Cognitive Science

Understanding of

- Human Memory
- Encoding & Retrieval Processes
- Cognitive Processes in Learning
- Mental Models, Schemata
- Theories of Multimedia Learning

Overview

- Long-Term Memory Models
- Encoding & Retrieval
- Dual-Coding Theory (DCT)
- Implication of DCT for Design of Instructional Technology
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Long-Term Memory

- Part of the human memory system that stores most of the information that has been learned along with rules for processing it, characterized by a slow rate of decay and a large capacity
- Episodic v. semantic memory

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Information Processing

- How do we represent information for storage in long-term memory?
- What LTM storage models did you read about, and how do they differ?
- What would the world be like for us if we stored information according to a Network model or Feature Comparison Model?
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Models

- Network Models
  - Interconnected Hierarchies with nodes => concepts, connections => relationships
  - Explains individual differences in learners: different memory network
  - Problem: Difference in recognition of Canary as bird vs. Penguin as bird cannot be easily explained => Typicality of Concepts is problem (Collins & Quillian, 1996)

- Feature Comparison Models
  - Concepts stored with sets of defining features; Association to other concepts through comparison of overlapping features
  - Distinguish between defining features and characteristic features
  - Problems:
    - Not economical: large collection of features required
    - Does not account for semantic flexibility
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• **Propositional Models**
  – Idea unit is information stored as propositions, ideas
  – Recall tends to reflect proposition structure rather than sentence structure
  – ACT-R* Model (John R. Anderson): most comprehensive network model that emphasizes propositional structure

Long-Term Memory

Models

• **Parallel Distributed Processing (PDP) Models**
  – Multiple operations occur simultaneously
  – (as opposed to sequentially)
  – Building blocks of memories are sub-symbolic connections that describe how units interact with each other
  – Learning: Strengthening connections through activation
  – Benefits: can explain: incremental nature of learning, process/function of goals, cognitive development

Encoding

• Cognitive processing of information so it can be stored in LTM: relating to prior knowledge

Retrieval

• Previously stored information is “brought back to mind” (Driscoll, 2000)
Group Activity—15 min.

- How can retrieval of information be supported in multimedia instruction? Focus your discussion on research on to retrieval and forgetting.
- Be prepared to present a summary of your conclusions to the class.

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Long-Term Memory

Retrieval

- Recognition
- Recall
- Encoding Specificity (Thomson & Tulving, 1970; Anderson & Ortony, 1975)
- State-dependent learning (Bilodeau & Schlosberg, 1951)

Forgetting

- Failure to encode
- Failure to retrieve
- Interference (retroactive, proactive)
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Dual-Coding Theory (Paivio, 1986)

Verbal Information
- Modality-specific verbal codes, Visual, auditory, articulatory, etc.
- Arbitrary symbols, denote concrete objects, abstract ideas
- Retain separate and discrete identities even in hierarchies or associative networks
- Processed in a serial or sequential manner

Non-Verbal Information
- Modality-specific images for shapes, sounds, actions, skeletal or visceral sensations...
- Analogous representations, can encode information parallel or simultaneously
- Complex images can integrate parts -> objects may become spatially embedded
- Amenable for dynamic spatial transformations not possible with verbal representations

Dual Coding Theory

VERBAL STIMULI NONVERBAL STIMULI

SENSORY SYSTEMS

Logogen

VERBAL SYSTEM

VERBAL RESPONSES

Imagery

NONVERBAL SYSTEM

NONVERBAL RESPONSES

Paivio, 1986, 1990
**Scenario**

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**Dual-Coding Theory**

**Associative Connections**
- Links within systems
  - Join representations within the verbal and within nonverbal systems
  - Words joint to other words
  - Images joined to other images in either the same or different sensory modalities

**Scenario**

**Cognitive Science**

**Dual-Coding Theory**

**Referential Connections**
- Links between systems
  - Join corresponding verbal and imaginal codes
  - Allow operations such as imaging to words and naming to pictures

**Mayer & Sims (1994)**
What did Mayer and Sims find in their research on Dual Coding Theory?
Scenario

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Dual-Coding Theory

Mayer & Sims (1994) – Contiguity Effect

How can Dual-Coding Theory be used to inform the design of multimedia instruction for these projects?

1. Design multimedia software to introduce medical students to human anatomy.
2. Design multimedia instruction to train experienced Airline Pilots on the navigational instruments of a new type of airplane.
3. Design multimedia instruction to teach university students in the history of the American civil war.

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Dual-Coding Theory

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Critique of Mental Imagery

(Pylshyn, 1973)

- We are more likely to recall images in which objects were present at a specific scene without recalling their exact position than
- All the detailed information but with low precision

- Picture representations are not stored in memory, but can be constructed during processing, and used for making new interpretations, and then discarded.
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Critique of Mental Imagery

- Representations of sensory stimulation (Images) are stored as propositions
  - Images not stored as raw sensory pattern, rather, highly abstracted and interpreted
  - Not different in principle from the kind of knowledge asserted by a sentence
- Classification of sensory events into a finite class of concepts and relations, description

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Instructional Design

ISD & Cognitive Science