1	Representation and Categorization October 16, 2008
2	 Representation "any notation or sign or set of symbols which 're-presents' something to usthat is, stands for something in the absence of that thing" objects of the external world (things) objects of the internal world (ideas) The "what" and "how" of representation is critical to most core issues in cognitive psychology implies some storage of information key problem: what is stored? nature of representation can be revealed through performance, but there are limitations
3	Types of Representations
4	 Representations: Another classification Perceptually-based representations Imagery (encodes visual+spatial structure) visual (object-based) spatial Linear Orderings (encodes sequence) Meaning-based representations (encode what is significant about an event) Propositions (code relations 'linguistically') Schemas (large, complex units of knowledge) event schemas (concepts) object schemas (concepts) prototypes
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8	 Images vs. Propositions Are images really different from propositions? YES (Paivio dual-coding theory) NO (Pylyshyn, Anderson & Bower) Does imagery have any functional significance? What is the relationship between perception and imagery?
9	 Memory for Visual Images Although people are generally good at remembering the general 'gist' (meaning) of pictures, memory for picture details is relatively poor Representative studies: Mandler & Ritchey (1977): study classroom pictures, present with distractors (next slide) Nickerson & Adams (1979): people virtually at chance in reproducing the correct configuration of a penny Conclusion: meaning-based representations ARE really different from perceptually-based representations
10	

 Paivio's Dual-Coding Theory Two basic coding systems: verbal and nonverbal Each is specialized for encoding, storing, organizing and retrieving information Each system consists of sensorimotor subsystems Basic representational units: logogens and imagens Systems interconnected by 'referential links'
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 15 Evidence for and against dual-coding theory 1 FOR Free recall of pictures > words Concrete words > abstract words Free recall of words encoded with imagery instructions > pronunciation Spatial interference effects (Baddeley et al., Brooks) Hemispheric differences in abstract-concrete word recognition
 2 AGAINST Interactive imagery instructions enhance cued-recall, but separate-imagery instructions do not (enhance relational organization) Little evidence for cognitive mechanisms of imagery (but see next slides; this may be changing)
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18 🔲 Structure of Images
 From psychological studies, results suggest that mental operations on images are similar to mental operations on percepts
 MENTAL ROTATION: RT to determine if a figure is mirror reversed is related to how much it is rotated (Cooper & Shephard) IMAGE SCANNING: time to scan between two points is a linear function of the distance between them (Kosslyn) Images have both visual and spatial properties
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	 Most popular concept of how <i>meaning</i> is represented in memory Proposition: smallest unit of analysis that can stand as a separate assertion Most clearly applies to language information 	
26	 Xample of propositional analysis 1. NIXON GAVE A BEAUTIFUL CADILLAC TO BREZHNEV, WHO WAS THE LEADER OF THE USSR Decomposition: 2. Nixon gave a Cadillac to Brezhnev. 3. The Cadillac was beautiful. 4. Brezhnev was the leader of the USSR. 5. Brezhnev was given a Cadillac by Nixon. Two ways of representing information: 'propositional calculus' (relations:arguments) 6. (Give: Nixon, Cadillac, Brezhnev, Past) 7. (Beautiful: Cadillac) 8. (Leader-of: Brezhnev, USSR, Past) propositional networks (next slide) 	
27		
28	 Production Systems Collections of IF-THEN rules (productions) Rules represent procedural knowledge If condition is true, action will be performed ACT-R, SOAR (two general cognitive architectures) Applications in AI, medical decision making (expert systems) 	
29 🔲	Production Systems	
30	 Chemas Encode generic knowledge that can be applied to many different situations Represent the structure of an object/event according to a <i>slot structure</i>, where slots represent relations as well as values on specified attributes Slots can contain sub-schemata Event schemas: scripts 	е
31	Schema for a "house"• Superset:building• Parts:rooms• Materials:wood, brick, stone• Function:human dwelling• Shape:rectilinear, triangular• Size:100-10,000 ft²	
32		
33 🔲	Relevance of Schemas Influence memory significantly Permit inferences about unencountered objects or events (generalization) Clinical relevance: 	

	 pathological generalization false memory
34	 Representation in Connectionism An alternative to localized, symbolic representations Represent information as a distributed pattern of connections between 'sub-symbolic' units Representation stores the connection strengths between units Different patterns can represent different representations
35	
36	 Concepts and Categories How do we group objects and experiences together to form higher-order knowledge structures like concepts (e.g., big, round) and categories (e.g., furniture, games)? Similarity is key principle in many organizational schemes Objects vs. relations between objects
37	Why have concepts/categories?
	Cognitive Economy
	 By dividing the world into classes of things to decrease the amount of information we need to learn, perceive, remember, and recognise (Collins & Quillian, 1969) Concepts Mental representations of classes of objects or other entities Categories Classes of objects embodied in concepts
38 🔲	Types of Concepts
	 Hierarchies Rosch, Mervis, Gray, Johnson, and Boyes-Braem (1976) Superordinate categories (e.g., furniture) Basic-level categories (e.g., chair) Subordinate categories (e.g., easy chair) Rosch et al. (1976) – list attributes at each level; picture naming We generally use basic-level categories (culturally most meaningful; enter the language first; best balance of informativeness and distinctiveness
39 🔲	
40	 Three Broad Theories of Concept Formation Defining-attribute theory (rule) Defining- + Characteristic-attribute theory (exemplar) Prototype theory
41	Defining-Attribute Theory – meaning captured by conjunctive list of attributes – each attribute necessary and all jointly sufficient

- boundaries clearly defined
- all members of the concept are equally representative

 – concepts organized hierarchically
 "belongingness" calculated based on how many attributes are present
42
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 Problems with Defining-Attribute Theories All attributes are not equally salient All members of a category are not equally "good" examples Some categories do not have defining attributes (e.g., games) Some categories are "fuzzy" (e.g., bookends are office supplies and furniture)
 46 Defining- + Characteristic-Attribute Theory (Exemplar Theory) Essentially defining-attribute theory with added assumption that concepts have attributes that are more or less characteristic of items in the class Feature-comparison process defining attributes = core definition characteristic attributes = how typical the object is (i.e. How like others it is) two stage process: first all attributes are verified, then defining "Belongingness" calculated with reference to available examples
47
 48 Prototype Theories Categories organized around central prototypes Prototype is the best example or a standard for other things in the category Category members have good match between their attributes and those of the prototype – concept of "family resemblances" "Belongingness" calculated based on typicality (closeness to extrapolated prototype)
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JNMD, 1998

"age= 38, gender = female, marital status = single." (*1*) "A 38-year-old woman was brought to an emergency room after attempting to kill herself by jumping in front of a subway train. (*2*)

The woman had flat affect and spoke matter-of-factly during the interview. She said that the driver of the subway train had been her lover and that a major fear of these drivers was that someone would leap in front of their train in a suicidal act. (*3*) This lover had recently stopped seeing the woman after his wife learned of his affair and the wife had physically beaten up the patient in a nightclub. (*4*) The patient is an obese women of at least 250 pounds who works at a mortuary. She has been employed at the mortuary since the death of her mother (*5*) Her mother and father were divorced when the patient was 15. Initially, the father won custody, but, when the patient kept running away from him, she was permitted to live with her mother. (*6*) She and her mother were very close. The mother contracted cancer, and the patient took care of her until her death. Then the patient requested a job with the mortuary that buried her mother. (*7*) Until recently, the patient had had no social life outside the mortuary. However, while riding the subway, she became fascinated with the voice of one driver and was determined to learn about this man. (*8*) She took leave from her job and managed to learn who the driver was, what his schedule was, and where he lived. She approached him and they became lovers. (*9*) 56 57 Correlations between performance on various tasks and theoretical predictions of prototype and exemplar theories. Based on data in Storms et al. (2000). 58 Goal-derived Categories: a problem for prototype theory Partial correlations (removing statistically the effects of other factors) between family resemblance and typicality for two types of categories (common vs. goal-derived). Prototype theory has difficulty handling goal-derived categories. Data from Barsalou (1985). ⁵⁹ Concept Learning Classification task – used widely Markham and Ross (2003) - Knowledge we acquire when learning concepts in everyday life may differ from the knowledge acquired on most classification tasks, and is likely to be broader Chin-Parker and Ross (2004) – next slide - Classify bugs or infer which piece (tail) is the correct missing part - People performing the classification task focus on diagnostic features between the categories - Those performing the inference task focus mainly on the relationship among features within each category 60 Prototypes for the various categories of bugs. From Chin-Parker and Ross (2004). Copyright © 2004 by the American Psychological Association. Reprinted with permission 61 Categorization Task Example ⁶² Knowledge-Based Views • Murphy (2002, p. 183): "Neither prototype nor exemplar models have attempted to account for knowledge effects ... The problem is that these models start from a kind of *tabula rasa* [blank slate] representation, and concept representations are built up solely by experience with exemplars." 63 🔲 The Role of Knowledge in Concept Learning

- A "tuk". The numbers are used to describe its parts: (1) noose; (2) hand guard; (3) handle; (4) end of the rope. Or: (1) loop; (2) tank; (3) knob; (4) outlet pipe.
- From Lin and Murphy (1997). Copyright © 1997 by the American Psychological Association

⁶⁴ D Explanation-based Theories

- Murphy and Medin (1985)
 - "Clean" and "unclean" animals
 - Explanatory framework
- Murphy and Medin (1985, p. 290)
 - "Causal knowledge certainly embodies a theory of certain phenomena; scripts may contain an implicit theory of entailment between mundane events; knowledge of rules embodies a theory of the relations between rule constituents; booklearning scientific knowledge certainly contains theories."

65 🔲 Summary

- Current view calls for multiple representations (some percept-based, some meaningbased)
- Nature of representation can be inferred by performance data
- Information arranged hierarchically in various representational schemes
- · Symbolic v. distributed representations a topic of current interest