The Function of Perception

- Forming Mental Representations of...
- Objects and Events Experienced in the...
- Present Environment so that...
- Behavior is Governed by the Meaning of the Current Stimulus

Perceptual Activity Ends with the Identification and Categorization of the Distal Stimulus

Perception, Categorization, and Memory

If every act of perception involves an act of categorization…. (as Bruner said it did)

Memory provides the conceptual knowledge that permits categorization to occur.

Relations Between Perception and Memory

- Memory as Background of Perception
  - Knowledge, Expectations, Beliefs
  - Cognitive Basis for Perception
- Memory Trace as a Byproduct of Perceptual Activity
  - Record of Perceptual Activity
  - Description of Percept

Decomposition of Human Form into Cylinders

Marr & Nishihara (1978)

More Cylinder-Figures

Marr & Nishihara (1978)
Decomposition into Geons

Biederman (1985)

Some Phenomena of Face Recognition

- Classification of Errors in Face Recognition
  - Familiarity
  - Identification

- Prosopagnosia
  - Cannot Recognize Familiar Faces
  - Can Determine Gender, Emotional Expression
  - Can Read Lips

- Evidence from Reaction-Time Studies
  - Familiarity < Occupation < Name
  - Cannot State Name Before Occupation (?)

Model of Face Recognition

Bruce & Young (1986, 2012); Young & Bruce (1991, 2011)

- Face Recognition Unit
  - Activated by Recognition
  - Person Identity Node
    - Occupations
    - Person Identity
  - Face Belongs to Person
  - Semantic Information Units
    - Occupation
    - Personality
  - Name Recognition Unit
    - Verbal Label

Parallels Between Face, Object, and Word Recognition

Bruce & Young (1986)

Interactive Activation Model of Face Recognition

Burton et al. (1990)

Taxonomy of Memory

- Procedural
- Motor

- Declarative
- Cognitive
- Episodic
- Semantic
Two Forms of Knowledge

Winograd (1975); Anderson (1976)

• Declarative Knowledge
  – Factual Statements
  – Propositional Format

• Procedural Knowledge
  – Directions for Action
  – Production Format

Declarative Knowledge

• Factual Statements
  – About World, Past

• Sentence Format
  – Propositions
  – Subject - Verb – Object

• Types of Representations
  – Meaning-Based
  – Verbal Description
  – Perception-Based
  – Mental Image

A bicycle is a two-wheeled vehicle with seat and handles, propelled by pedaling.

A bicycle looks like this:

Procedural Knowledge

• Directions for Goal-Directed Action

• “If-Then” Format (Productions)
  – Goal - Condition – Action
  – Production System

• Motor
  – Actions Take Form of Overt Behavior
  – Alter Objective, Publicly Observable World

• Mental
  – Actions Take Form of Mental Transformation
  – Alter Internal, Private Mental Representations

Types of Declarative Knowledge

Tulving (1972, 1983)

• Episodic
  – Autobiographical Memory
  – Factual Knowledge About Personal Experiences
  – Spatio-Temporal Context
  – Self-Reference

• Semantic
  – Mental “Dictionary” or “Encyclopedia”
  – Abstract, Conceptual Knowledge About the World

Episodic Memory

• Autobiographical/Personal
  – Specific Experiences
  – Narratives

• Elements
  – Description of event
  – Episodic context
  – Time, Place
  – Causal Relations
  – Self-Reference
  – Agent or Patient, Stimulus or Experiencer
  – Internal Mental State

Semantic Memory

• Abstract, Context Free
  – Mental Lexicon
  – Generic Memory?

• Object Knowledge

• Linguistic Knowledge

• Categorical Knowledge
  – Subsets-Supersets
  – Similarity
  – Category-Attribute

\[ X + 6 = 38 \]
Declarative Social Memory

• Factual Knowledge
  – Has Truth Value
• Propositional Representation
  – Subject-Relation-Object
    • The subject *verbed* the object
  – Propositional Network
• Examples
  – John smiled at Lucy
  – John is a neurotic extravert
  – Neurotics are anxious and excitable, while Extraverts are talkative and sociable

Structure of Declarative Memory

• Nodes
  – Represent Concepts
• Associative Links
  – Represent Relations Among Concepts
• Perception Activates Corresponding Nodes
• Activation Spreads Across Associative Links
• Spreading Activation Creates Priming
  – Processing of One Event
  – Facilitates or Impairs Processing of Another

Propositional Representation

After Anderson (1976)

The Hippie Touched the Debutante

An Associative Network

The hippie touched the debutante

Relations Between Episodic and Semantic Memory

• Semantic Knowledge Begins in Episodes
  – Learning Experiences
• Accumulation Blurs Episodic Features
• Episodic Memory Formed Against Background of Semantic Knowledge
  – Cognitive Basis for Perception

Memory in Social Cognition

<table>
<thead>
<tr>
<th>Procedural</th>
<th>Declarative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor</td>
<td>Semantic</td>
</tr>
<tr>
<td>– Eye Contact</td>
<td>– Implicit Personality Theory</td>
</tr>
<tr>
<td>– Handgrip</td>
<td>– Episodic</td>
</tr>
<tr>
<td>– Display Rules</td>
<td>– Autobiographical Memory</td>
</tr>
<tr>
<td>– Interpersonal Distance</td>
<td>– Person Memory</td>
</tr>
<tr>
<td>Cognitive</td>
<td></td>
</tr>
<tr>
<td>– Impression Formation</td>
<td></td>
</tr>
<tr>
<td>– Self-Regulation</td>
<td></td>
</tr>
</tbody>
</table>
Person Memory

- Knowledge Concerning Another Person
- Mix of Declarative Memories
  - Episodic
    - Memories of Past Encounters
    - Knowledge of Behavioral Episodes
  - Semantic
    - Generic Knowledge About Person
    - Traits, Attitudes, Other Characteristics

Memory and Person Memory

- Person Memory Can Be Studied with Techniques Used in Nonsocial Memory
- Social Context is Important
  - Impression Formation Improves Person Memory

What Do Person Memories Look Like?

Associative Structure of Person Memory

James Bartlett

Kind

Rescued the Kitten

Thoughtless

Caused the Accident

Individuation and Reference in Person Memory

First You Learn:
- James Bartlett rescued the kitten.
- James Bartlett adopted the child.
- The lawyer caused the accident.
- The lawyer cursed the salesgirl.

Then You Learn:
- James Bartlett is the lawyer.

Now You’re Asked:
- Did James Bartlett cause the accident?
Retrieval from Episodic Memory
Anderson (1974)

- Learn Facts about People, Locations
  - The doctor is in the bank (1-1)
  - The fireman is in the park (1-2)
  - The lawyer is in the church (2-1)
  - The lawyer is in the park (2-2)
- Memorize to criterion of perfect recall
- Recognition
  - Studied targets
    - The doctor is in the bank
  - Unstudied lures
    - The doctor is in the park

People and Locations
Anderson (1974)

- Doctor → Bank
- Fireman → Park
- Lawyer → Church

The Fan Effect
Anderson (1974)

Response Latency (secs)

<table>
<thead>
<tr>
<th>Item Type</th>
<th>Targets</th>
<th>Locations</th>
<th>Targets</th>
<th>Locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>True</td>
<td>0</td>
<td>0.4</td>
<td>1.2</td>
<td>1.6</td>
</tr>
<tr>
<td>False</td>
<td>0.8</td>
<td>1.2</td>
<td>1.7</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Facts
- 1
- 2
- 3

Separate Representations

- James Bartlett
  - Rescued the kitten
  - Adopted the child
  - Is the lawyer
- The Lawyer
  - Is James Bartlett
  - Caused the accident
  - Cursed the salesgirl
- Can’t Answer the Question
  - Knowledge Not Represented in Memory
- But We Can Answer the Question

Single Representation

- James Bartlett
  - Lawyer
  - Rescued the Kitten
  - Adopted the Child
  - Cursed the Salesgirl
  - Caused the Accident
**Single Representation**

- James Bartlett
  - is the lawyer
  - rescued the kitten
  - adopted the child
  - caused the accident
  - cursed the salesgirl
- Answer Question by Memory Retrieval
  - Knowledge Represented Directly

**Linked Representations**

- James Bartlett
  - rescued the kitten
  - adopted the child
  - is the lawyer
    - caused the accident
    - cursed the salesgirl
- Answer Question by Inference
  - From Knowledge that Bartlett is the Lawyer

**Experimental Procedure**

- Study Facts
  - About James Bartlett
  - About the Lawyer
- Learn Identity
  - Before Learning Facts
  - After Learning Facts
- Sentence Verification
  - No Inferences
    - James Bartlett rescued the kitten
  - Inferences
    - James Bartlett cursed the salesgirl

**Response Latencies in Sentence Verification**

*Anderson & Hastie (1974)*

![Response Latency Graph](image)

**How Persons Are Represented in Memory**

- Node Representing a Person
  - James Bartlett
  - The Lawyer
- Nodes Representing Facts about Person
  - Behaviors, Experiences
  - Traits, Attitudes
- Associative Links
  - Connect Person Nodes to Fact Nodes
**Individuation and Reference**

- If Reference Known at the Outset
  - Reference Treated as Another Fact

  James Bartlett
  
  Rescued the Kitten
  Adopted the Child
  Is the Lawyer
  Cursed the Salesgirl

- If Reference Learned Later
  - Reference Links Representations
  - Knowledge of B not Transferred to A
  - Get from A to B via Associative Link

  James Bartlett
  
  Rescued the Kitten
  Adopted the Child
  Lawyer
  Cursed the Salesgirl
  Caused the Accident

**Associative Structure of Person Memory**

- James Bartlett
  
  Kind
  Thoughtless
  Rescued the Kitten
  Caused the Accident

**Schematic Effects on Person Memory**

- Information in Person Memory
  - Semantic
    - General Characteristics
  - Episodic
    - Specific Behaviors, Experiences

- What is the Relation Between Semantic and Episodic Person Memory?
  - How Does Semantic Knowledge Affect Episodic Knowledge
  - How are Relations Represented?

**Memory and Schema-Congruence**

- Bartlett (1932)
  - Memory Favors Schema-Congruence

- Conflicting Results
  - Congruence > Controls
  - Congruence = Controls
  - Congruence < Controls

- Result Depends on Control Condition

**Schematic Effects on Person Memory**

- Hastie & Kumar (1979)
  
  Present Trait Ensemble
  - Traits Descriptive of Target Person
  - Induce Schema for Person
    - Prior Beliefs and Expectations

- Study Specific Behaviors
  - Vary Relationship to Schema
    - Schema-Congruent
      - \( P(Behavior | Schema) > P(Behavior | No Schema) \)
    - Schema-Incongruent
      - \( P(Behavior | Schema) < P(Behavior | No Schema) \)
    - Schema-Irrelevant
      - \( P(Behavior | Schema) = P(Behavior | No Schema) \)
Sample Materials

- Judy is:
  - intelligent, clever, bright, smart, quick,
    wise, knowledgeable, decisive
- Judy:
  - won the chess tournament.
  - attended the symphony concert.
  - made the same mistake three times.
  - was confused by the television show.
  - ordered a cheeseburger for lunch.
  - took the elevator to the third floor.

Schematic Effects on Memory
Hastie & Kumar (1979), Exp. 1

Schematic Effects on Memory
Hastie & Kumar (1979), Exp. 2

Incongruent Irrelevant Congruent
Proportion Recalled

The Schematic Processing Principle

The Memorability of an Event is a Function of its Relationship to Pre-Existing Schemata.

Two Processes in the Schematic Processing Effect

- Schema-Congruent
  - Schema Provides Internally Generated Cues
  - Facilitates Retrieval
- Schema-Incongruent
  - Surprise Instigates Explanatory Activity
  - Facilitates Encoding
- Schema-Irrelevant
  - Get Neither Advantage

Explanation in Terms of Network Model of Memory
Srull (1981)

- Behavioral Items Linked to Person Node
- Interitem Associations
  - Among Incongruent Items
  - Between Incongruent and Congruent Items
- Retrieval by Tracing Associative Links
  - Favor Incongruent Items
    - Most Associative Links
  - Ignores Irrelevant Items
    - No Associative Links
Srull's Model of Person Memory

Srull (1981)

Effects of Schema-Incongruent Behaviors on Memory

Srull et al. (1985)

- Induce Schema
  - Memorize Trait Ensemble
- Study Behaviors
  - 12 Schema-Congruent
  - 12 Schema-Neutral
  - 0, 6, or 12 Schema-Incongruent
- Test Recall for Behaviors

Recall and Schema-Congruence

Srull et al. (1985)

Priming Effects on Person Memory

Srull et al. (1985)

- Test Recognition for Behaviors
  - Response Latency
- Priming Mediated by Associative Links
  - Between Incongruent Items
  - Between Congruent, Incongruent Items

Priming in Sentence Verification

Srull et al. (1985)

How Are Traits Represented in Person Memory?

- Nodes Representing...
  - Person
  - Behaviors
  - Traits
- Relation Between Traits and Behaviors
  - Traits, Behaviors Linked Independently
  - Behaviors Organized by Traits
Traits and Behaviors Represented Independently

James Bartlett

Kind

Thoughtless

Rescued the Kitten

Caused the Accident

Adopted the Child

Cursed the Salesgirl

Behaviors Clustered by Traits

James Bartlett

Kind

Thoughtless

Rescued the Kitten

Adopted the Child

Caused the Accident

Cursed the Salesgirl

Organization of Person Memory

Klein & Loftus (1990)

• 20 Behavior Descriptions
  – 4 per trait
    • Athletic, Intelligent, Honest, Religious, Sociable
  • 3 Conditions
    – Impression Formation
    – Memorization
    – Category Sorting

Recall and Clustering

Klein & Loftus (1990)

Beyond Clustering: Priming

• Nodes Representing…
  – Person
  – Traits
  – Behaviors
• If Behaviors Clustered Under Trait nodes
  – Traits Should Prime Behaviors
• If Traits, Behaviors Linked Independently
  – No Priming Effects
Priming Effects in Person Memory
Klein, Loftus, Trafton, & Fuhrman (1992)

- Target Person: Mother
- Rate Descriptiveness of Each Trait
- Present Trait Term
  - Define
  - Describes Mother
  - Remember Event Involving Mother
- Compare Performance
  - Trial N vs. Trial N-1

Does Remembering a Trait Prime Remembering a Behavior?

Traits Highly Descriptive of Mother
Klein, Loftus, Trafton, & Fuhrman (1992)

- Traits Highly Descriptive of Mother
  - Describe Remember
  - Does Remembering a Trait Prime Remembering a Behavior?

Traits Less Descriptive of Mother
Klein, Loftus, Trafton, & Fuhrman (1992)

- Traits Less Descriptive of Mother
  - Describe Remember
  - *Does Remembering a Trait Prime Remembering a Behavior?

Implications for the Organization of Person Memory

- Retrieval of Highly Descriptive Traits
  - Does Not Prime Retrieval of Trait-Related Behaviors
  - Highly Descriptive Traits are Represented Independently of Trait-Related Behaviors
- Retrieval of Less-Descriptive Traits
  - Does Prime Retrieval of Trait-Related Behaviors
  - Trait Judgments are Based on Retrieval of Exemplary Behaviors

Evidence from Amnesia
Tulving (1993); Klein & Loftus (1996)

- Amnesic Patients
  - Anterograde (Postmorbid Memories)
  - Retrograde (Premorbid Memories)
- Cannot Remember Episodes
  - No Episodic Self-Knowledge
- But Can Describe Personality
  - Spared Semantic Self-Knowledge
- Can Even Appreciate Personality Change
  - Source Amnesia?

Forms of Amnesia

- Memory
  - Anterograde Amnesia (Premorbid)
  - Retrograde Amnesia (Postmorbid)
- Injury
- Time
The Case of K.C.
Tulving (1993)

- Motorcycle Accident at Age 30
- Complete Amnesia
  - Anterograde
  - Retrograde
- Personality Change
  - Premorbid, Extraverted
  - Postmorbid, Introverted

Ratings of K.C.’s Postmorbid Personality
- K.C.’s vs. Mother’s Ratings of K.C.
  - $Q = .77$
- K.C.’s vs. Mother’s Ratings of Mother
  - $Q = .80$

K.C.’s Personality: Premorbid vs. Postmorbid
- 2-Alternative Forced Choice
  - Matched Items for Social Desirability
- Reliability of K.C.’s “Post” Ratings
  - 76% Agreement
- Mother’s ratings of K.C. “Pre” vs. “Post”
  - 50% Agreement (Chance)
- K.C. “Post” vs. Mother “Post”
  - 73% Agreement
- K.C. “Post” vs. Mother “Pre”
  - 53% Agreement (Chance)

The Case of W.J.
Klein, Loftus, & Kihlstrom (1996)

- 18 y/o College Undergraduate
  - 2nd-Quarter Freshman
- Concussive Blow to the Head
  - No Neurological Abnormalities
- Anterograde Amnesia
  - 45 Min After Injury
- Retrograde Amnesia
  - Covering Previous 6-7 Months
  - Cleared in 11 Days

Memory Testing in W.J.
Klein et al. (1996)

- Digit Span
- Free Recall
- Semantic Memory
- Episodic Memory
  - Galton Cued-Recall Technique
    - Unconstrained
    - Constrained
- Personality Testing

Autobiographical Memory During Amnesia
Klein et al. (1996)
Autobiographical Memory Post-Amnesia
Klein et al. (1996)

W.J.’s Personality in College
Klein et al. (1996)

• Agreement with Boyfriend, College
  \[- r = .65^*a \] Controls, \[- r = .65^*a \]
  Knows What She’s Like Now

• College vs. High-School
  \[- r = .53^b \]
  Some Relation to High-School Personality

• Test-Retest Reliability, College
  \[- r = .74^c \]
  Controls, \[- r = .78^c \]
  College Self Not Accounted For by High-School Self

Trait and Behavioral Self-Knowledge in Amnesia

• Amnesics Retain Knowledge of Personality
  – Forget Knowledge of Events

• Trait, Behavioral Information
  – Represented Independently
  – Confirms Results of Priming Studies

Structure of Person Memory

• Persons Represented as Nodes
  • Traits, Behaviors Represented as Nodes
  – Fan Out from “Person” Node

• Trait and Behavioral Knowledge Represented Separately
  – Behaviors Do Not Fan Out from the Traits They Exemplify

Neural Representation of Memory

• Distributed (Lashley; Hebb)
  – Reverberating Pattern of Neural Activity
  – Distributed Widely Over Cerebral Cortex

• Localist (Penfield)
  – Activity of Single Neurons
    • Or Small Clusters of Neurons
  – Centered on Specific Cortical Location
    • A “Grandmother Neuron” (Lettvin, 1967)
Invariant Visual Representation by Single Neurons
Quian Quiroga, Reddy, Kreiman, Koch, & Fried (2005)

• 8 Patients with Intractable Epilepsy
  – Electrodes Implanted to Localize Seizures
    • Medial Temporal Lobe
      – Hippocampus, Amygdala
      – Entorhinal Cortex, Parahippocampal Cortex
    • 8 Active Microwires per Electrode

• Responses to Visual Stimulation
  – Individuals, Objects, Animals, Landmarks
    • Selection Based on Interviews with Patients
    • Activity Spikes Within 1 Second
      – 5 SD Above Baseline

The “Jennifer Aniston” Neuron?
Quian Quiroga et al. (2005)

Single Unit in Left Posterior Hippocampus

The “Halle Berry” Neuron?
Quian Quiroga et al. (2005)

Single Unit in right Anterior Hippocampus

Summary of Findings
Quian Quiroga et al. (2005)

• Tested 993 Units
  – 343 Single Units, 650 Multi-Units
• Response to 1+ Pictures in 132 (14%)
• Then Test 3-8 Variants
  – 51 of 132 Showed Invariant Representation
    • People, Landmarks, Animals, Food Items
• Representations are Abstract
  – Different Views of Subject
  – Photographs and Line Drawings
  – Pictures and Names

Maybe there is a “Grandmother Neuron” After all!

• Sparse Neural Representation
  – Small Number of Units Active At Any One Time
• Psychophysical Linking Principle (Barlow, 1972)
  – Whenever two stimuli can be distinguished reliably...
  – …the physiological messages they cause in some single neuron
    would enable them to be distinguished with equal or greater reliability
• Knowledge Distributed Widely in Cortex
  – But Comes Together in Single Units
• Hippocampus as Index
  – Relates Memories to Each Other