determine meaning
- **Selective filter:** Prevents overload by sifting incoming stimuli
  - Lets through stimuli with certain properties
  - Excludes others
- **Application (party conversation):** Filter screens out non-speech sounds; sounds with certain properties (e.g., voice of conversation partner) are admitted to the attended channel
- **Filter characteristics:**
  - Flexible (can shift attention to a different conversation)
  - Can only use lower-level auditory characteristics (e.g., loudness), not meaning
  - Bottleneck: Filter cannot shift back and forth across channels fast enough to follow two conversations at once
- **Early selection theory:** Filtering occurs early in processing

Improvements to Broadbent's Theory:

- **Problem:** Oversimplified; subjects notice their names in unattended channels
- **Expanded model (three stages):**
  1. **Stage 1:** Incoming stimuli analyzed for physical characteristics (pitch, speech vs non-speech); decisions/responses can be made (e.g., who is speaking)
  2. **Stage 2:** Stimuli checked against permanent memory list of high-priority messages (danger signals, vocal patterns of one's name); such stimuli are attended to
  3. **Stage 3:** Stimuli not selected at Stage 2 matched against current priorities
     - High priority: Sounds matching conversation partner's voice
     - Low priority: Other voices, non-speech sounds
     - Low priority signals ignored; high priority moved up for further processing (comprehension)

Role of expectation: A person's expectations influence what information is processed

Late Selection:

- Some research suggests bottlenecks occur after stimuli have been recognized and placed in short-term memory
- Information in short-term memory that is not rehearsed or elaborated is likely to be forgotten

Capacity Theories of Attention

Basis:

- Limited pool of attentional resources
- Resources are depleted as information is processed

Implications:

- Two tasks that do not need too much cognitive effort should not interfere with each other
- Whether two tasks interfere depends on how much they draw on the same resource pools
- Resources can be allocated; if one task is more important, resources can be devoted to it at the expense of another

Resource pools:

- Evidence suggests **multiple pools** (e.g., visual tasks vs auditory tasks)
- Explains why auditory and visual tasks can be performed together more easily than two visual or two auditory tasks

Binding

Definition: Binding perceptual features together into a coherent representation of objects

Process:

- Objects consist of properties at a single spatial location (e.g., colour and shape: red triangle)
- Properties initially processed independently (as shape and as colour)
- At some point, information is brought back together—this is binding

Visual Search Task:

- Display with multiple objects; search for a target (e.g., red circle)
- **Single feature search:** Easy (e.g., red T among blue letters)
    - Consistent with idea that focusing on a single dimension (colour) makes it easy to distinguish values (red vs blue)
- **Conjunction search:** Difficult (e.g., red T among red Ls and blue Ts)
    - More difficult searching for a conjunction of properties (colour AND letter T)
- **Search time:**
    - Single feature: Does not increase with display size
    - Conjunction: Increases with display size

Feature Integration Theory:

- **Pre-attentive stage:** Different brain parts automatically gather information about basic features (colours, shape, movement) found in the visual field
- **Focused attention stage:** Individual features are combined to perceive the whole object

- Requires attention
- Selecting an object occurs within a "master map of locations"
- Master map contains all locations where features have been detected
- When attention is focused at a particular location, features at that position are attended to

Conjunction of features:

- Two features are part of the same object if they occupy the same location in space and time
- Example: Green triangle = co-occurrence of green and triangle at the same spatial location
- Must combine "what" (triangle, green) and "where" (location) information
- Neuropsychological evidence: "What" and "where" systems are neuroanatomically separable, parallel systems

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5. Capacity and Automaticity

Automaticity

- **Most stringent view:** A process is automatic if it requires no cognitive resources
- **More common:** Automaticity means a significant reduction in perceived difficulty
- **Evidence:** Whether practice leads to reduced attentional demands depends on type of practice and task structure

Research on Automaticity: Visual Search with Practice

Typical scenario: Visual search task

- Subject tells if a target (e.g., T) appears in a display (e.g., BKQR) shown briefly
- **Sternberg (1966) result:** Time to say target is in display increases by 35–40 ms per item
  - Example: 320 ms base + (2 items × 35–40 ms) = 390–400 ms

Two scenarios with practice:

1. **Consistent mapping:**
   - If an item is a target on one trial, it never appears as a distractor
   - Target set and distractor set do not overlap
   - Example: Detecting a letter among digits (or digit among letters)
   - **Result:** Reaction time lower; search time per additional item substantially lower
2. **Varied mapping:**
   - Distractor set and target set overlap
   - Example: Detect a letter among other letters (or digit among other digits)
   - A given letter may appear as target on some trials, as distractor on others
   - **Result:** Reaction time lower (learning helped), but time per additional item increases by a constant amount (as in Sternberg)

Implication: Consistent mapping leads to more automatic processing (less attention per item) than varied mapping.

Quick Reference

Topic	Key idea
Attention facets	Concentration, selection, capacity limits, automaticity
Ideal observer	Theoretical optimal performance; real systems are sub-ideal
Focusing	Limiting items processed
Perceptual enhancement	Increasing stimulus gain; works when signal is clear
Binding	Combining features into coherent objects
Sustaining behaviour	Maintaining action despite distractions
Action selection	Choosing and ordering actions
Sensory stores	Iconic (visual), echoic (auditory); high capacity, brief decay
Dichotic listening	Attend to one channel; aware of other but cannot report details
Early selection	Broadbent: filter early based on physical properties
Late selection	Bottleneck after recognition/in short-term memory
Capacity theory	Limited resource pools; multiple pools (visual, auditory)
Feature integration	Pre-attentive (features) → focused attention (binding)
Consistent mapping	Target never a distractor → automatic processing
Varied mapping	Target can be distractor → less automatic