Test 2 Study Guide

**Cognitive Science - Interdisciplinary by Origin**

* Cognitive science is an interdisciplinary field that combines various disciplines to study the mind and cognitive processes.
* The CRUM paradigm proposes that the mind contains mental representations and performs procedures on those representations.
* Mind- computer- brain analogy:
* The mind can be compared to a computer, with mental representations as the information stored and processed, and procedures as the operations performed on that information.
* The brain serves as the physical basis for the mind and its cognitive processes.
* History of cognitive science:
* Philosophers like Plato, Aristotle, Descartes, and Kant laid the groundwork for understanding knowledge, reasoning, and innate abilities.
* Behaviorists like Pavlov, Watson, and Skinner focused on observable behavior.
* AI pioneers like McCarthy, Minsky, Newell, and Simon contributed to the development of artificial intelligence.
* Chomsky rejected behaviorism and emphasized the role of innate mental structures in language acquisition
* Scientific Theories and Their Characteristics
* Scientific theories should be about phenomena in the world and provide descriptive, explanatory, and prescriptive aspects.
* Descriptive theories rigorously measure or describe phenomena.
* Explanatory theories explain existing data and predict new data.
* Prescriptive theories provide tools and methods for interacting or modifying phenomena.
* Cognitive Models and the Tri-Level Hypothesis
* Cognitive models involve multiple levels of abstraction, as proposed by Marr and extended by Thagard.
* The tri-level hypothesis includes computational (task analysis), algorithmic/programmatic (data structures and algorithms), and implementation (physical realization) levels.

**Representations**

* Evaluation
* Representations can be evaluated based on their representational power, computational power, psychological plausibility, neurological plausibility, and practical application.
* Representational power refers to what can be represented within the system and how efficiently.
* Computational power assesses the system's ability to solve problems, make decisions, provide explanations, learn, and process language.
* Psychological and neurological plausibility examines if the representations align with psychological and neurological evidence.
* Practical application considers how representations can be used in education, design, intelligent systems, and mental illness
* Analog vs symbolic:
* Analog representations link qualities in one domain to another based on common relationships, while symbolic representations rely on convention and culture.
* Analog representations preserve relationships and behave similarly, while symbolic representations are arbitrary and culturally established

**Logic, Abduction, and Inductive Reasoning**

* Logic systems use rules of inference to derive conclusions from premises.
* Abduction is a reasoning process that infers the best explanation for observed facts.
* Inductive reasoning involves generalizing conclusions from specific examples.

* **Rule Systems:**
* Isomorphic vs homomorphic
* Isomorphic rules have a one-to-one mapping between the represented and representing worlds.
* Homomorphic rules have a many-to-one mapping between the represented and representing worlds.
* Ex: The homomorphic mapping might involve reducing the complexity of the car to its key components, such as the engine, wheels, and chassis. The model captures the essential features of a car without replicating every detail.
* Rules and resolution
* Rule systems consist of a set of rules, resolution strategies, and short-term memory.
* Resolution strategies determine the order in which rules are applied, such as most/least specific, most/least recently fired, most distinct from prior, priority ordering, or arbitrary.
* Application
* MYCIN was an early rule-based system for medical diagnosis.
* Rule-based systems use a set of rules and resolution strategies to make recommendations or decisions based on input.

**Concepts**

* Different theoretical perspectives on concepts:
* Compositional view: Concepts are composed of smaller concepts.
* Prototype view: Concepts have probabilistic structure based on shared features.
* Classical view: Concepts have definitional structure and are necessary and sufficient.
* Grounding problem: Exploring how concepts are formed and where the initial concepts come from.
* Frame: sets of related schemas
* Frames/schema and hierarchical computational constructs: Understanding how concepts are organized and represented as networks.
* Costs and benefits of conceptual networks: Exploring how organizing information in conceptual networks relates to computational problems of rules and logic.
* The relationship between concepts and rules: Investigating whether logic or rules are possible without concepts.

**Metaphor**

* Common use of linguistic metaphor vs. cognitive science use:
* Linguistic metaphor: Figurative language that associates one concept with another for expressive purposes.
* Cognitive science use: Viewing metaphor as a fundamental part of our conceptual system for thinking and acting.
* Systematicity and importance of metaphors:
* Metaphor allows us to understand and experience one concept in terms of another.
* Metaphors provide structure, understanding, and performance in our conceptual system.
* Primary metaphors and grounding problem:
* Primary metaphors are formed through embodied experiences and help address the grounding problem.
* Example: Metaphors based on physical experiences, such as "prices are rising."

**Analogy**

* Analogy process:
* Defining the target problem.
* Finding a relevant analog source.
* Mapping relevant features from the analog to the target problem.
* Transferring and adapting solutions from the analog source to the target problem.
* Storing the new solution.
* Superficial, structural, and pragmatic similarity:
* Superficial similarity: Matching based on simple "filler" values of slots.
* Structural similarity: Matching based on relationships, often causal or functional.
* Pragmatic similarity: Matching based on goals and purposes.
* Case-based reasoning:
* Using similar cases to solve new problems.
* Indexing and retrieval of relevant cases.
* Adaptation of existing solutions to new problems.
* General uses for analogy:
* New solution generation.
* Explanation and definition.
* Evaluation and prediction.
* Problem formulation and problem solving.
* Learning through analogy:
* Simple learning: Storing new cases from analogical experiences.
* Complex learning: Abstracting patterns from multiple analogies to develop expertise.

Comparison Table of Logic, Rule, Concept, Analogy and Metaphor based on Representational Power, Computational Power, Psychological Plausibility, Neurological Plausibility, and Practical Application

|  | **Representational Power** | **Computational Power** | **Psychological Plausibility** | **Neurological Plausibility** | **Practical Application** |
| --- | --- | --- | --- | --- | --- |
| Logic | Logic provides precise and unambiguous representations of relationships between propositions and allows deductive reasoning. | Logic is highly computational, enabling the use of formal proofs and automated reasoning systems. | Logic is psychologically plausible for certain tasks that require strict rules and reasoning based on formal principles. | Logic is associated with neural activity in various brain regions, such as the prefrontal cortex. | Logic is commonly used in mathematics, computer science, and formal systems for problem-solving and decision-making. |
| Rule | Rules capture general principles or guidelines for behavior and decision-making. They can be explicit or implicit and guide actions in specific contexts. | Rules can be computationally implemented through algorithms and decision trees. However, complex rule systems can become computationally expensive. | Rules are psychologically plausible, as humans often rely on rule-based reasoning and follow social and cultural norms. | Rule-based processing involves the activation of different brain areas, including the prefrontal cortex and basal ganglia. | Rules are utilized in various domains, such as law, regulations, programming, and expert systems. |
| Concept | Concepts are mental representations that categorize and organize information based on shared features or characteristics. They allow for generalization and abstraction. | Concepts can be computationally implemented through knowledge representation systems and similarity measures. Concept learning algorithms are used in machine learning. | Concepts are psychologically plausible, as they enable cognitive processes like categorization, memory, and knowledge acquisition. | Conceptual processing involves the activation of distributed neural networks, including the sensory and association cortices. | Concepts are extensively applied in cognitive psychology, artificial intelligence, information retrieval, and natural language processing. |
| Analogy | Analogy involves mapping similarities between two or more domains or situations to transfer knowledge or make inferences. It relies on structural and relational correspondences. | Analogical reasoning can be computationally challenging due to the need for mapping and mapping constraints. It requires relational representations and similarity measures. | Analogical reasoning is psychologically plausible and plays a crucial role in problem-solving, creativity, and learning by analogy. | Analogical reasoning engages various brain regions, including the prefrontal cortex, hippocampus, and anterior cingulate cortex. | Analogy is used in various fields, such as education, design, problem-solving, and scientific discovery, to draw insights from familiar domains to new situations. |
| Metaphor | Metaphor uses the mapping of concepts from one domain (source domain) to another (target domain) to facilitate understanding and convey meaning. It involves structural correspondences and highlighting certain aspects while downplaying others. | Metaphor processing can involve computational complexity due to the need for conceptual mapping and inference. It may require conceptual blending and probabilistic models. | Metaphor is psychologically plausible and influences cognition, perception, and language understanding. It shapes how we think, reason, and communicate about abstract concepts. | Metaphor comprehension engages distributed neural networks, including the sensory, association, and prefrontal cortices. | Metaphors find practical applications in communication, literature, advertising, therapy, and creative problem-solving. They enable conceptual framing and the exploration of alternative perspectives. |

### Metaphor

### Analogy

Analogy Process 1. Define target problem to be solved 2. Find (remember) a relevant analog source 3. Map relevant features from analog to target 4. Transfer and adapt from analog source to target problem 5. (Learning) Store new solution

Case-based reasoning starts from a domain of very similar problems – Use domain specific indexing schema for retrieval – Straightforward mapping – Requires a small adaptation to existing solution • Simple substitution (cooking ingredients) • Systematic adaptation (converting a computer program

Analogical reasoning uses distant domains – Requires general purpose indexing – Mapping is less obvious – Adaptation may be extensive – For example biologically inspired design (Velcro

### Images

### Visual Reasoning

### Connections (Neural Networks)

### Brain