Comparing Animal "SMARTS" Using Four Stages of the Model of Hierarchical Complexity

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Model of Hierarchical Complexity

- The *Model Of Hierarchical Complexity* (MHC) is a formal theory and a mathematical psychology framework for scoring how complex human behavior is .
  - Neo Piagetian Model of Human, androids and animal development Commons' Model identifies 18 Orders Of Hierarchical Complexity.
  - It classifies tasks by their highest Order Of Hierarchical Complexity
  - It deconstructs tasks into the actions that must be done at each order to build the behavior needed to successfully complete a task
- Humans acquire stage proclivity on tasks determined by their order of hierarchical complexity
- Behaviors performed at each higher stage of development are always more complex than those performed at the immediately preceding stage
  - Movement to a higher stage of development occurs by the human brain
  - The Model of Hierarchical Complexity is a behavioral model of developmental and evolutionary stage, based on task analysis.
- Tasks are ordered in terms of their Order of Hierarchical Complexity (OHC)
- OHC is an ordinal scale that measures task difficulty.
- Successful performance on a task is called the behavioral stage.
- This model can be applied to non-human animals, humans as well as to androids.
  - Using data from simple animals and more complex one, we will describe the three lowest behavioral stages.
  - We illustrate them using the behaviors of a range of simple organisms.

The Model of Hierarchical Complexity Generates 18 Known Orders

Order Number	Order Name	Order Number	Order Name
0	Computational	9	Concrete
1	**Automatic**	10	Abstract
2	**Sensory or Motor**	11	Formal
3	**Circular Sensory Motor**	12	Systematic
4	**Sensory Motor**	13	Metasystematic
5	Nominal	14	Paradigmatic
6	Sentential	15	Cross-paradigmatic
7	Preoperational	16	Meta-Cross-paradigmatic
8	Primary	17	Ultra meta-cross-paradigmatic

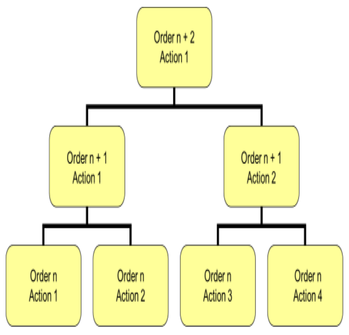
Three Axioms of The Model of Hierarchical Complexity

Higher order actions are:

a) Defined in terms of tasks actions from the next lower order of hierarchical complexity

b) Defined as the higher order task action that organizes two or more less complex actions

c) The ordering of the lower task actions have to be carried out in a non – arbitrary way



Stage 1: Automatic

- For most of evolutionary time, there were only single-celled organisms. For this review, we assume that single-celled organisms in the evolutionary past only had "hard wired" responses including taxis, tropisms and phagocytosis, much like today's single-celled organisms.
  - Examples of such built in or automatic actions include taxis, tropisms, phagocytosis and unconditionable reflexes (Commons & White, 2006/2009).
  - Obviously, single celled animals do not have nervous systems. Here, conditionable and unconditionable reflexes are distinguished. Unconditionable reflexes are a Stage 1 behavior.
  - Reflex, is nearly an instantaneous movement in response to a stimulus (Purves, 2004).

Example 1: This is an example of unconditionable reflex and habituation as an Automatic Stage 1 behavior in protozoan, Vorticella convallaria by Patterson (1973).

Stimulus 1 (S_1). Electric stimulation of different intensities administered every 10 seconds for 5 minutes. Response 1 (R_1). Response to (S_1) was contraction of the body and stalk. The S_1. eliciting R_1 is an example of unconditionable reflex which is an Automatic Stage 1 behavior.

Stimulus 2 (S_2). Mechanical stimulus administered by dropping different weights on the microscope stage every 10 seconds for 5 minutes.

Response 1 (R_1). Response to S_2 was contraction of the body and stalk. S_2 eliciting R_1 is also example of unconditionable reflex which is an Automatic Stage 1 behavior.

Stimulus 3 (S_3). Mechanical stimulus was administered by modifying the media of the organism. Response 1 (R_1). Response to S_3 was contraction of the body and stalk. S_3 eliciting R_1 is also example of unconditionable reflex which is an Automatic Stage 1 behavior. Habituation occurred with administration of all the three stimuli. The longer the organisms were exposed to the stimuli, the longer became the periods in which the organism were non-responsive.

Stage 2: Sensory or Motor

At Sensory or Motor Stage 2, organisms coordinate two stimulus response pairs from the lower Automatic Stage 1.

An example of this is respondent conditioning. The criterion for classifying something as Sensory or Motor Stage 2 is that the pairing of stimuli leads to conditioning (Commons, Miller, Commons-Miller, & Chen, 2012).

Example 1 - Sea Slug – Definition Demonstration		
Definition 1	NS	sterile glass probe for tactile stimulation
	UCS	food chemicals
	CS	probe after being paired with the food chemicals
	UCR_1	withdrawal and bite-strike response
	UCR_2	feeding behavior after the presentation of food chemicals
Definition 2	NS is paired with UCS NS becomes CS CS elicits UCR_2	
Definition 3	CS does not elicit UCR_1	

Stage 3: Circular-Sensory Motor

- At Order 3, animals operantly condition
- Operant conditioning is coordinates four conditioned reflexives
- Animals coordinate perception with action, or two or more actions
  - Hunting behavior of animals is controlled by consequences (e.g. most predatory fish, insects).
  - Corrette (1990) observed prey capture in the praying mantis.
  - This behavior coordinated capture and strike movements.
- Human infants make perceptual discriminations including picking the larger of the two sources of reinforcement
- Simple discrimination, such as peck right key when red light is on; peck left key when green light is on

How Operant Conditioning Is Build Out Of Respondent Conditioning

Steps	Question	Stimulus Pairing		Response
Step 1	What is the value of doing it?	S_{Drive} o $S_{Consequence}$	→	R_{Value}
Step 2	What to do?	s_{rb} - $R_{"Operant"}$ o S^{R+}	→	$R_{Operant\ Strengthening}$
Step 3	When to do it?	$S_{Environment}$ o s_{rb}-$R_{"Operant"}$	→	$R_{Conditioned\ Reflex}$
Step 4	Why to do it?	$S_{Environment}$ o S^{R+}	→	$R_{Incentive}$
Step 5	Where to do it?	$S_{Environment}$ o S_{Drive}	→	$R_{Environment}$

Stage 4: Sensory Motor

- At Sensory-Motor Stage 4, organisms coordinate two or more circular sensory-motor subtask actions into a superordinate concept.
- In the tradition of Hull (1920), concepts are defined as several stimuli organized by following common response.
- For example, a participant could be tasked with sorting stimuli for color. Alternatively, they could sort for shape. Color or shape are each superordinate concepts organizing the operant selection behaviors. New and untrained instances of the concept are responded to correctly.
- These correct responses do not depend on simple stimulus generalization, as concepts like shape and color are superordinate properties of stimuli and not stimuli themselves. This analysis argues that nonarbitrary coordination of multiple operant tasks is required for concept learning to be successful demonstrated with novel stimuli.

Limitations

1. One limitation with any model that makes use of concepts like behavior and conditioning is the lack of correspondence of what people mean when they use these terms (Abramson & Wells, 2018).
2. Fundamentally, this analysis is more concerned with the organization of adjacent lower order tasks into the next order task than meeting the requirements for the various definitions, such as classical and operant conditioning.
3. Attempts that were made demonstrate sufficient evidence for popular definitions of these terms to apply.
4. Until animal research that is specifically designed to test predictions of the MHC is performed, claims about animal stages will not be statistically supported.
5. Investigations that interpret pre-existing work according to a new model are subject to definition problems between the author of the pre-existing work and the new interpretation.
6. To ameliorate this problem, this paper focuses on descriptions of the procedures the animals went through. This reduces the potential for the error of asserting that the original authors share the same definitions the authors of this paper do.

Implications

This paper explains the following:

1. It explains a major theoretical contribution of the First Three Developmental and Evolutionary Behavioral Stages. This applies to all of child development and evolution, and AI
2. How the evolution of operant conditioning takes place
3. How to construct simpler and better neural networks out of 4 instances of respondent conditioning. If there is even one step missing, that will block the occurrence of operant conditioning

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