

A decorative graphic on the left side of the slide consisting of white and light blue lines and circles, resembling a circuit board or neural network, extending from the top to the bottom.

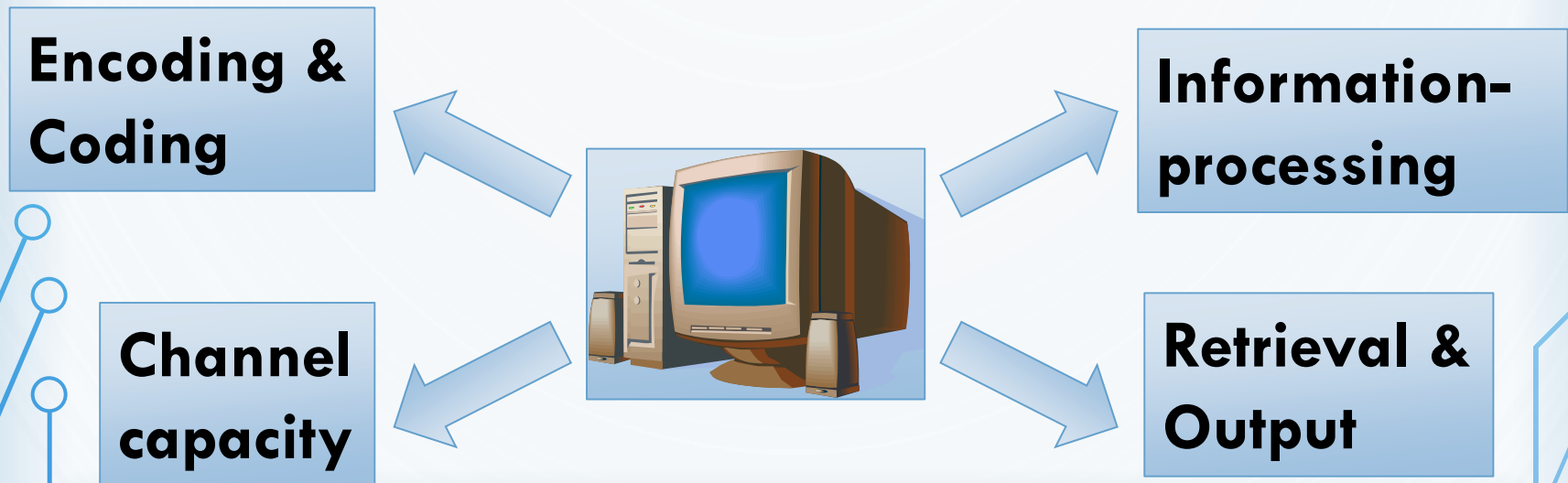
HUMAN PERFORMANCE

COMPUTATIONAL MODELLING

DR KATE WILLIAMS

COGNITIVE MODELLING

- Relies heavily on the computational metaphor.
 - Brain is thought of as a computer, with groups of neurons performing computations.
- Human behaviour and cognition is then simulated through software and programmes.



COMPUTATIONAL METAPHOR

	COMPUTER	HUMAN
HARDWARE	• Circuit board • Chips	• Brain structures
SOFTWARE	• Program/sequence of instructions. • Symbol manipulation	• Mental processes. • Abilities

- **Computer: Applies symbols as representations and then specifies logical operations to act on those symbols.**
- **Human: mind represents concepts by internal symbols and then performs stimulus analysis and response selection by performing computations on those symbols.**

COMPUTATIONAL METAPHOR

Computer

Human

Serial vs. Parallel Processing

Binary Coding (0s & 1s)

Neurons (“On” or “Off”)

Internal and auxiliary memory

Short-term ‘working’ memory and Long-term memory

Independent “chips” for processing specialised tasks

Distinct processing areas performing specialised task

Miller (1985, p.3): “The ability to accept input symbols and generate output symbols, to store and erase them, to compare them and to branch according to the outcome of the comparison are the only kinds of building block required for the synthesis of intelligence...”

COMPUTATIONAL METAPHOR

- **Cognitive psychology uses computational metaphor to describe encoding of incoming stimuli, processing and computing of internal codes and then the output – what is the output?**
 - **Actions & behaviours = performing**
- **Models attempt to explain what's actually happening in the point between encountering a stimulus and then producing a response or output.**

Neisser (1967)

“The task of....trying to understand human cognition is analogous to that of... trying to understand how a computer has been programmed” (p.6).

COMPUTATIONAL METAPHOR

- Fundamental aspect of the metaphor is the description of human cognition in terms of **information processing**
- To understand this we have to be able to differentiate between **content** of information and the **process** by which it is transmitted or transferred.
- Other important factors about the computer metaphor
 1. Information processing can be described by a number of stages.
 2. the form or manner of information can change during the processing.

Relation to human performance?

- Performing a cognitive function requires energy and use of resources.
- Models show the capacity limits of cognition, which help explain conditions under which performance can be improved or hindered.
- Ability to perform depends on speed of processing information and the amount of storage available to allocate to a task.

Relation to human performance?

- But there's also a distinction between ***fixed*** and ***variable*** resources.
- Typically cognitive theories treat resources in general as a processing-level construct.
- Performance Psychology also considers how someone's goals, motivations, and voluntary choices can influence performance.

Relation to human performance?

- To bypass this issues, cognitive models often implement a **control loop** to mimic the processing associated with voluntary control.
- Open-loop control: any stimulus directly triggers a sequence of processing operations (instinctive behaviours).
- Closed-loop control: sensitive to feedback signalling whether an error has occurred (allows us to adapt or change behaviour).
 - So, voluntary control relates to closed-loop control in that reaction to error feedback is goal-dependent.

Relation to human performance?

- Closed-loop control:
 - But the feedback itself can also be of a different nature:
 - Intrinsic (can also be sub-divided into exteroceptive and interoceptive).
 - Extrinsic
 - We can also implement control of performance through using certain strategies
 - A chosen and voluntary style of performance.

Relation to human performance?

- A strategy does not affect the cognitive architecture but it does affect the way it is used.
- A persons strategy can also be manipulated by changing the goals of a task.
- So, different symbol-processing models are needed to explain performance depending on the type of strategy a person employs.

Relation to human performance?

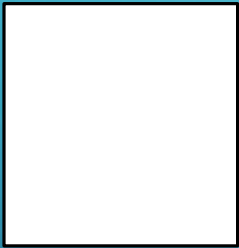
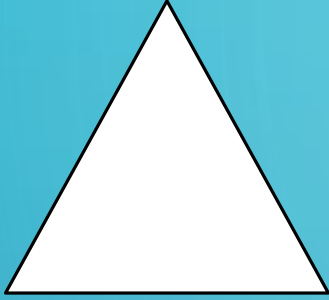
- Let's have a practice using the picture-sentence verification task (Clark & Chase, 1972).
- Your task is to decide as quickly as possible whether a sentence matches with what the picture is showing.
- Shout out “YES” if what is displayed in the picture and sentence match or “NO” if they don't.



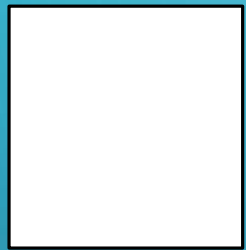
STAR IS ABOVE



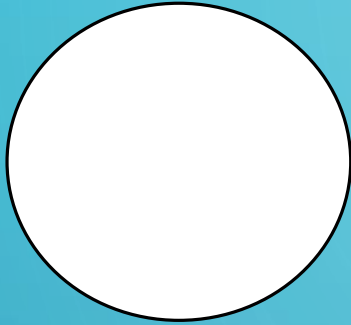
PLUS



**SQUARE IS
ABOVE TRIANGLE**



**SQUARE IS
ON THE LEFT
OF PLUS**



**STAR IS NOT
ABOVE CIRCLE**

Investigating Strategy

- Performance on the picture-sentence verification task shows different types of items can be constructed depending on two points:

1. Whether the sentence is affirmative or negative.
2. Whether the description of the picture is true or false.

According to MacLeod, et al., (1978) people use one of two strategies:

1. Linguistic: encode sentence and picture verbally, and then the meaning can be compared.
 2. Visually: mental image of sentence compared to picture.
- Which strategy did you use?

Modelling Strategy

- Both can be modelled and used to predict pattern of response time across different trials.
 - E.g., processing negative sentence tends to be slower when using linguistic strategy.
- So, strategies influence control of information flow through the architecture rather than influencing the architecture itself.
- However, when strategies are very different, the descriptions of the processing structures involved are also going to be dramatically different.

Modelling Strategy

- Understanding strategies may help us to understand the energetics that go into performance:
 - By investigating why people choose certain strategies, it allows an integration of knowledge level and cognitive architecture perspectives.
- However: can we always assume a particular strategy is used?

General Cognitive Architecture Models

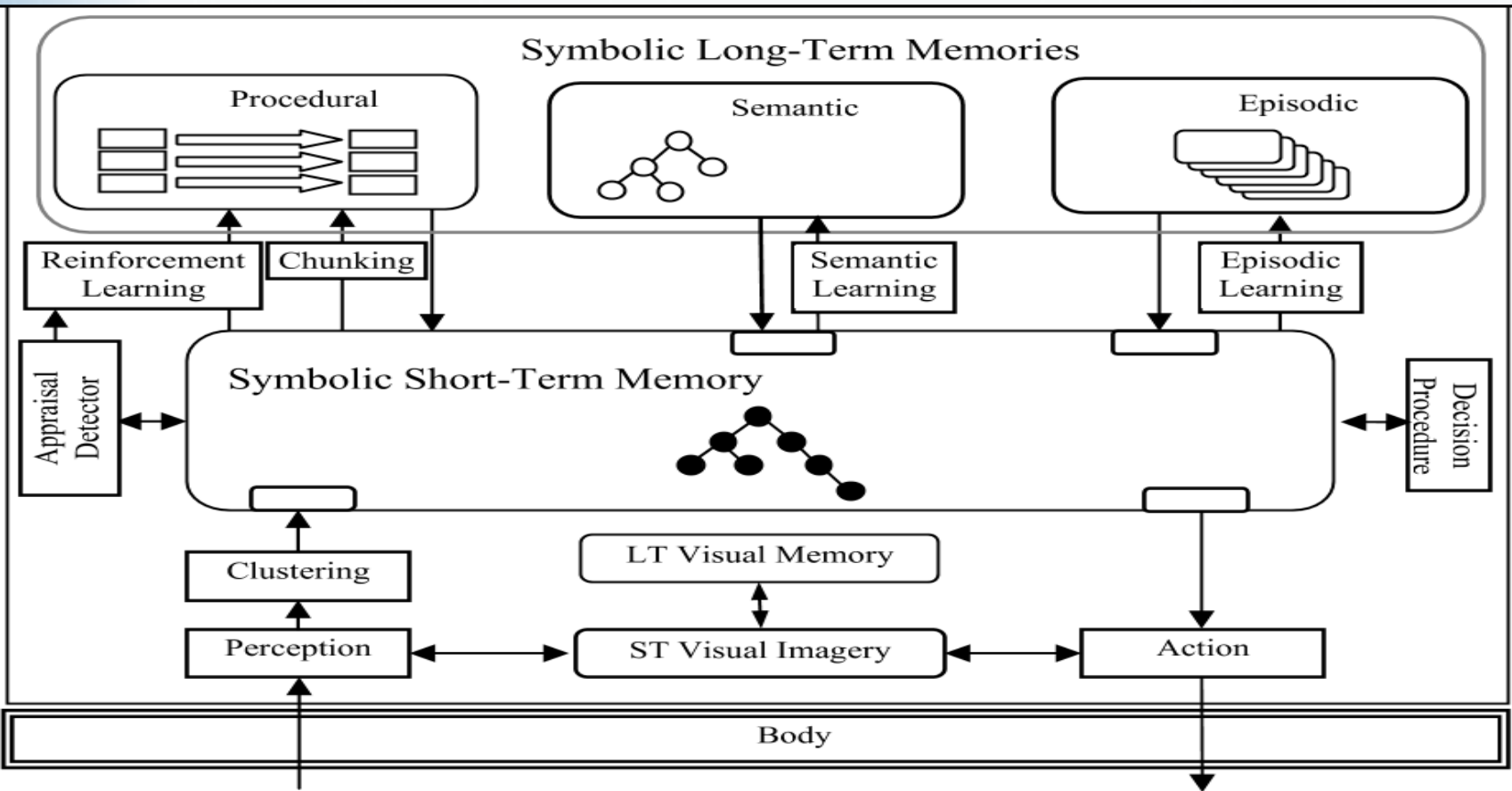
- Laird, Newell, & Rosenbloom's **SOAR** model (since 1983)
 - Mainly used by AI researchers & cognitive scientists, and has evolved to a 9th version.
 - Intends to work on full range of tasks expected of an intelligent agent, from highly routine to extremely difficult, open-ended problems.
 - All decisions it makes are made through the combination of relevant knowledge at run-time.
 - Every decision is based on the current interpretation of sensory data, the contents of working memory created by prior problem solving, and any relevant knowledge retrieved from long-term memory.

SOAR

Website:

<http://soar.eecs.umich.edu/>

- Has multiple learning mechanisms (chunking, reinforcement learning, episodic and semantic learning), and multiple representations of long-term knowledge (productions for procedural knowledge, semantic memory, and episodic memory).



Modularity of the Mind

- Some models try to describe general principles of cognition.
 - However, they only actually describe a small portion.
- Alternative = model sub-systems.
 - To do this, we need to understand modularity of the mind.
 - The mind is composed of multiple modules (functional units that do particular task or processes particular type of information)
 - E.g., Chomsky: specific language unit dealing only with language

Modularity of the Mind

- Fodor: modules are domain specific –
 - They only deal with a particular type of task or information.
 - E.g., mechanisms for colour perception, for the analysis of shape, and for the analysis of three-dimensional spatial relations.
- Modules complete specific processes in an automatic way with minimal interference from other modules - **information encapsulation**.
- A system divided in to modules is likely to be more efficient because it can deal with threats at a quicker rate, which is key to survival.

Modularity of the Mind

- However.....
 - There are times when we need to combine or coordinate information from different sensory domains.
- Fodor: there are a set of more general processes that deal with output of many modules.
 - The mind is composed of domain specific modules that operate relatively independently of one another and which feed their output in to more general processing mechanisms.

Key sub-systems

- A class of models propose the architecture comprises independent sub-systems:
 - Levels of Control models:
 - For voluntary and involuntary control.
 - Schema Activation Models
 - Various models of memory

SESSION SUMMARY

- Computational modelling used as means to understand human performance.
- A number of different models proposed within each area in an attempt to explain performance.
 - Some focus on specific sub-systems due to the argument of mind modularity.