Studying Cognition

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Converging Evidence for Dissociations and Associations

Behavioral Methods

Correlational Neural Methods: The Importance of Localization

Causal Neural Methods

Modeling

Neural-Network Models

Behavioral Methods

A behavioral method measures directly observable behavior such as the time to respond or the accuracy of a response. Researchers attempt to draw inferences about internal representation and processing from such directly observable responses.

Major Behavioral Measures and Methods Used in Cognitive Psychology

Measure or Method	Example	Advantages	Limitations
Accuracy (percent correct or percent error)	Memory recall, such as trying to remember the main job requirements during an interview	Objective measure of processing effectiveness	Ceiling effects (no differences because the task is too easy); floor effects (no differences because the task is too hard); speed–accuracy trade-off ("jumping the gun")
Response time	Time to answer a specific question, such as whether you know the requirements of a certain job	Objective and subtle measure of processing, including unconscious processing	Sensitive to experimental expectancy effects and to effects of task demands; speed-accuracy trade-off
Judgments	Rating on a seven-point scale how successful you felt an interview was	Can assess subjective reactions; easy and inexpensive to collect	Participant may not know how to use the scale; may not have conscious access to the information; may not be honest
Protocol collection (speaking aloud one's thoughts about a problem)	Talking through the pros and cons of various job possibilities	Can reveal a sequence of processing steps	Cannot be used for most cognitive processes, which occur unconsciously and in a fraction of a second

Correlational Neural Methods: The Importance of Localization

Cognitive psychology has become extraordinarily exciting during the past decade because researchers have developed relatively inexpensive, high-quality methods for assessing how the human brain functions. These methods are ***correlational***: although they reveal the pattern of brain activity that accompanies information processing, they do not show that activation in specific brain areas actually results in the task's being carried out.

Correlation does not necessarily imply causation.

Correlational Neuroimaging Methods

Method	Example	Spatial Resolution	Temporal Resolution	Invasiveness	Cost (Initial; Use)
Electrical (electroencephalography, EEG; event-related potentials, ERP)	Track stages of sleep (EEG), brain response to novelty (ERP)	Poor (perhaps 1 inch)	Excellent (milliseconds)	Low	Low purchase cost; low use cost
Magnetoencephalography (MEG)	Detect activity in auditory cortex to tones of different pitches	Good (under 1 centimeter), but only in sulci, not in gyri (because of the way dendrites line up)	Excellent (milliseconds)	Low	High purchase cost (and needs a special magnetically shielded room); medium use cost (needs servicing so superconductors remain extremely cold)
Positron emission tomography (PET)	Detect activity in language areas as participants speak	Good (about 1 centimeter, but in theory higher)	Poor (an image every 40 seconds)	High (must introduce radiation)	High purchase cost (needs a cyclotron plus the PET camera); high use cost (about $2,000 per participant)
Magnetic resonance imaging (MRI) and functional magnetic resonance imaging (fMRI)	Show structure of the brain (for MRI), show activity in brain areas, same as PET (for fMRI)	Superb (millimeter range); fMRI often about 0.5 centimeter	Depends on level of resolution; typically several seconds	Low	High purchase cost (needs a specially shielded room); medium use cost (needs servicing)
Optical imaging	Show activity in brain areas, same as PET	Poor at present (about 2 centimeters)	Depends on level of resolution; typically several minutes	Medium/low (light is shined through the skull)	Low purchase cost; low use cost

Causal Neural Methods

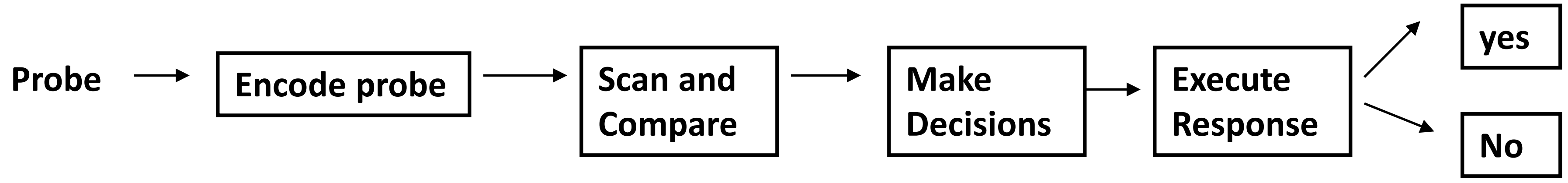
Causal Neural Methods Used in Cognitive Psychology

Method	Example	Advantages	Limitations
Neuropsychological studies (of patients with localized or diffuse brain damage)	Examine deficit in understanding nouns but not verbs	Tests theories of causal role of specific brain areas; tests theories of shared and distinct processing used in different tasks; relatively easy and inexpensive to collect	Damage is often not limited to one area; patients may have many deficits
Transcranial magnetic stimulation (TMS)	Temporarily disrupt occipital lobe and show that this has the same effects on visual perception and on visual mental imagery	Same as for neuropsychological studies, but the transient "lesion" is more restricted, and the participant can be tested before and after TMS	Can be used only for brain areas near the surface (TMS affects only tissue about 1 inch down)
Drugs that affect specific brain systems	Disrupt the action of noradrenaline, which is crucial for the operation of the hippocampus	Can alter the processing of specific brain systems; typically is reversible; can be tested in advance with animals	Many drugs affect many different brain systems; the temporal resolution may be very poor

Modeling

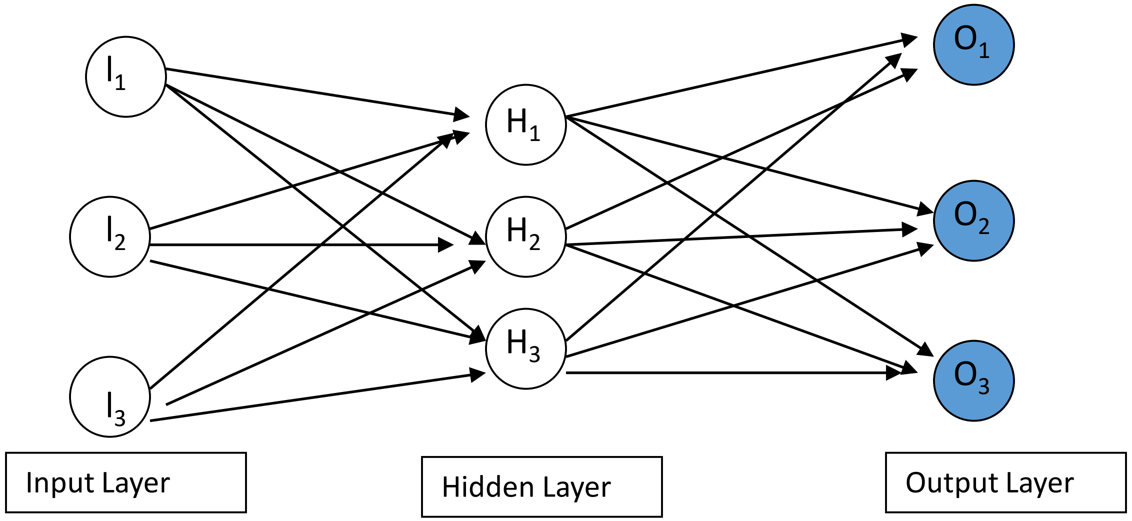
In psychology models are often implemented as computer programs which are meant to mimic the underlying mental representations and processes that produce specific types of human performance

1) ***Process Models*** *- specify a sequence of processes that convert an input to an output. Such models can be illustrated by using flow charts (for e.g.,)*



Modeling

2) ***Neural Network Models*** *– rely on sets of interconnected units each of which is intended to correspond to a neuron or to a small group of neurons. Units are not same as neuron but rather they specify the input-output process group of neuron perform (for e.g.)*



A Simple Feed-Forward

Neural Network Model

A Brief History of Cognitive Psychology

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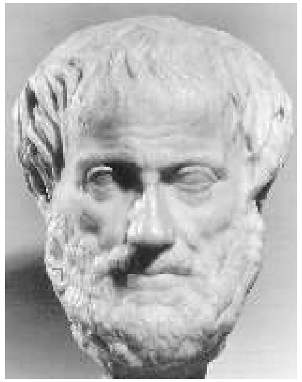
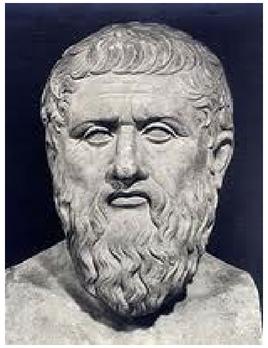
Empiricism vs **Nativism**



Aristotle

John Locke
"Blank slate"



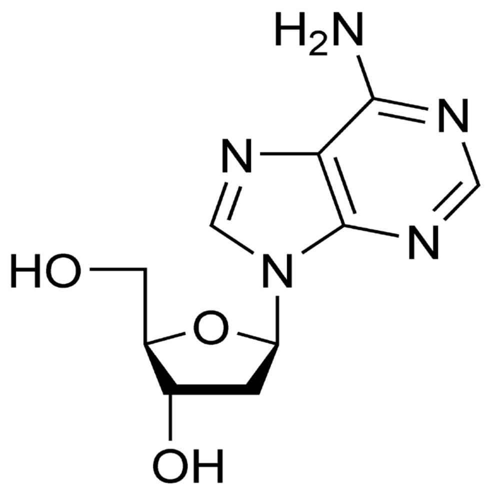
Plato

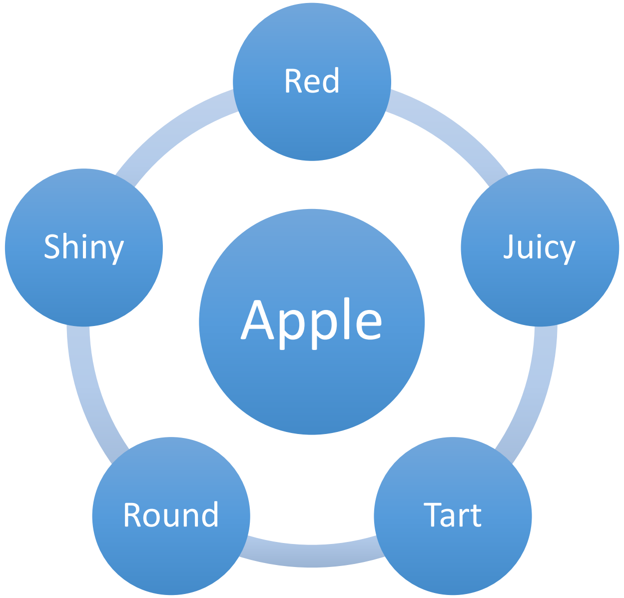
Descartes

Experience

Heredity & Biology

Structuralism (Wilhelm Wundt)





Wundt's school made at least two major contributions:

(1) They showed that mental activity can be broken down into more basic operations.

(2) They developed objective methods for assessing mental activity.

Functionalism (William James)

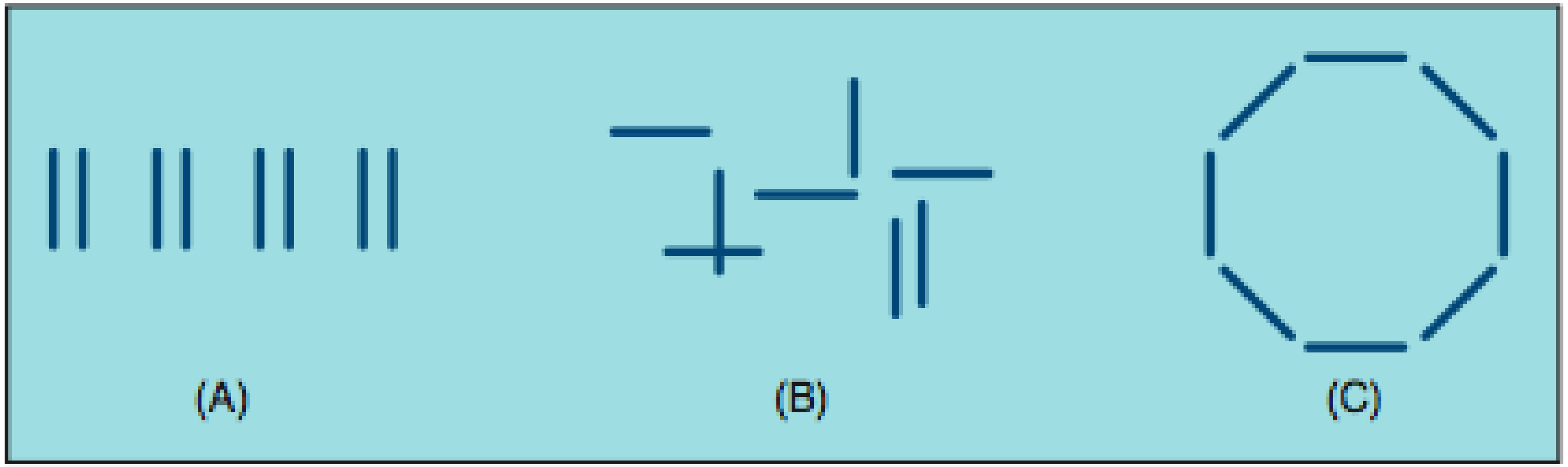
William James (1842–1910): focused not on the nature of mental activity, but rather on the ***functions*** of specific mental activities in the world.

The *functionalist* perspective: certain practices or approaches are better suited than others to accomplishing certain tasks, and that we should change our thoughts and behavior as we discover those that are increasingly "better adapted" to our environment.

It relied in large part on ideas about evolution proposed by **Charles Darwin**.

Preferred to study behavior in the real world rather than a sterile laboratory

Gestalt Psychology



The whole is greater than the sum of the parts.

Behaviorism

Clark L. Hull (1884–1952): proposed that internal events that are inferred directly from behavior such as motivation, even though these events were not themselves immediately observable.

B. F. Skinner (1904–1990): went so far as to reject absolutely all discussion of internal events.

Behaviorists limits:

It simply could not explain the most interesting human behaviors, notably language (Chomsky, 1957, 1959). (*p. 7*)

Failed to provide insights into the nature of perception,

The Cognitive Revolution

This new approach, developed in the late 1950s and early 1960s, was directly tied to the development of the computer (Gardner, 1985).

Researchers seized on the computer as a model for the way in which human mental activity takes place; the computer was a tool that allowed researchers to specify the internal mechanisms that produce behavior.

Herbert A. Simon and **Alan Newell** and linguist **Noam Chomsky** played a central role in this revolution, providing examples of how progress could be achieved by comparing the mind to a computing machine.

Understanding the Mind

The cognitive revolution led formulation of a theory of mental activities but comparing mental activities with computer programs are not very correct.

The hardware that runs these programs (mental activities vs. computer programs) are made up of different materials.

Also computer OS can run on several machines in the same way, but the same is not true for mental activities

Mind and Brain

It is not wholly correct to state the mind and brain as comparable to ***hardware and computer programs***. Some times repetitive programs are converted into electrical circuits (hardware) which perform the same functions as software program but the same cannot be done with brain and mind.

The true distinction between brain and mind can only be understood by examining it through various **levels of analysis**. For e.g., Computer can both be described in terms of its physics (electrical circuits) and OS (software). Similarly for decoding any mental process we need information about its functions as well as the structures that lead to this process. For e.g., Emotions

Mental Representations

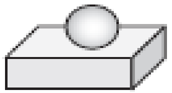
All mental activities are about something – a job choice, a friends face, thoughts about your summer holidays etc. Cognitive psychologists try to understand how information is stored is internally represented.

a representation is a physical state (marks on page, neural connection in the brain, magnetic fields in computers) that conveys information specifying an object, event or category or its characteristics. They have 2 important facets –

- **(a) form –** *the format of conveying information*
- **(b) content** – *the meaning conveyed by the representation*

Mental Representation

"A BALL IS ON A BOX"

Description (Propositional Representation)	Depiction (Quasi-Pictorial Representation)
ON (BALL, BOX)	
1. Relation (e.g., ON)	1. No distinct relation
2. Argument(s) (e.g., BALL, BOX)	2. No distinct arguments
3. Syntax (rules for combining symbols)	3. No clear syntax
4. Abstract	4. Concrete
5. Does not occur in spatial medium	5. Occurs in spatial medium
6. Arbitrarily related to represented object	6. Resemblance used to convey Information

The same content can be represented either by descriptions (abstract, language-like propositional representations) or depictions (picture-like representations). Some of the differences between the two types of formats are listed. A "relation" specifies how entities are combined, and an "argument" is an entity that is affected by a relation.

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Mental Processing

In order to understand how representations work we need to understand the process that operate on them.

A ***process*** is a transformation of information that obeys well-defined principles to produce a specific output when given a specific input.

A ***processing system*** is a set of processes that work together to accomplish a type of task, using and producing representations as appropriate.

An ***algorithm*** is a step-by-step procedure that guarantees that a certain input will produce a certain output.

Why study the Brain?

Turning to the brain helps us to grapple with the challenge of identifiability.

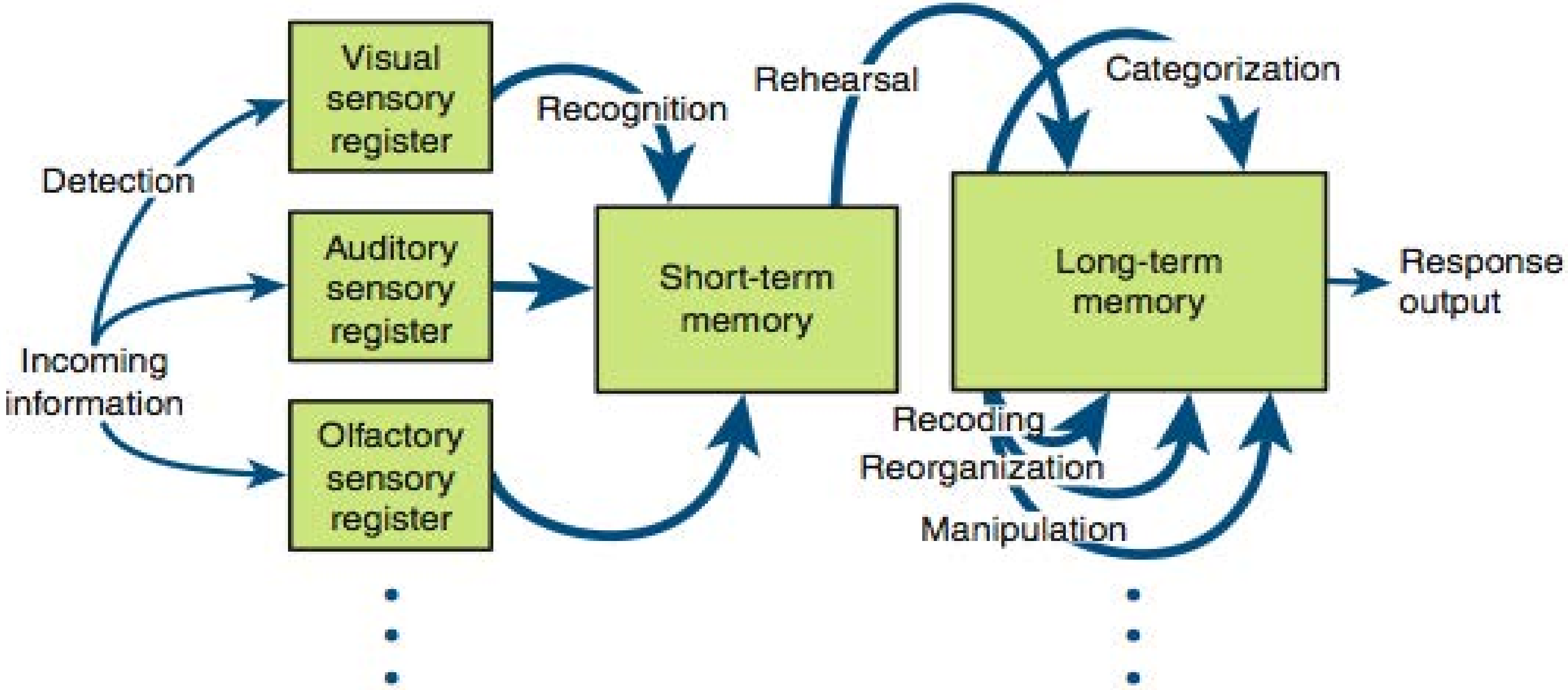
Identifiability refers to the ability to specify the correct combination of representations and processes used to accomplish a task.

Facts about the brain can help us test the ***adequacy*** of a theory, which lets us know whether a theory is—to that point—valid.

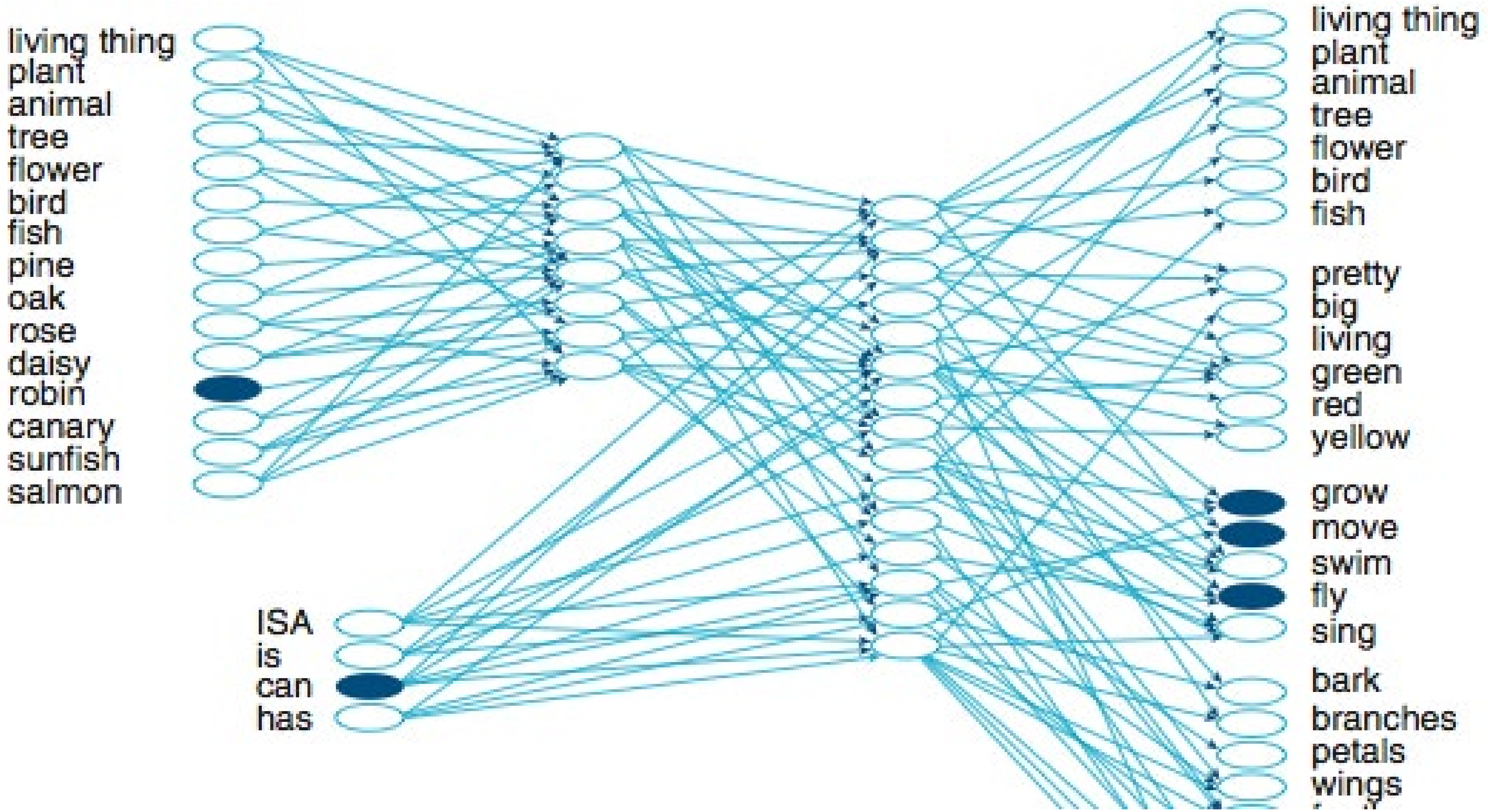
Paradigms of Cognitive Psychology

- What is a paradigm?
  - Body of knowledge structured according to what its proponents consider important and what they do not
    - Assumptions made by investigators
    - Appropriate types of research methods
    - Appropriate questions for the field
    - Appropriate analogies

The Information Processing Approach



Connectionism



The Evolutionary Approach

- Human beings have specialized areas of competence produced by our evolutionary heritage
- The environment that shapes us is not only physical, but also ecological and social

The Ecological Approach

- All cognitive activities are shaped by the culture and by the context in which they occur
- Focus on studying cognition in everyday contexts

Perception: Making Meaning of Sensations

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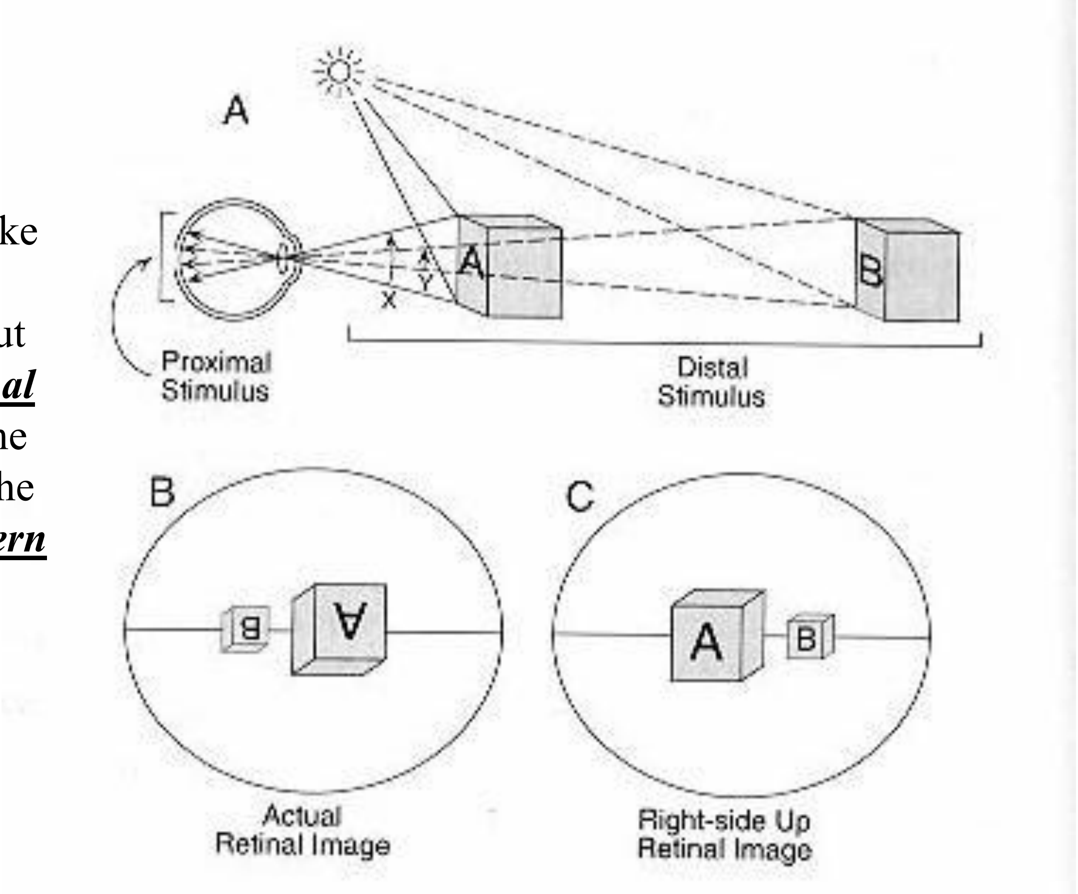
Object Perception and Pattern Recognition

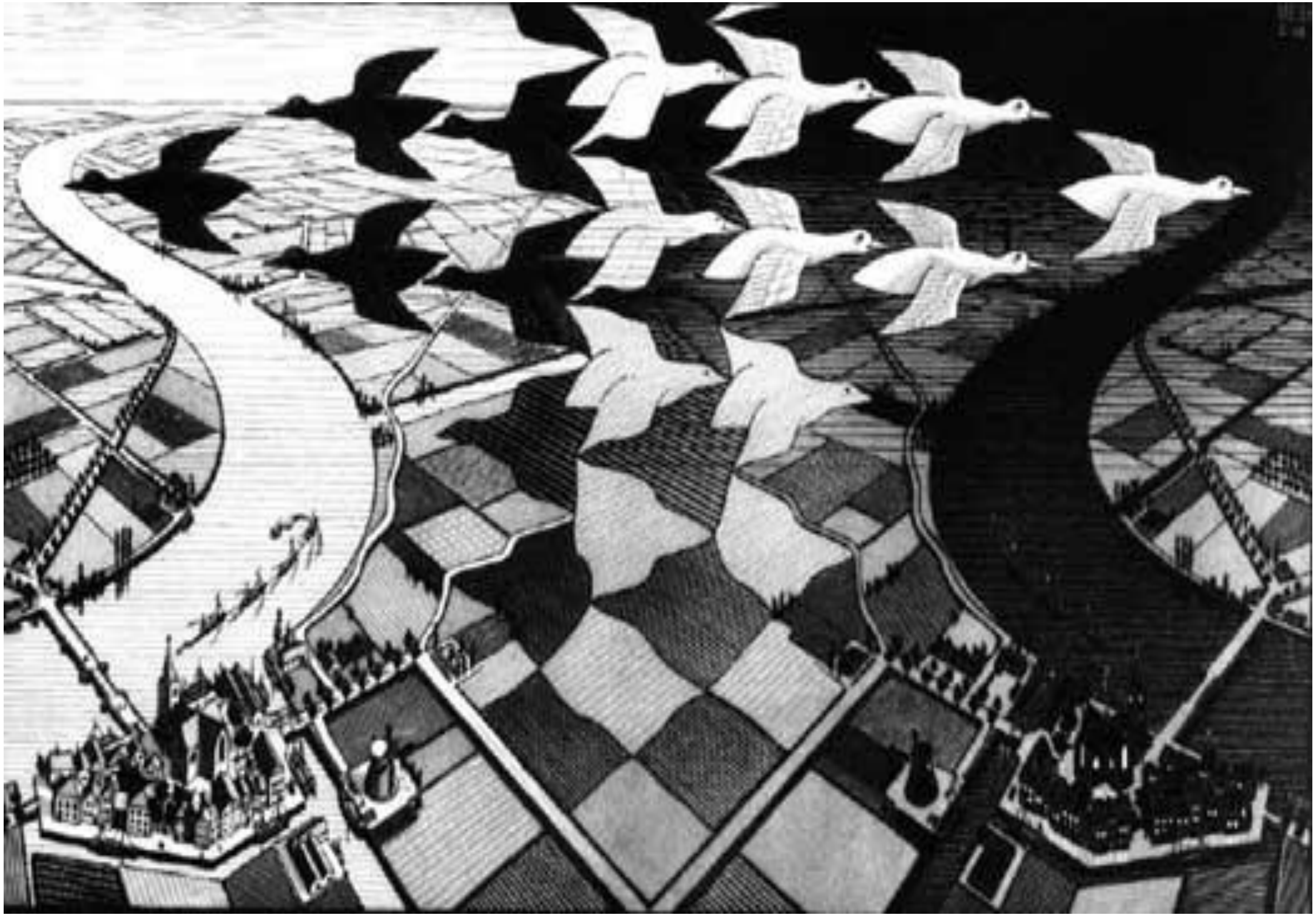
The process via which sensory inputs are gathered and meaningfully interpreted is called perception. There are several forms of perception. When we look at an object we acquire specific bits of information about it (location, kolor, shape, texture etc).

Is it true that we also at the same time when we perceive an object we also acquire information about its function?

Classical approach to perception

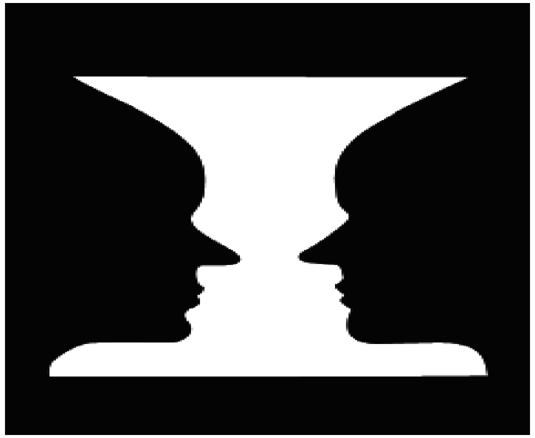
Each of the objects/events in the real world like trees, books etc are ***distal stimulus***. The reception and registration of information about such o/e by sense organs make up the ***proximal stimulus***. The meaningful interpretation of the proximal stimulus is the ***percept.*** Related to the process of perception is a process called ***pattern recognition*** – which is the recognition of a particular o/e as belonging to a class of o/e.





Gestalt Approach to Perception

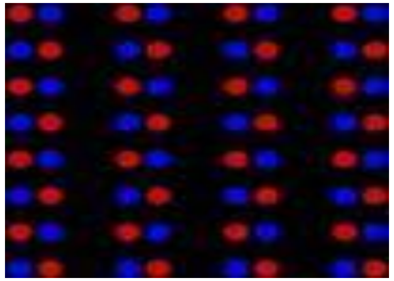
Gestalt approach interprets visual perception as how interpretation of stimulus arrays are done as ***objects*** and ***backgrounds***. For example the figure show two distinct percepts: a white vase against a black background / two silhouetted faces against a white background. This whole segregation of the whole display into objects (figure) and the background (ground) is called ***form perception***. The part of the display seen as figure is seen to have a definite shape and is better remembered than the ground which is less formed and shapeless. Form perception happens as we assume intuitively that we perceive objects and ground because they really are so and we merely perceive them



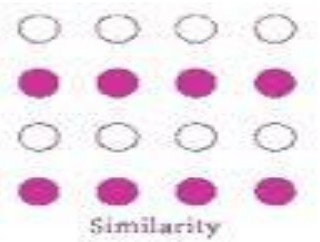
The gestalt psychologists believed that perceivers follows certain laws or principles of organization in coming to their interpretations The first assumed that ***the whole (gestalt) is not the sum of its part.***

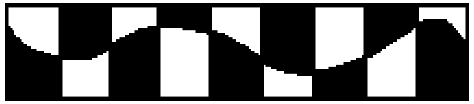
Gestalt principles of perceptual organization – there are five major principles

a) *Principle of proximity or nearness – this principle allows us to group together things that are nearer to each other.*



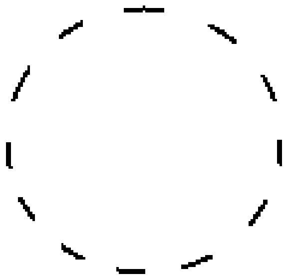
b) ***Principle of similarity*** *– allows us to group together objects that are similar*

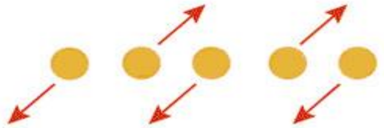




c) ***Principle of good continuation*** *– states that we group together objects whose contours form a continuous straight or curved line*

d) ***principle of closure*** *– allows us to see images as complete by mentally filling the gaps in the image*





e) *Principle of common fate – allows us to depict elements that move together to be grouped together*

Law of Pragnanz (Koffka, 1935) *– is a general principle of gestalt that houses all the other principle. It states that of all the possible ways of interpreting a display, the organization that yields the most simplest and stable shape or form is the one that is selected to interpret the element in question.*

Limitations of Gestalt approach

a) *There is no explanation how these principles are translated into cognitive/physiological processes*

b) The law of pragnanz seems to be circular (if additional specification is not given)

Bottom-Up Processes of Perception

The term bottom up (data driven) essentially means the perceiver starts with small bits of information from the environment that he combines in various ways to form a percept.

example: a bottom up process of perception and pattern recognition might describe you seeing edges, rectangular and other shapes and certain lighted regions and putting this information together to "conclude" you are seeing doors and a hallway.

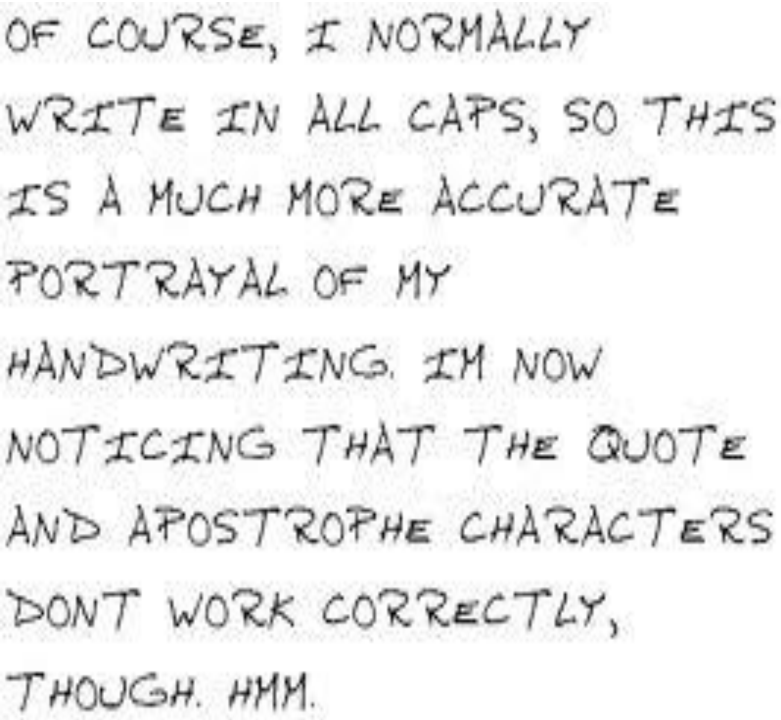
Picture = depth + figure + ground + texture + semicircular arch + semi circular block (door) like + ..

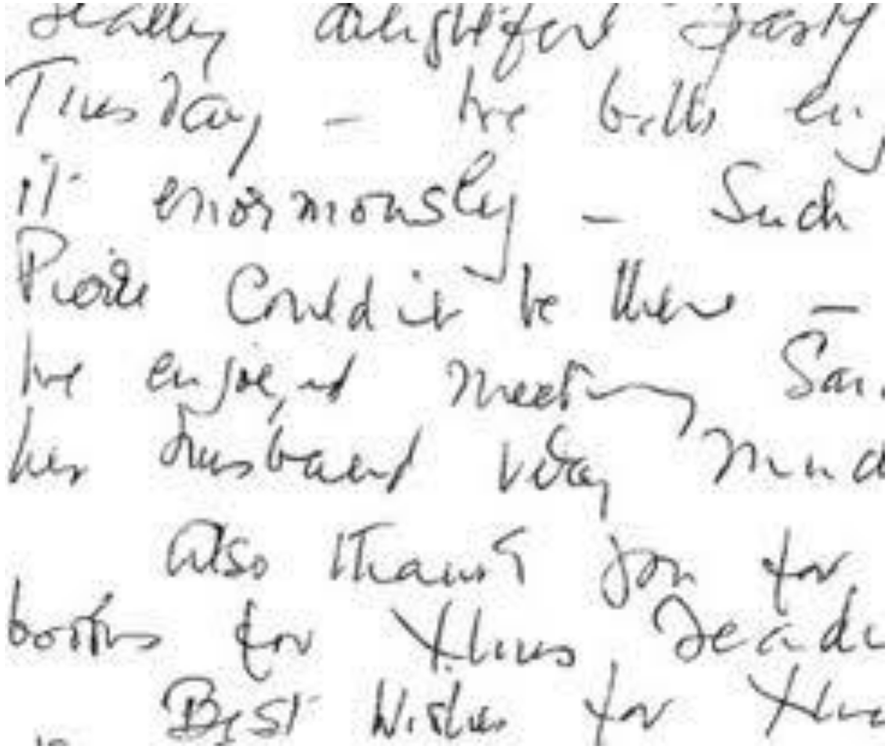
Template Matching – Every event, object or stimulus that we want to derive meaning from is compared to some previously stored pattern or template. The process of perception in *template matching* thus involves comparing incoming information to the templates we have stored and looking for a match.

Limitations: a) requires a huge database to compare from

b) recognition of new objects

c) people recognize many patterns as more as less same thing

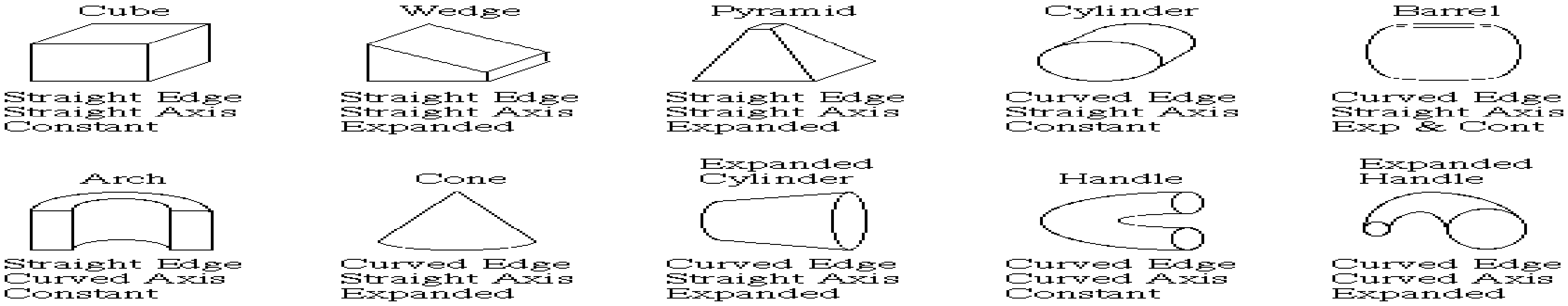




Featural Analysis – Instead of processing stimuli as whole units, we might instead break them down into their components, using our recognition of those parts to infer what the whole represents. The parts searched for and recognized are called *features*. Recognition of a whole object in this model depends on recognition of its features.

Support for FA model: Studies done on retinas of frogs using microelectrode recording of single cell revealed that certain stimulus caused these cells to fire more rapidly then certain others. Certain cells responded strongly to *borders between light and dark* were called *edge detectors,* while certain other cells responded *selectively to moving edges* were called *bug detectors.*

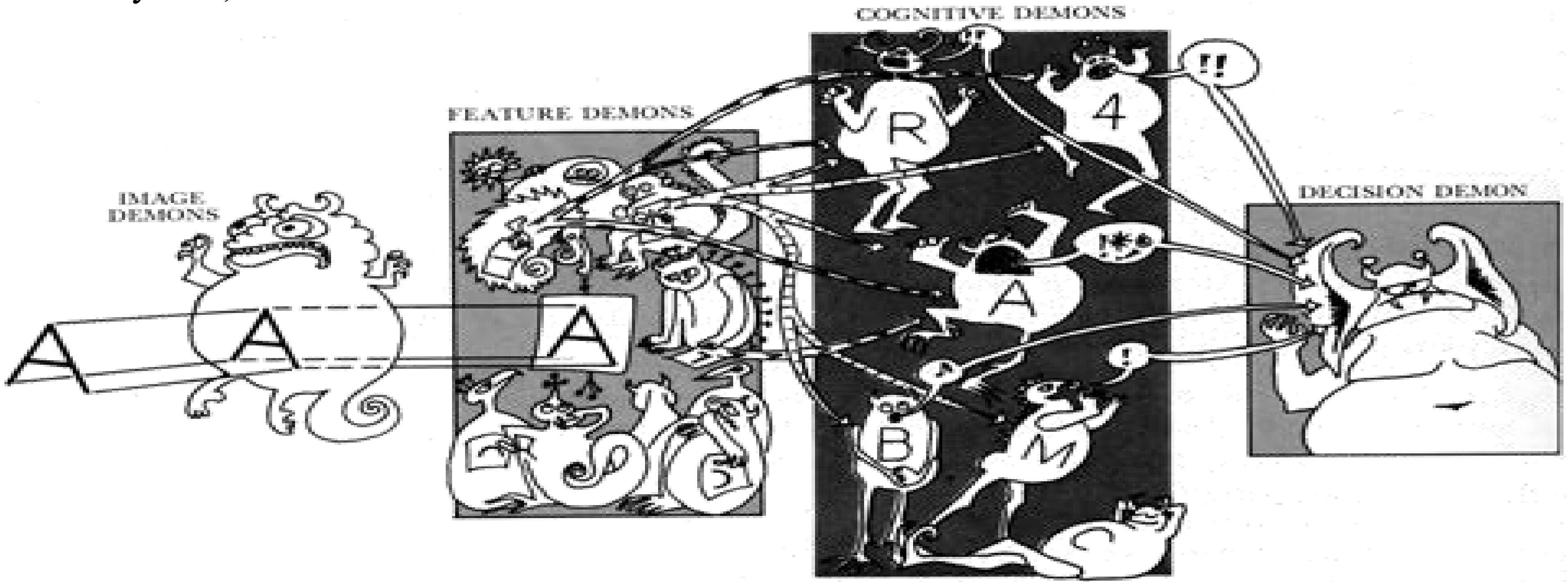
Irving Biederman's (1987) theory of object perception – proposes that when people view objects they segment them into simple geometric components like *geons*. Biederman proposed a total of 36 such primitive components.

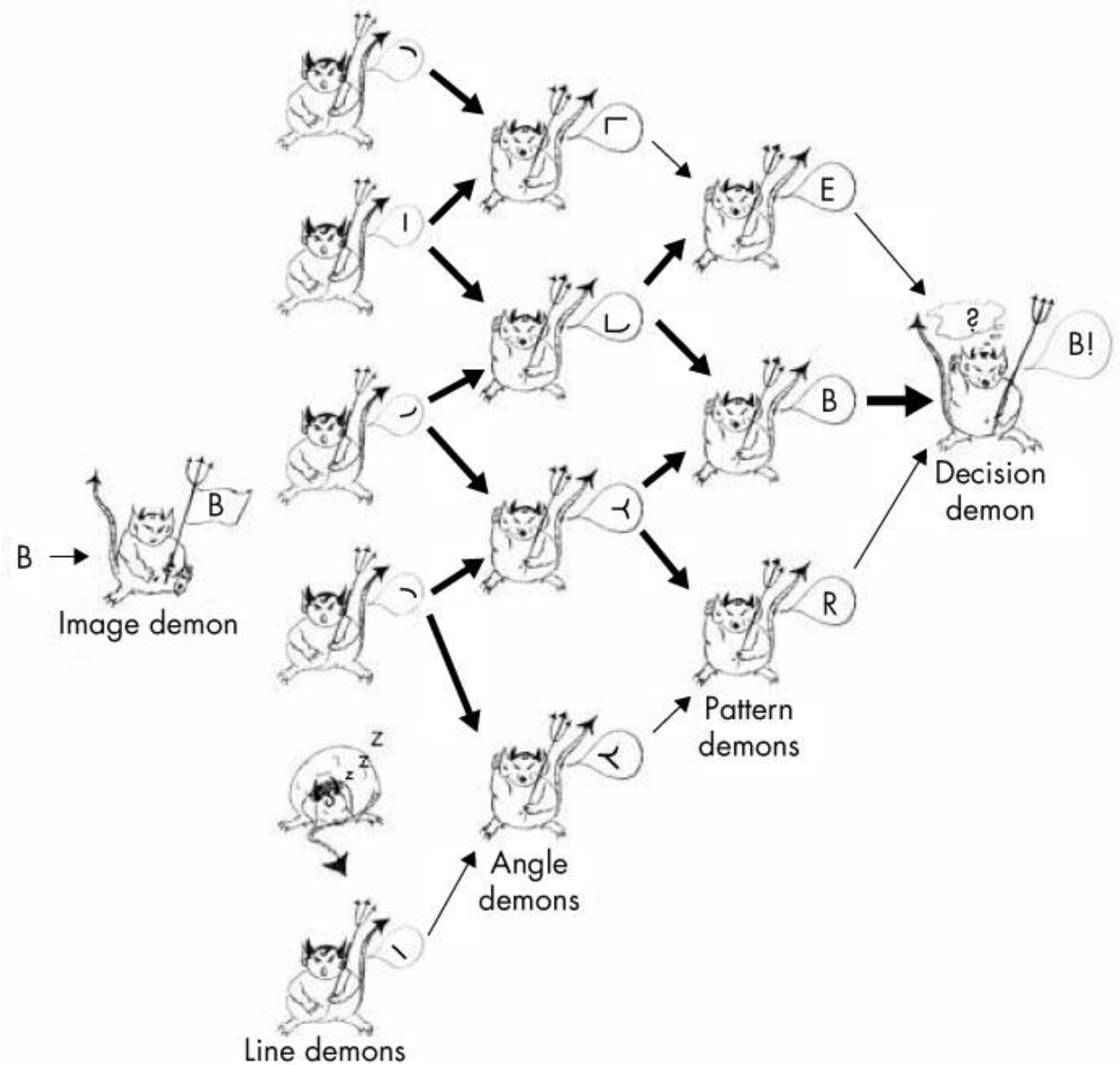


Biederman makes an analogy between his theory of object perception with speech perception using *phonemes* (which are 44 in number and are the basic unit of sound like /tS/ as in *ch*air). As an evidence to this theory Biederman offers the case of any fictional object that non of us has seen but can try to decipher its parts with considerable agreement

Support for the featural theory also comes from the works of Eleanor Gibson (1969) which proved that people are more likely to confuse with G & C then with G & F as G & C share the same features of curved line open to the right.

Sefridge (1959) – *Pandemonium model* – consists of number of different kind of *"demons"* which function basically as feature detectors. *Demons* at the bottom level (first) of processing scan the input and *demons* at higher levels scan the output from the lower level *demons*. In response to what they find, the demons *scream.*




B
B
Image demon
E
B
R
B!
?
Decision
demon
Pattern
demons
Angle
demons
Line demons

Limitations of FAM – FAM suffers from the following shortcomings

a) There is no good definition of what can and cannot be a feature except the restricted domain of perception of letter / line drawings

b) If there are different sets of features for different objects, how does the perceiver know which ones to use to perceive an object

Prototype Matching – explains perception in terms of matching an input to a stored representation of information as do template models. In this case, however the stored representations , instead of being a whole pattern that must be matched exactly or closely, is rather a *prototype* – an idealized representation of some class of objects or events – the letter *M*, a cup, a CAR etc.

According to prototype matching model – when a sensory device registers a new stimulus, the device compares it with previously stored prototypes. An exact match is not required, only an approximate match is expected. Prototype matching models allows for discrepancies between the input and the prototype. An object is *perceived* when a match is found

Where do prototypes come from?

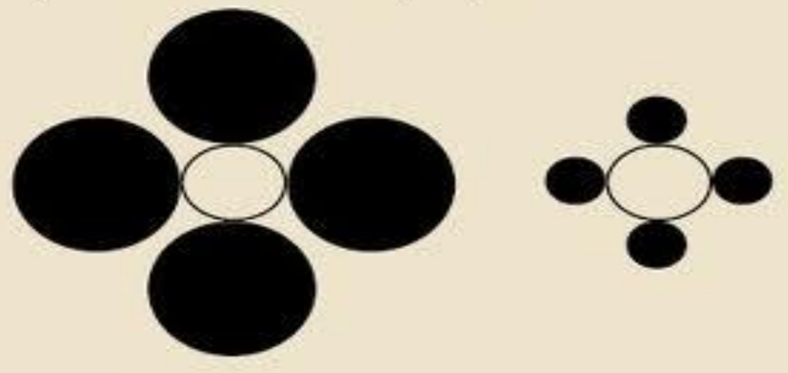
Posner & Keele (1968) demonstrated that people can form prototype very quick. They found that people during an initial classification task, from some sort of mental representation of each class of items.

Top-Down Processes

*In **top-down processing** (also called **theory-driven** or **conceptually driven** processing) the perceivers expectation, theories or concepts guide the selection and combination of the information in the pattern recognition process. (for example)*

You know from experience that archways generally mark alleys. When you look down the alley and see it blocked in black you mostly expect a closed door etc………….

Figure 3. Effect of context on perception of size



The context in which patterns or objects appear apparently sets up certain expectations in the perceiver as to what objects will occur. Both accuracy and the length of time needed to recognize an object vary with the context.

Top-down or conceptually driven processes are directed by expectations derived from context or past learning or both.

David Marr – presented a computational and most elegant model of perception which involves both the bottom up and top down process. According to this model visual perception proceeds by constructing three different mental representations

a) ***primal sketch*** – *depicts areas of relative brightness and darkness in a 2D images as well as localized geometric structures. This helps in* ***boundary detection***

b) ***2 ½ D sketch –*** *using cues such as shading, texture edges and others the viewer derives* ***what the surfaces are*** *and how they are positioned in* ***depth*** *relative to the viewers vantage point*

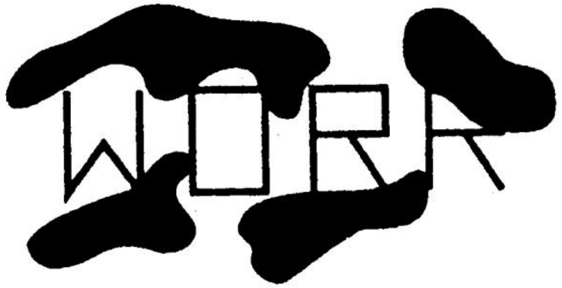
c) ***Final 3D sketch –*** *involves both recognition of what the objects are and understand the meaning of the visual scene*

<u>Perceptual Learning</u> – perception changes with practice has been well documented (E. J. Gibson, 1969), and this phenomenon is called ***perceptual learning.*** (Gibson’s original experiment with round coil cards). Making individuals practice more with perceptual stimuli’s enable them to learn what aspects of the stimulus to attend to and try harder to consciously distinguish between different kinds of stimuli. Using top-down processing the perceivers experience guides him in selecting the most optimal features to for more information

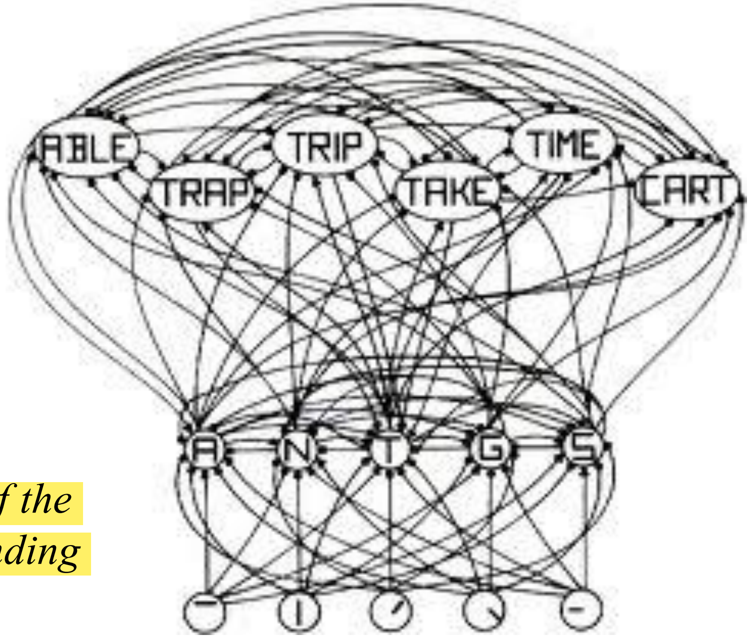
<u>Change Blindness</u> -

Change blindness *– (Rensink, 2002) is the inability to detect changes to an object or scene, especially when given different views of that object or scene and it illustrates the top-down nature of perception. The change blindness paradigm reinforces the idea that perception is driven by expectations about meaning. Instead of keeping track of every visual detail we instead seem to represent the overall meaning of the scene.*

The word superiority effect – *word superiority effect or word advantage advances that letters are apparently easier to perceive in familiar context (a word) then in an unfamiliar or no context environment.*



Connectionist model of word perception – *the model assumes that input (written, spoken, thought) is processed at several different levels, whether in terms of features, letters, phonemes or words. Different levels of processing feed into one another, with each level of processing forming a representation of the information at a different level of abstraction., with features considered less abstract then letters and letters less abstract then words.*



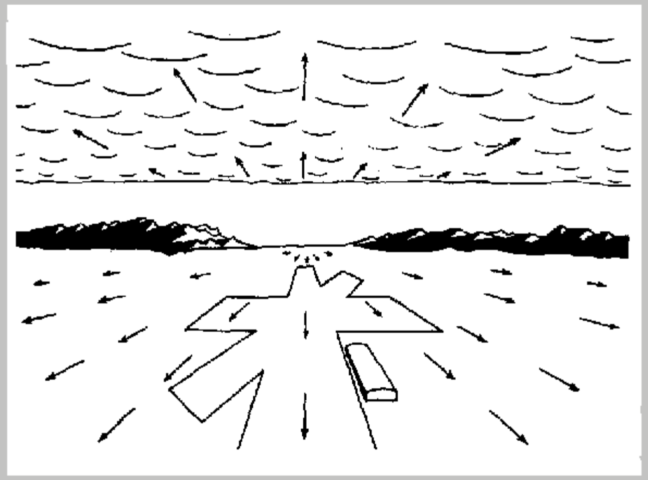
According to this model – *perception of a word (activation of the relevant node for the word) also activates the nodes corresponding to all the letters within the word thereby facilitating their perception*

Direct Perception

Top-down and bottom down processes of perception believe that the perceiver does something to the proximal stimulus for perception to proceed. This happens presumably because the proximal stimulus doesn’t contain all the information we need to identify the object. This idea is called the ***constructivist approach to perception.*** *It describes people as adding to and distorting the information in the proximal stimulus to obtain a percept.*

James Gibson (1979) et.al., adopted an opposite view to the connectionist approach and believed the perceiver does very little work in perception mainly because the word offers so much information leaving little need to construction percepts and draw inferences. This view is called ***Direct Perception***. *According to this view the light hitting the retina contains highly organized information that requires little or no interpretation. In the world that we live in, certain aspects of stimuli remain invariant despite changes over time or in our physical relationship to them.*

Gibson became convinced that patterns of motion provide a great deal of information to the perceiver. His work with pilots in WWII led him to develop the idea of *optic flow* as the visual array presented to a pilot approaching the runway for landing. The arrows represent perceived movement (apparent motion of clouds, grounds etc wrt the pilot). There is a texture in the motion namely nearer things appear to move faster and direction in which objects seem to move depends on the angel of plane motion in relation to them. These information are used by the pilot to land the plane



idealised flowfield (after Gibson, 1950)

For Gibson the central question of perception is not how we look at and interpret the stimulus array but how we see and navigate among real things in the world. An important ideal of Gibson's theory is that information available to an organism exists not merely in the environment but in an animal-environment ecosystem.

Organisms directly perceive not only shape and whole objects but also each objects ***affordance's – the acts or behaviors permitted by objects, places and events*** *(e.g. chair affords sitting, door knob affords grasping, a glass window – looking etc)*

Attention: Mental Concentration at Play

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Attention

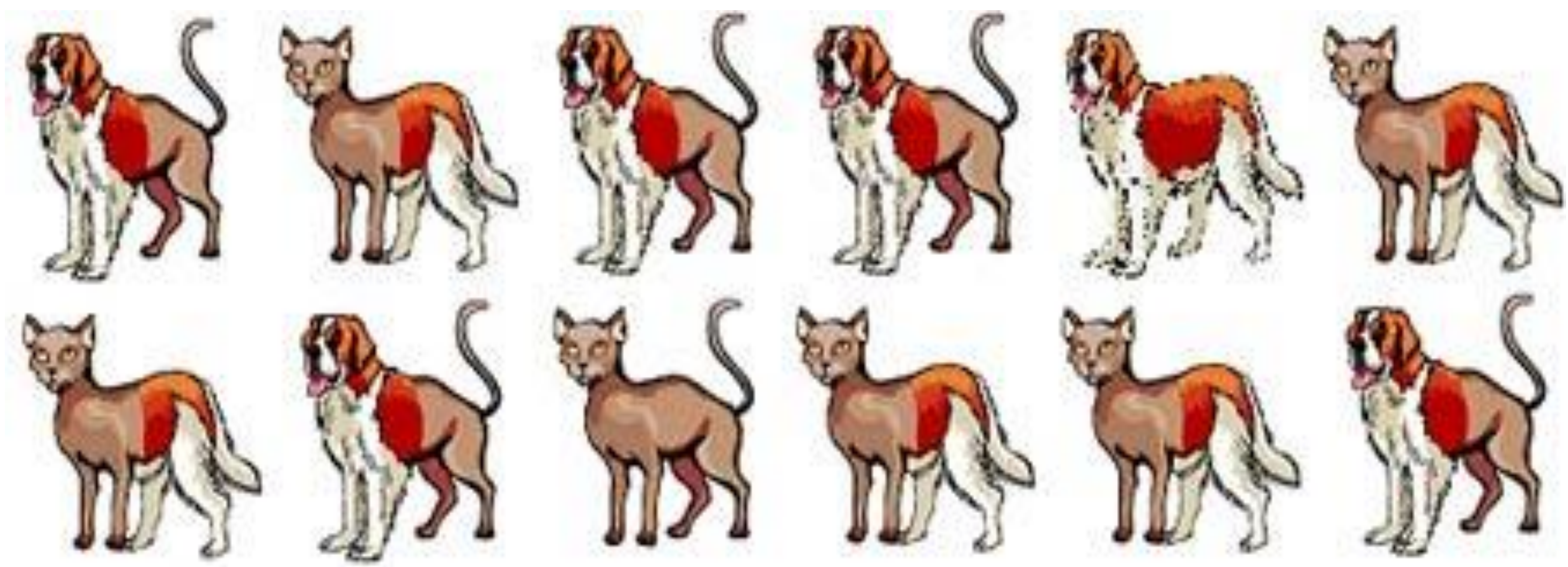
The study of attention concerns primarily the cognitive resources and their limitations. At any given time people have only a certain amount of mental energy to devote to all the possible tasks and all the incoming information confronting them. *Attention is sometimes synonymously used with mental concentration*.

Does people's concentration level change with practice ?

Selective Attention

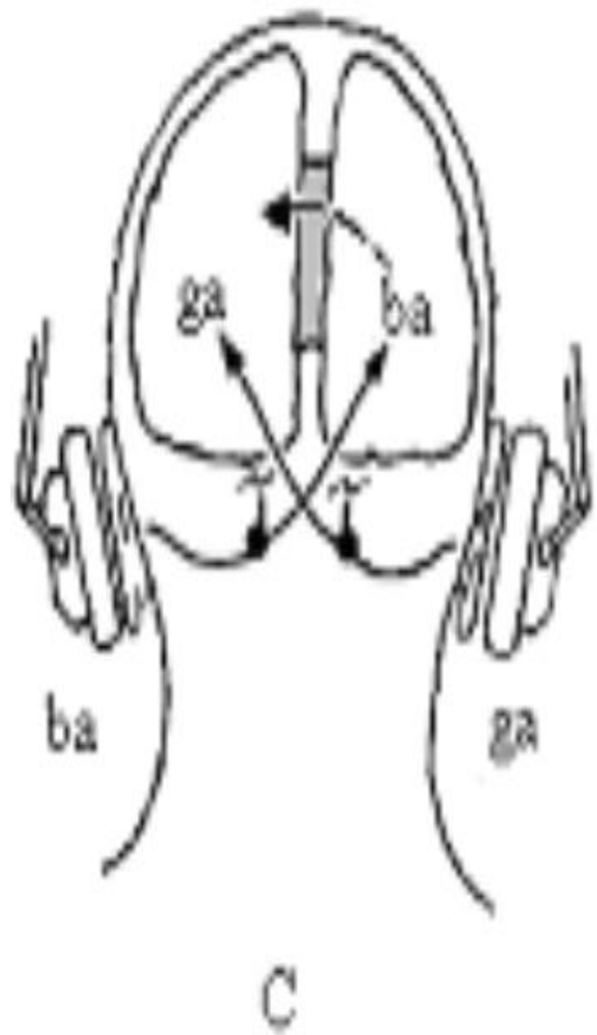
The term selective attention refers to the fact that we usually focus out attention on one or a few tasks or events rather than on many. We mentally focus our resources implies that we shut out (or atleast process less information from) other competing tasks. As attention researcher Hal Pashle puts it

at any given moment [people's] awareness encompasses only a tiny proportion of the stimuli impinging on their sensory systems



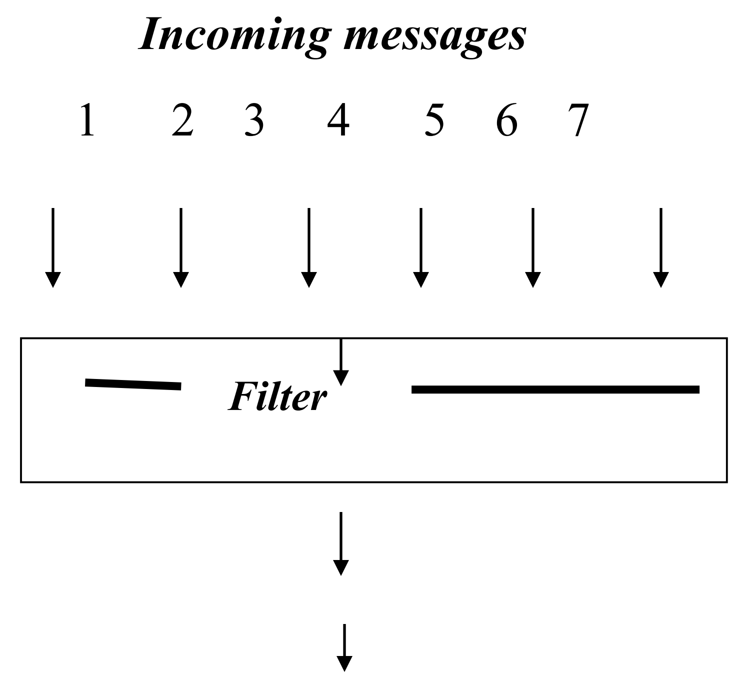
Selective attention requires that we focus attention more actively on some stimuli than on others. This being the case what happens to other information's. In order to study this cognitive psychologists found a solution in the ***dichotic listening task***

DLT – involves a listener listening to audiotapes over a set of headphones. On the tapes are ***different messages recorded*** *so as to be* ***heard simultaneously in opposite ears****. The participant is asked to* ***shadow – "repeat aloud"*** *one of the messages. Information in the messages are typically presented at a* ***rapid rate (150 wpm)*** *requiring the shadowing to be demanding. At the end of the task the participants are asked to reveal what information they have gathered from the messages.*



Filter Theory

To explain the findings of DLT Broadbent (1958) proposed the ***filter theory*** of attention which states that there are **limits on how much information a person can attend** to at any given time. If the information available at any given time exceeds capacity, the person uses an attentional filter to let some information through and block the rest. *The filter theory is based on some **physical (basic acoustic in case of DLT)** aspect of the attended message (location, pitch, loudness etc)*



Filter theory explains why so little of the meaning of the unattended message can be recalled: *The meaning from the unattended message is simply not processed.*

Does this imply that people can never pay attention to two messages at once ?

Broardbent (1958) proposed that two messages that contain little information or that information slowly can be processed simultaneously.

*Moray (1959) discovered the "**Cocktail Party Effect**": **shadowing performance is disrupted** when **one's own name** is embedded in either the attended or the unattended ear. This happened as "**important materials**" can penetrate the filter setup to block unattended messages. Pashler (1998) however reported - that when not cued in advance to be vigilant only 33% people ever noticed their names in DLT proving that shadowing in "**Filter theory**" does not always take 100% of ones attention.*

*Anna Treisman (1960) conducted a **ear switching experiment** with the messages and found the **subject reported one or more words from the unattended ear.** Treisman explained this deviation of filter theory by assuming that the **participants were attending the messages, in part, based on their meaning**.*

*Similar experimentation by **Wood & Cowan (1995) and Conway, Cowan & Bunting (2001)** resulted in showing the messages from the unattended ear was also processed thus challenging the "**Filter Theory**"*

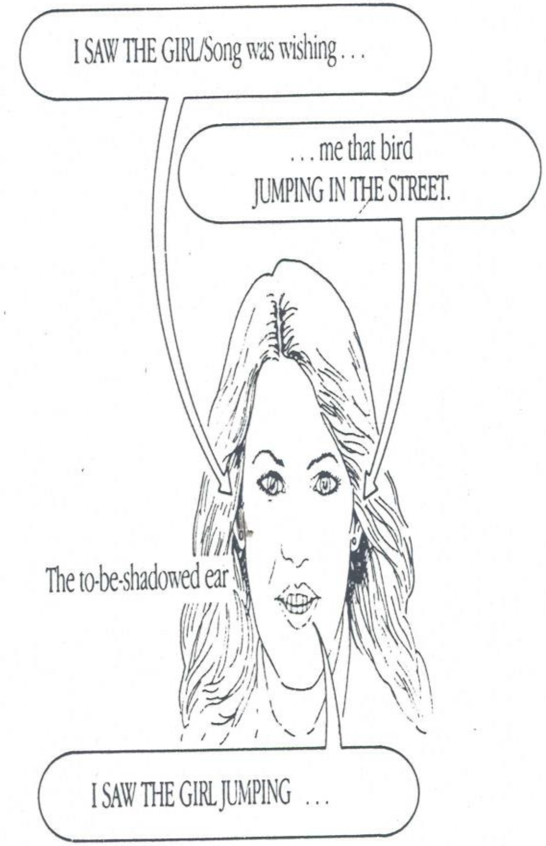


FIGURE 3.3: An illustration of the Treisman experiment. The meaningful message moves to the other ear, and the subject sometimes continues to shadow it against instructions. (Adapted from R. L. Klatzky, *Human memory*, 1st Edition, W. H. Freeman and Co. Copyright 1975.)

Attenuation Theory – Anna Treisman (1960) proposed a modified filter theory of attention which she called ***"Attenuation Theory"***. The theory proposes that instead of being completely blocked away the messages from the unattended ear is processed for meaning with a *"**turned down volume**"*. Her theory can be explained as follows:

Incoming messages are subjected to three kinds of Analysis. Some meaningful units (words of importance) are processed quite easily (e.g., one name, Fire, Watch Out etc). Also the context of the word may also lower its threshold (e.g., The Dog Chased the …. The word Cat is Primed).

Treisman (1964) believes that people process only as much as is necessary to separate the attended from the unattended message

Incoming Messages

Level 1 Analysis

Physical Properties (Pitch, Loudness)

Level 2 Analysis

Linguistic (Parsing as syllables + words)

Level 3 Analysis

Semantic (meaning of messages)

Late Selection Theory – Proposed by Deutsch & Deutsch (1963) and later modified by Norman (1968) the theory holds that

*all messages are **routinely processed for at least some aspects of meaning** – that selection of which response to attend to happens **"late"** in processing. In continuation with the "**Filter Theory**" this theory also describes a "bottleneck" but locates it later in the processing, after certain aspects of the message is extracted.*

*A messages "**importance" depends on many factors**, including its **content and the personal significance** of certain kinds of content (name). Also relevant is the **observer's level of alertness**. At low levels of alertness (sleep) only important messages are processed (new born crying) where as the opposite is true for high level of alertness (television program too gets processed !!!)*

Multimode Theory – Johnston & Heinz (1978) proposed the ***"multimode model"***. In their view

attention is flexible system that allow selection of one message over others at several different points. They described three stages of processing.

When messages are selected on the basis of Stage 1 processing (early selection) less capacity if required then if selected on the basis of Stage 3 (late selection) which makes it harder

<u>Stage 1</u>

Sensory representation constructed

<u>Stage 2</u>

Semantic representation constructed

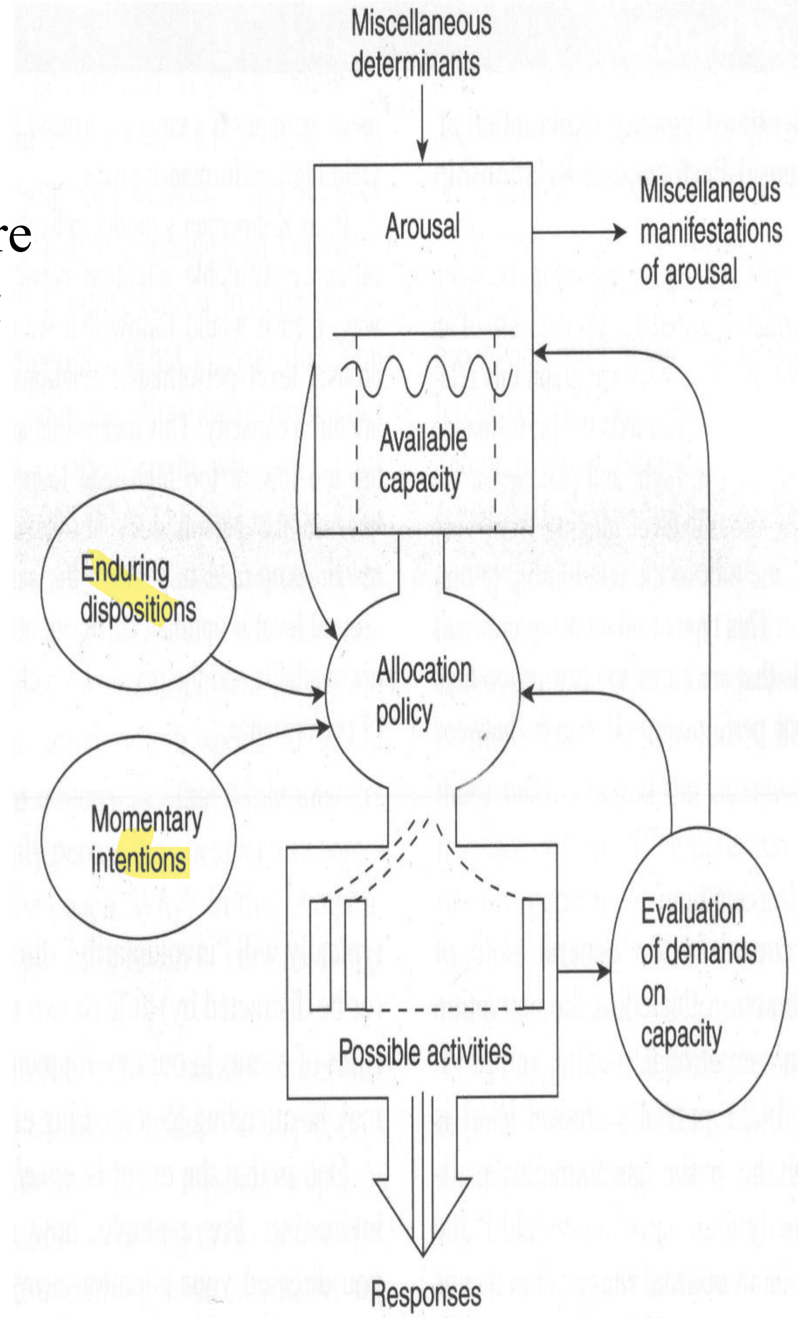
<u>Stage 3</u>

Semantic + Sensory representation enter consciousness

Kahneman's Model of Attention – Daniel Kahneman (1973) proposed a model which viewed attention as set of cognitive processes for categorizing a recognizing stimuli. The more complex the stimulus the harder the processing and therefore more resources are engaged.

Essentially this model depicts the allocation of mental resources to various cognitive tasks. This allocation depends on the extent and type of mental resource available. The availability of mental resource in turn depends on the level of arousal/alertness. Level of arousal however may be controlled by task's difficulty.

*The **allocation policy** in the model is affected by the individuals enduring dispositions, momentary intentions and evaluation of demands on one's mental capacity.*

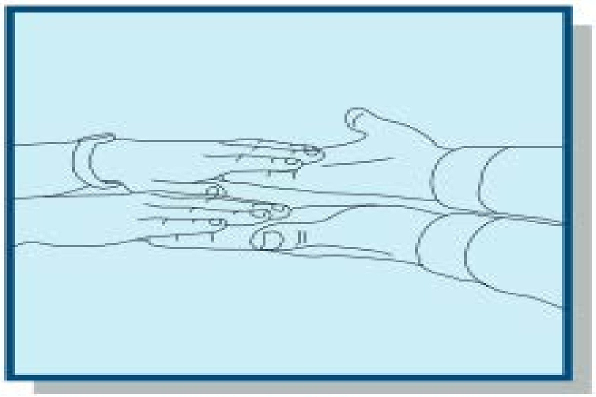


Schema Theory of Attention –

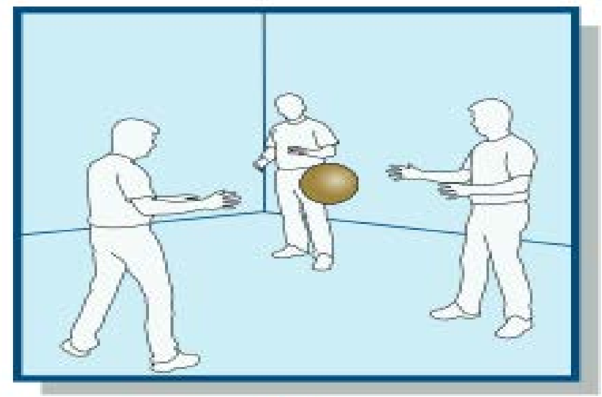
Ulric Neisser (1976) offered a very different conceptualization of attention called ***Schema Theory.***

he argues that we don't filter, attenuate or forget unwanted materials. ***Instead we never acquire it in the first place****.. Attention is like apple picking – the messages we attend to are like apples picked from the trees and the unattended are those left behind on the tree. To call the left behinds as filtered/attenuated is ridiculous.*

Neisser and Becklen (1975) study



(A)



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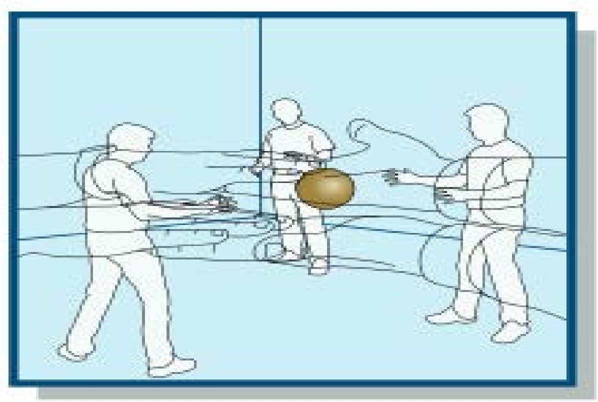


(C)

Inattentional blindness

Automaticity and the effects of practice

As we become well practiced doing something, that act takes less of our attention to perform. A good example is typing. If one is skilled at typing he can carry out typing fairly accurately and quickly and also carry out conversation with someone besides

What effects the capacity any given task require ?

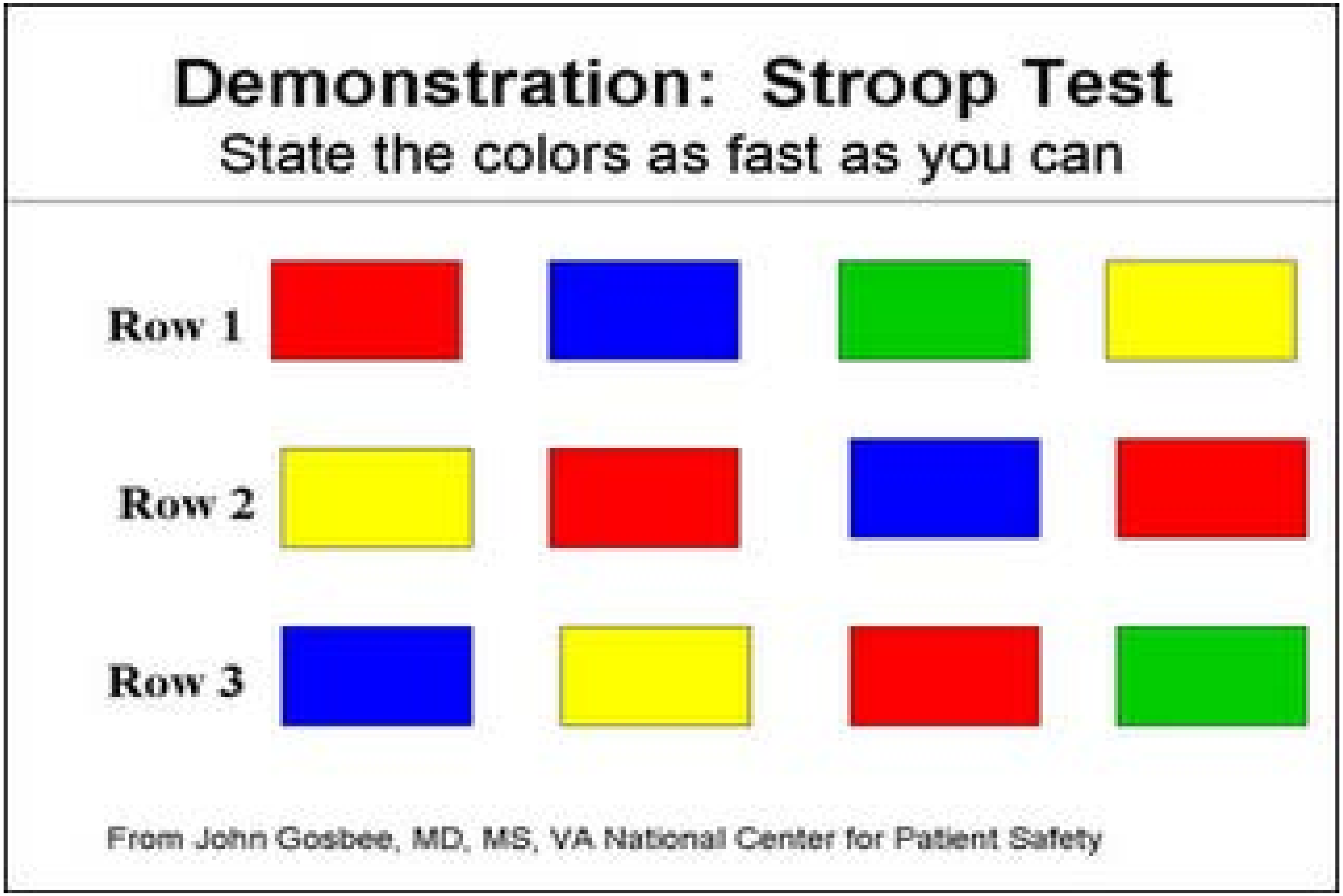
The answer to the above question can have two factors

(1) Task Difficulty

(2) Individuals familiarity with the task

Practice is believed to decrease the amount of mental effort a task requires thus making it automatic

The Stroop Task – John Ridley Stroop (1935) used a famous demonstration to show the effects of practice on the performance of cognitive tasks



Now state the colors as fast as you can

Row 1	**Red**	**Blue**	**Green**	**Yellow**
Row 2	**Yellow**	**Green**	**Blue**	**Red**
Row 3	**Green**	**Red**	**Yellow**	**Blue**

From John Gosbee, MD, MS, VA National Center for Patient Safety

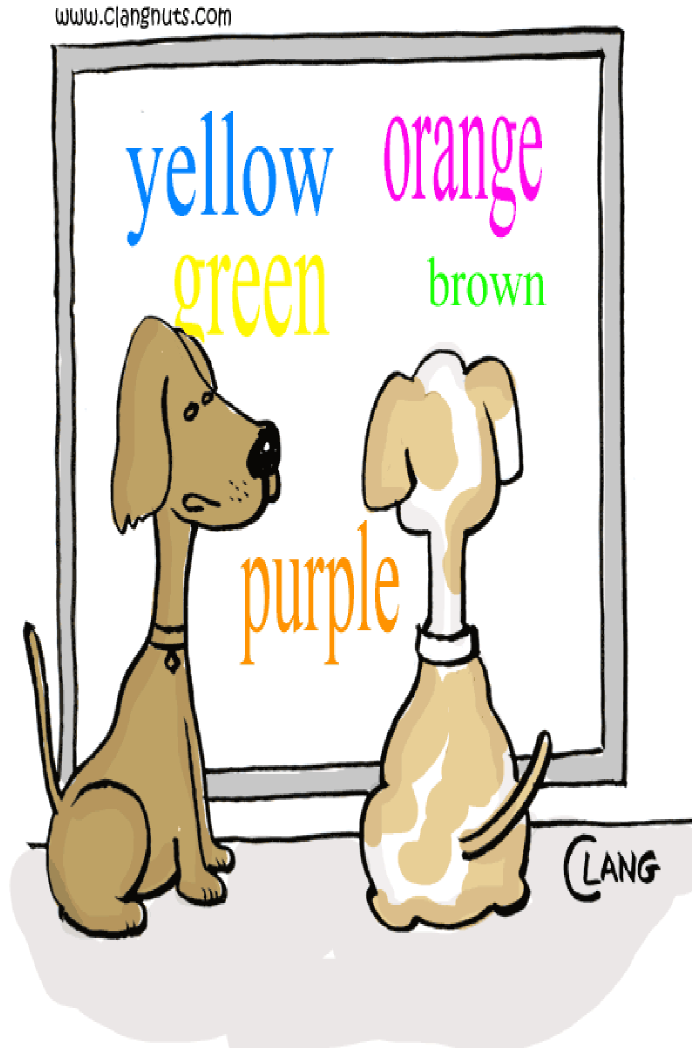
Again, state the colors as fast as you can

Row 1	Red	Blue	Green	Yellow
Row 2	Yellow	Green	Blue	Red
Row 3	Green	Red	Yellow	Blue

From John Gosbee, MD, MS, VA National Center for Patient Safety

Stroop task presents participants with a series of kolor bars (red, blue, green) or kolor words (red blue green) printed in conflicting kolors (the word red for example may be printed with green ink). Participants were asked to name as quickly as possible, the ink kolor of each item in the series.

*According to Stroop (1935) the difficulty stems from the following: Adult literate participants have had so much practice reading that the task requires little attention and is performed rapidly. Thus when confronted with items consisting of words participants couldn't help reading them. This type of response –one that takes little attention and effort and is hard to inhabit – as "**automatic**"*



...for some reason humans find these stroop tests really tricky!

What exactly does it mean to perform a task automatically?

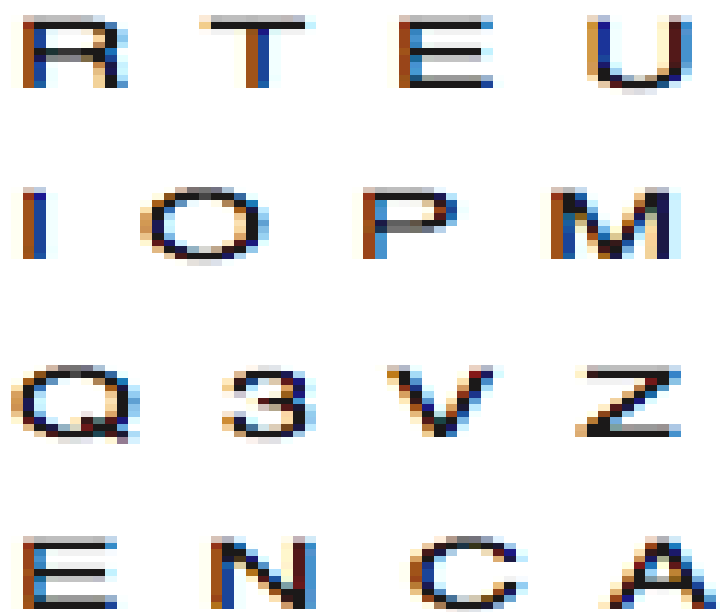
*Snyder & Posner (1975) offered three criteria for cognitive processing to be called“**automatic processing” -***

*a) it must occur without “**intention”***

*b) it must occur without involving “**conscious awareness**”*

*c) it must not interfere with “**other mental activity**”*

A single number "pops out" against a background of letters, no matter how many letters are in the array.



What role does attention and automaticity play in perception?

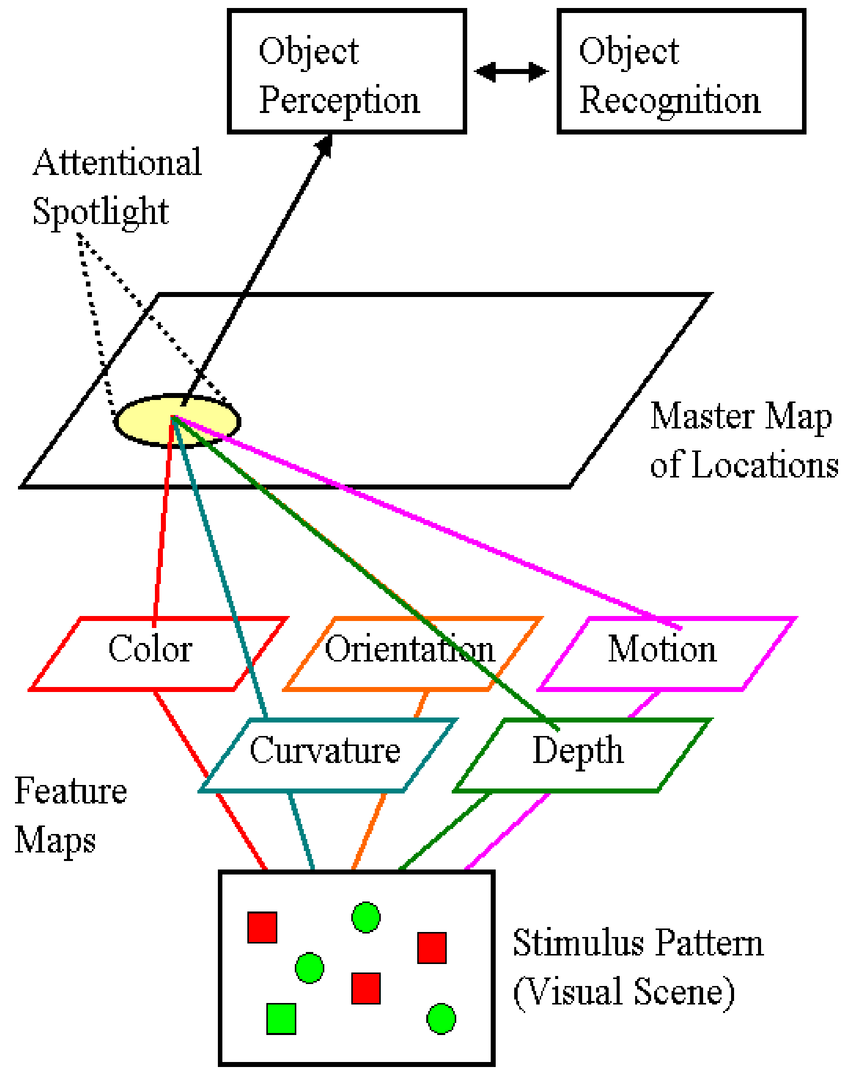
*Anna Triesman investigated this question and came up with the "**feature integration model**". The model proposes that we perceive objects in two distinct stages*

*a) **pre attentive/automatic** – we register features of objects (kolor, shape etc)*

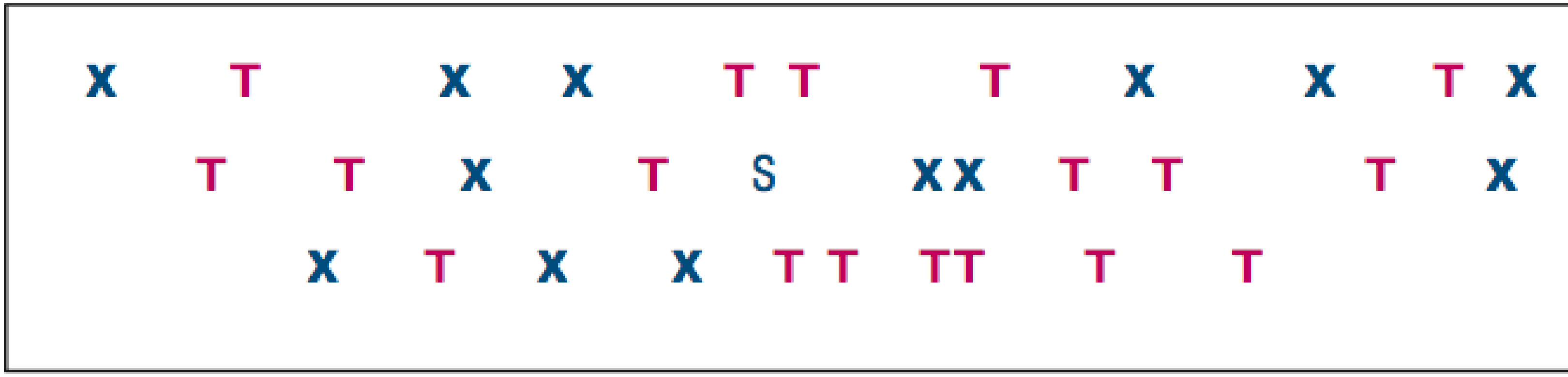
*b) **attentive** – here attention allows to "glue" the features into a unified object.*

*Triesman & Schmidt (1982) in an interesting study showed that when attention is **diverted/overloaded** participants make integration error resulting in "**illusory conjunctions**"*

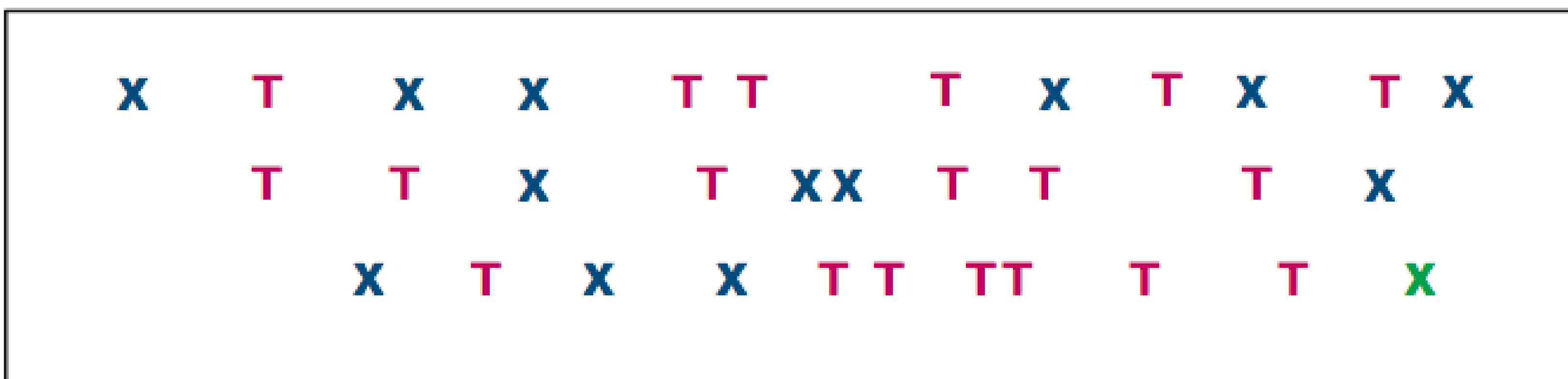
Feature Integration Theory (Treisman)



Feature integration theory



(A)



(B)

Attentional Capture –

Visual search task often involves "pop out" phenomenon in which certain stimuli seem to jump off the page or screen at the viewer, demanding attention. Experimental psychologists call this phenomenon ***"attentional capture"*** *by which they mean to imply stimuli that "cause an involuntary shift of attention"*

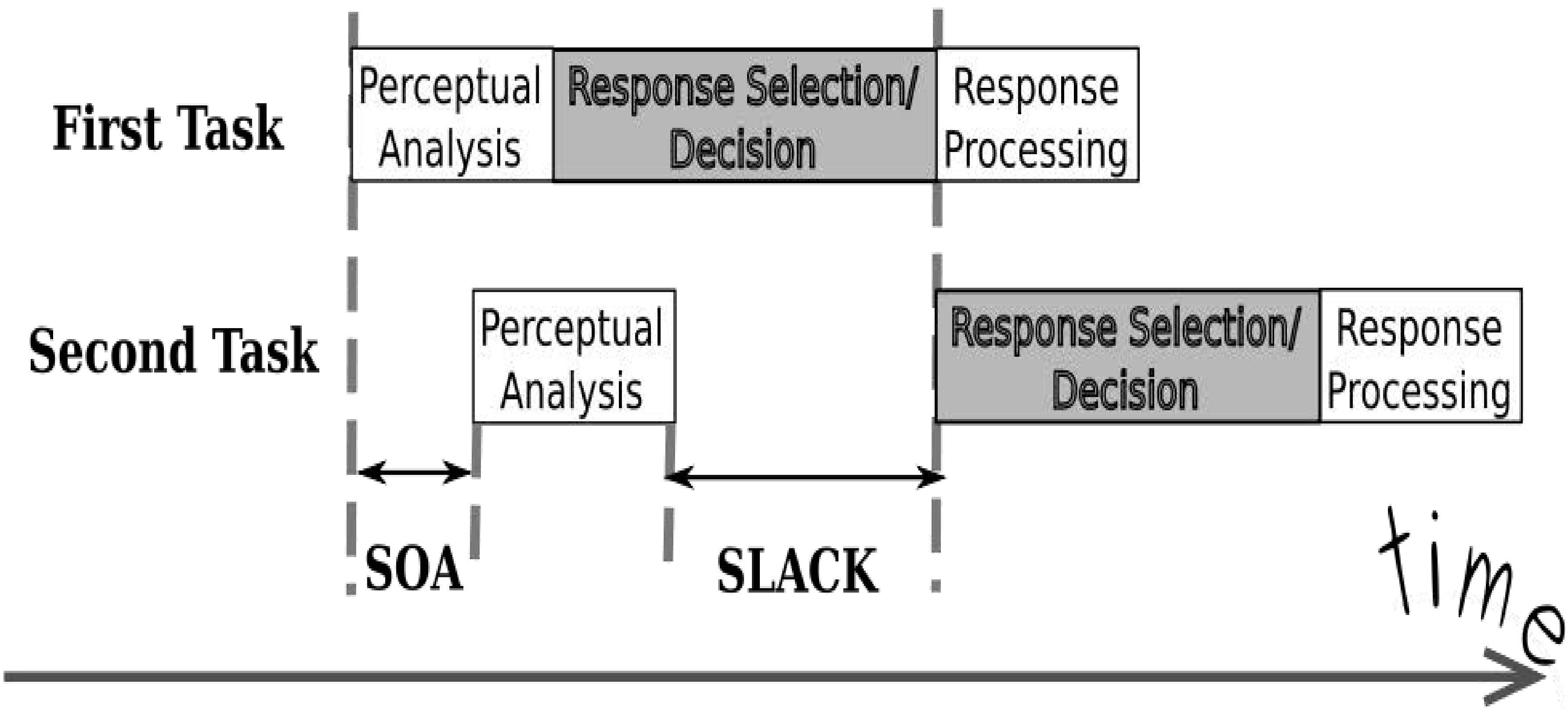
Psychologists have defined attentional capture to be a bottom up phenomenon driven almost entirely by properties of the stimuli rather than the perceiver's goal or objectives

Attention hypothesis of automatization

*Works by Gordon Logan & Joseph Etherton (1994, 1996) propose the **attention hypothesis of automatization**, which states that - attention is needed during the practice phase of a task and determines what gets learned during practice. Attention also determines what will be remembered from the practice. Simply stated - **"learning is a side effect of attending: people will learn more about the things they attend to and less about those which they don't attend".***

The Psychological Refractory Period (PRP)

Psychological refractory period refers to the delay observed in execution of the second of two tasks when it must be in close temporal succession with a prior task



A general interpretation of the ***PRP*** effect assumes the presence of a bottleneck when initiating response to stimuli. In simple words –

if we detect a stimulus and are processing that information while a second stimulus comes along we are unable to attend to and process the second stimulus until the first stimulus have finished processing, thus making our reaction time longer. This extra reaction time is called the ***"Psychological Refractory Period".*** *It is virtually impossible to initiate two responses simultaneously. People can however additional responses after the first one has been initiated.*

A very important question arose from Pashler’s (1993) work regarding the placement of the bottleneck that caused PRP. Pashler considered three distinct possibilities:

a) at the stage of presentation of the stimulus

b) at the stage in which a response is selected

c) at the stage of making a response

Pashler’s et.al (1993), working in the theory of Welford (1952) [the person who coined the term psychological refractory period] found evidence that retrieving information from memory caused a bottleneck and disrupted attention to the second task.

Memory: Yes I Remember or Wait I Know

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A MOUSE, YOU SAY?
DO YOU REMEMBER IT,
OR JUST KNOW IT?


MEMORY
SYNDROME
THERAPIST
RSJ

Forming & Using Memory Trace

Memory is one of the most basic processes that we use in our daily life. Right from the first hour of the morning to the last hour before sleep memory plays....''the most important'' part in the smooth running of our lives.

Psychologists define memory as ***"memory is an organisms ability to store, retain and recall information".*** *The loss of memory can be extremely devastating to people. Alan Baddeley (1990) describes the case of a musician broadcaster who suffered from intense amnesia.*

> *....his amnesia was so dense that he could remember nothing for more than a few minutes before. He was often found writing down time and events. The amnesia was so intense that if his wife returned after a few minutes he would greet her with great joy declaring that it was so long that they were meeting.....*

Metaphors of memory

Memory has been conceived as many different entities. Neath (1998) noted that ***Plato wrote*** about memory, comparing it variously to an *aviary* and to a *wax tablet* on which impressions are made. During the middle ages memory was compared to ***a cave, an empty cabinet etc***.

In 1950's memory was compared to *telephone systems* and later in the 1960's to ***computer system***. Cognitive psychologists found an important fact about memory in the 60's and 70's that there are different types of memory according to the length of time the information is stored.

The *modal model of memory – assumes information is received, processed and stored differently for each kind of memory. Unattended information presented very quickly is stored only briefly in "**sensory memory"**. Attended information is held in **"short term memory"** for periods up to 20-30 seconds. Information needed for longer periods of time – exam related knowledge or the name of our fourth grade teacher – is transferred to "**long term memory**"*

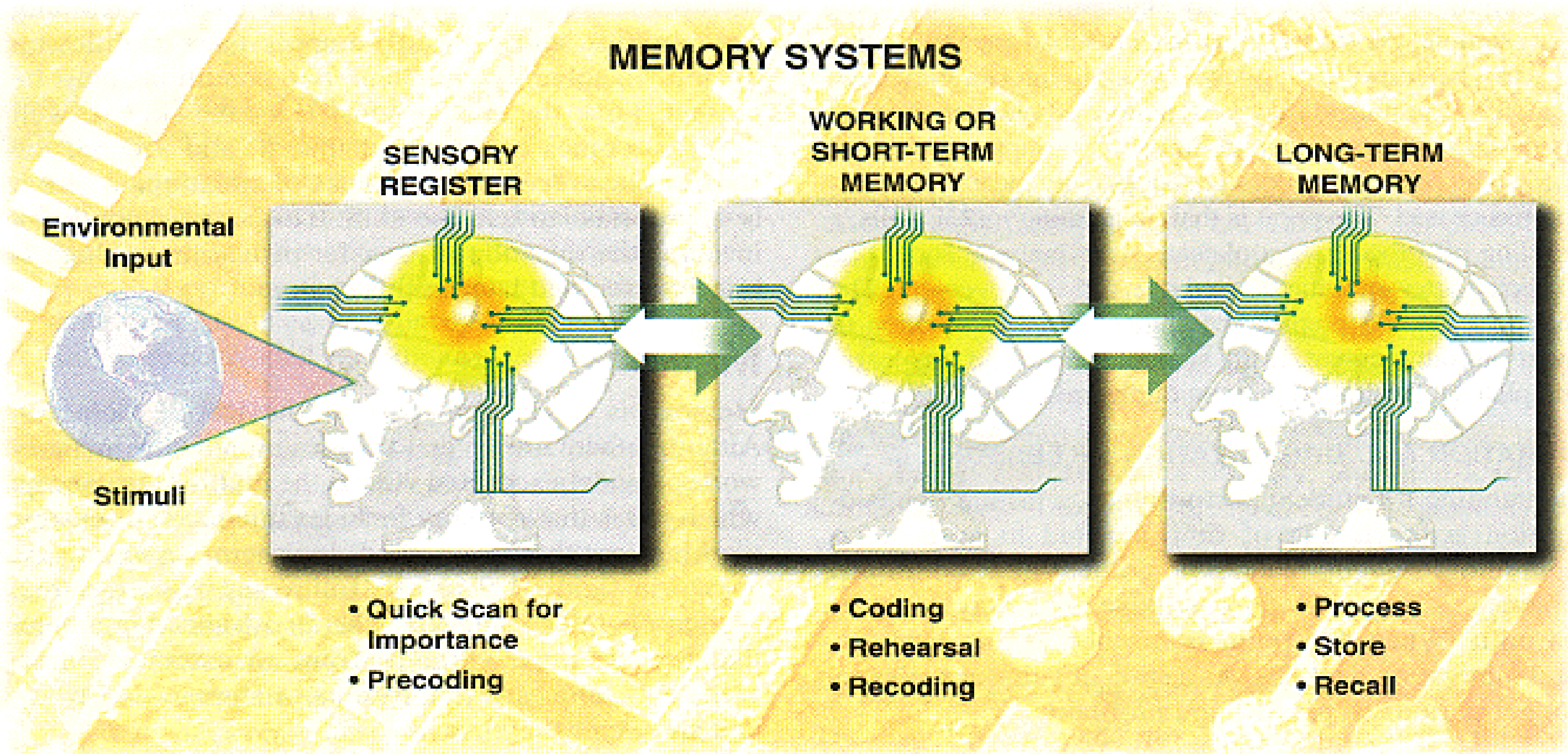


Figure 1-9. Information processing within the sensory register, working or short-term memory, and long-term memory includes complex coding, sorting, storing, and recall functions.

Sensory memory

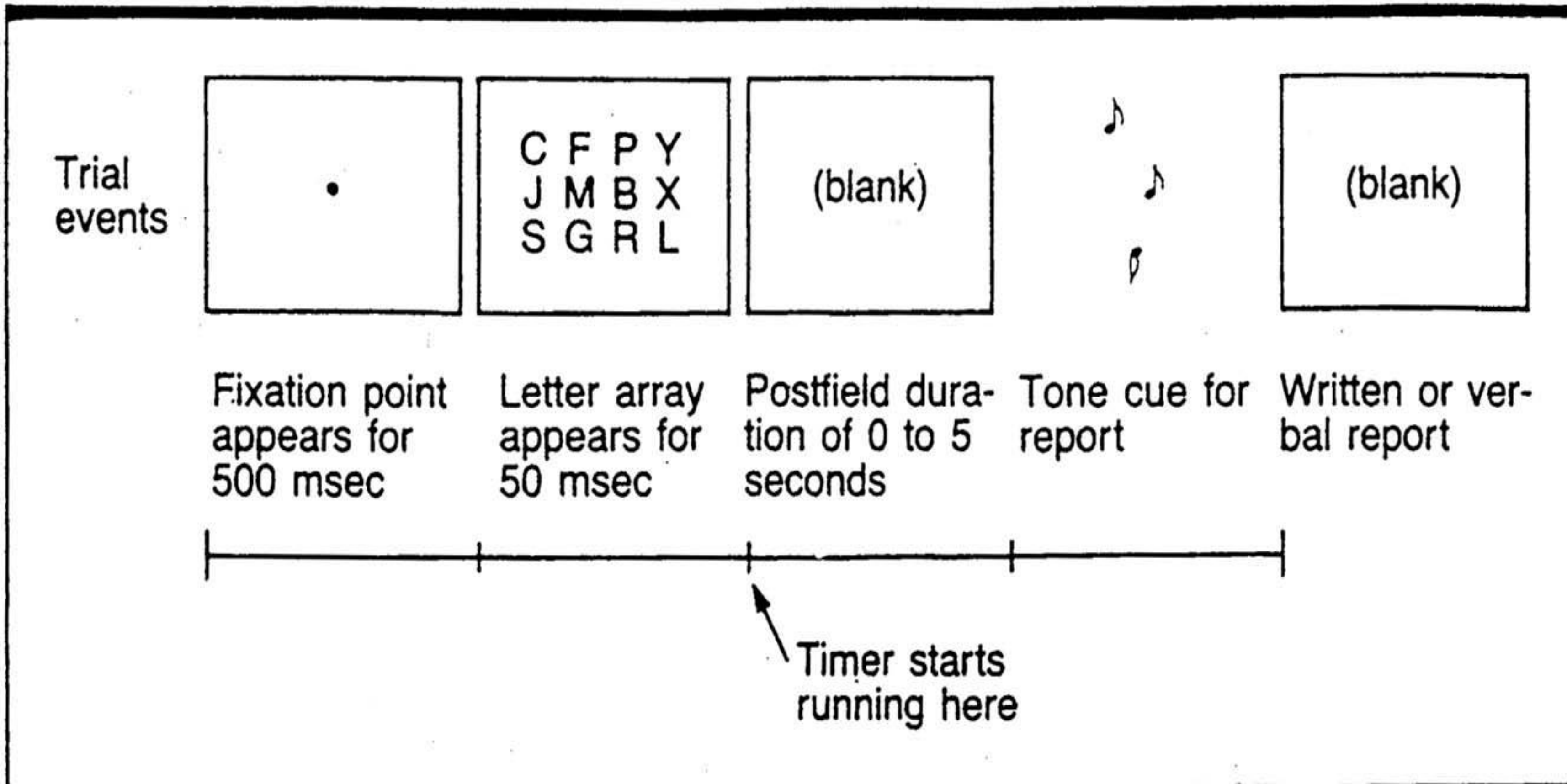
Sensory memory is closely connected to what we call "perception". This kind of memory has been described as a record of our percepts, because it refers to the initial brief storage of sensory information – what you might retain after a quick glance to an object field.

Separate sensory memories exists for different modalities. For visual there is the *icon,* for auditory it is the *echo,* for touch it is *haptic* and so on…

The Icon

Neisser (1967) called the ***icon*** *a very brief visual memory. The icon is a sensory memory storage system for visual material, holding information for up to about 1 second. The information it holds is in a relatively unprocessed form.*

The best demonstration of iconic memory can be done using Sperling's partial report technique (1960). Averbach & Coriell (1961) showed that the icon can be "erased" by other stimuli presented immediately after the icon, a phenomenon known as "masking"



A schematic diagram of a typical trial in Sperling's (1960) experiments. After a fixation point appears for 500 msec, the letter array is displayed. The visual field after the display is blank. The tone cue can occur at the same time as the postfield, or it can be delayed up to 5 seconds.

The Echo

There is also a sensory memory for auditory material, which Neisser (1967) called the ***echo.*** *Moray, Bates & Barnett (1965) offered a clever demonstration of the echo. Participants were given a "four-eared" listening task, similar to dichotic listening. Using Sperling's partial report technique with lights the participants were made to perform the task. They too found added performance increase in partial reports as compared to whole reports.*

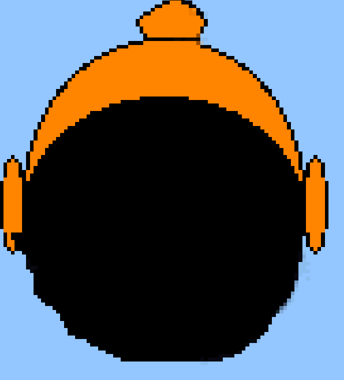
Darwin, Turvey & Crowder (1972) replicated Moray's experiment with better controls and found a much smaller partial report advantage. However their study revealed that

1) Echoic memory has larger capacity than Iconic Memory

2) Echo's can last about 20 seconds longer than Icons (Watkins & Watkins, 1980)

Darwin, Turvey, and Crowder (1972)

Left	Both	Right
B	8	F
2	6	R
L	U	10



Sensory memory can currently best be described by a number of properties

1) sensory memories are modality specific.

2) sensory memory capacities appear large but the length of time that information can be stored there is quite short much less than a second

3) the information that can be stored appears relatively unprocessed, meaning most of it has to do with physical aspects of the stimuli rather than with meaningful ones

EXAMPLES OF SENSORY MEMORY

Visual Sensory Memory. Hold your hand in front of your eyes and quickly wave it back and forth. If your hand motion is quick enough, you will be able to "see" your hand in one position for a fraction of a second after it has moved on to a different position.

Auditory Sensory Memory. With your hands, beat a quick rhythm on the desk. Can you still hear the echo after the beating is finished?

Tactile (Touch) Sensory Memory. Quickly rub the palms of your hands along a horizontal edge of your desk, moving your hands so that the heels touch first and the fingertips touch last. Can you still feel the sharp edge, even after your hand is off the desk?

Short term memory

Most of the time when people think about memory they think about holding onto information for longer than a second or two. This type of memory where information can be held for brief periods of time is called ***"short term memory"***.

short term/primary/active memory is the capacity for holding a small amount of information in mind in an active, readily available state for a short period of time.

Capacity of STM

*A classic paper by George Miller (1956) holds the capacity for STM to be 7 ± 2 chunks of items. **Chunking** is the process of combining smaller units of items into bigger meaningful units. For example consider the chunk*

F B I N S A K G B C B I C I A M I 5 B N D

The total string can be learnt by breaking it into initials for security agencies around the world

Coding in STM

The term coding refers to the way in which information is mentally represented; that is, the form in which information is held. When given a phone number how does one remember it? Conrad (1964) tried to address this question by presenting people with visual letters to remember. He found that people often committed errors while retrieving by replacing the original letter with similar sounding letters (e.g., Target: B, Errors: C, G, E etc). Later Neath (1998) found that people use the acoustic code dominantly for STM storage and recall

Short Term Memory

- Brown/Peterson & Peterson (1959)
- Trigram task

KHR

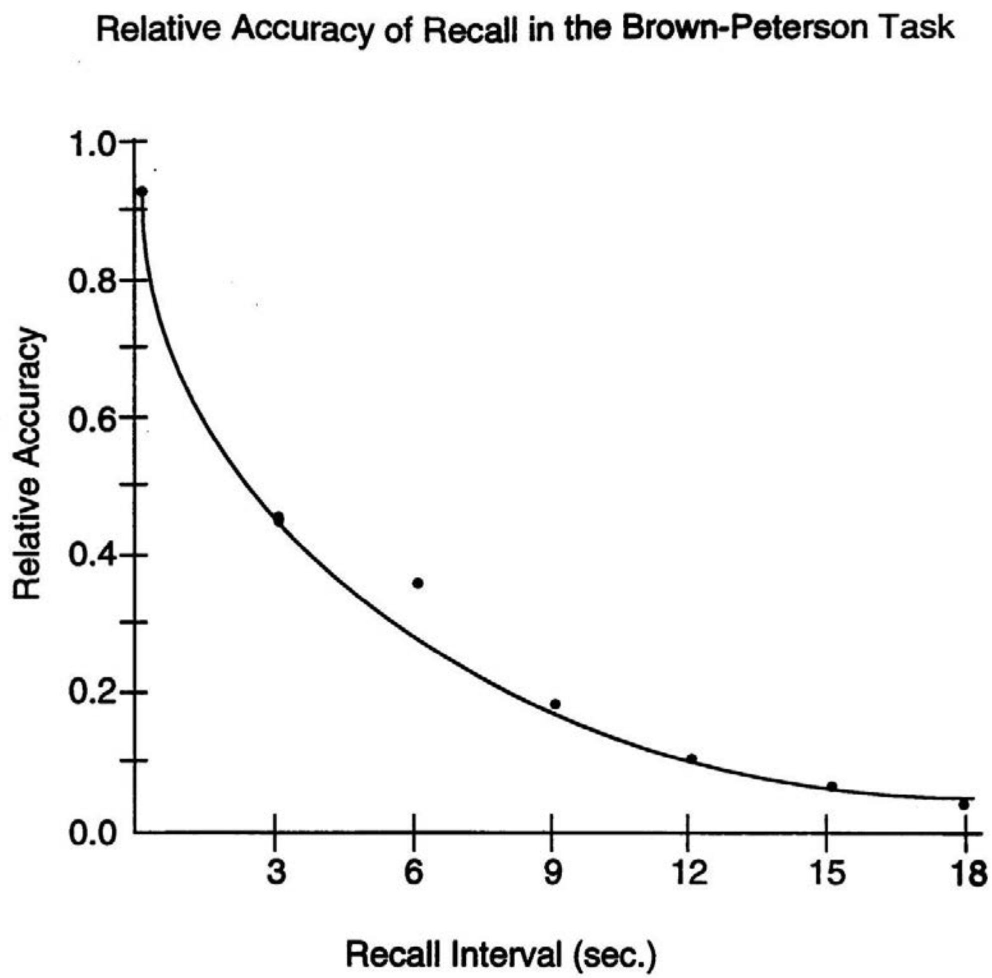
↓

0 – 18 seconds | Delay / Distractor | (947, 946, 945 . . . 939)

↓

Recall Trigram

Brown-Peterson Results



Trigrams

K X J

P L G

S Y T

H Z R

The results from both Brown's and Petersons study interpreted that failure to recall occurring due to "*decay of memory traces*" within about 20 seconds. The decays in STM happens as the items are not rehearsed.

A group of cognitive psychologists however challenged the decay theory of forgetting in memory and proposed a different mechanism called *"interference"* for forgetting from STM. The theory of interference proposes that

some information can "displace" other information making the former hard to retrieve.

Waugh & Norman (1965) – *Probe digit task for explaining interference*

In the task participants were given 16-digit numbers such as 1596234789024815. The last digit in the number is a cue for the participant to report the number that first came after the first occurrence of the cue in the number.

Waugh & Norman presented the numbers either quickly, at the rate of 4 digits per second or slowly at the rate of 1 digit per second. Their reasoning was that if decay caused forgetting in STM, then participants receiving a slow rate of presentation should not be as good at recalling digits from early in the number.

Keppel & Underwood (1962) found that forgetting in the Brown-Peterson task doesn't happen until after a few trials. They suggested that over time, proactive interference builds up.

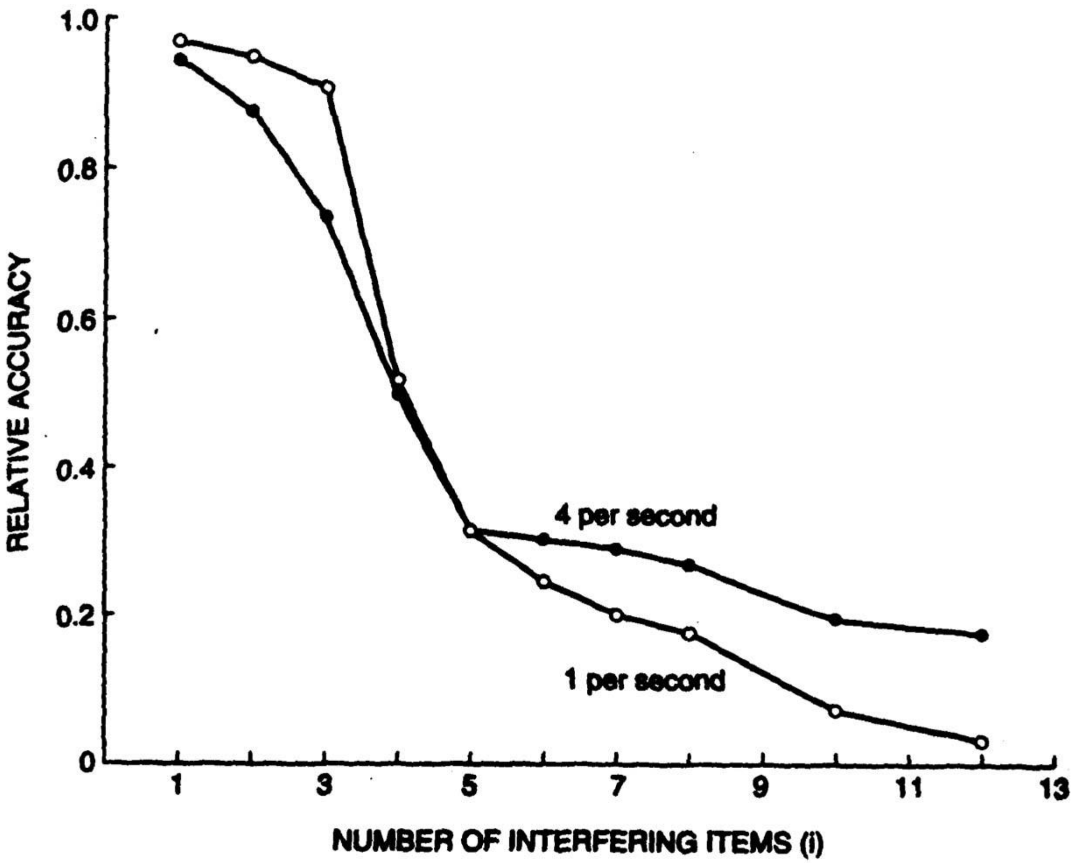
Digit Probe Task: Waugh & Norman (1965)

16 digits -----> probe digit

5 1 9 6 3 5 1 4 2 8 6 7 3 9 4

9 8 3 7 5 7 1 4 9 3 8 6 2 7 5 2

Effect of Presentation Rate vs. Number of Interfering Items on Recall (Waugh & Norman, 1965)



Is forgetting from STM a *decay or Interference* related phenomenon

This is a badly posed question as it rules out the possibility for loss by both the phenomenon. Baddeley (1990) argues that some trace decay does occur form STM. Altmann & Gray (2002) proposes that decay does occur and in fact is essential to avoid catastrophic proactive interference.

These authors believe that when information must be updated frequently in memory, its current value decays to prevent interference with previous values.

Retrieval from STM

How do we retrieve information from STM when we need it?

Saul Sternberg (1966, 1969) conducted a series of experiments and found some interesting facts relating to retrieval from STM. Retrieval from STM can be either using

a) ***Parallel Search*** – *where comparison of the probe is done with all items stored in the STM at the same time*

b) ***Serial Search*** *– where comparison of the probe is done with all items stored in the STM one at a time. Further serial search can either be*

a) ***self – terminating search*** *– which stops when a match to the probe is found*

b) ***exhaustive search*** *– where even if the match is found all item are checked with the probe*

Sternberg's result argue for serial exhaustive search as we retrieve information from STM

A review study done by Hunt (1978) found that people of all sorts showed results consistent with the idea that retrieval from STM uses serial exhaustive search, although search rate changes with the group.

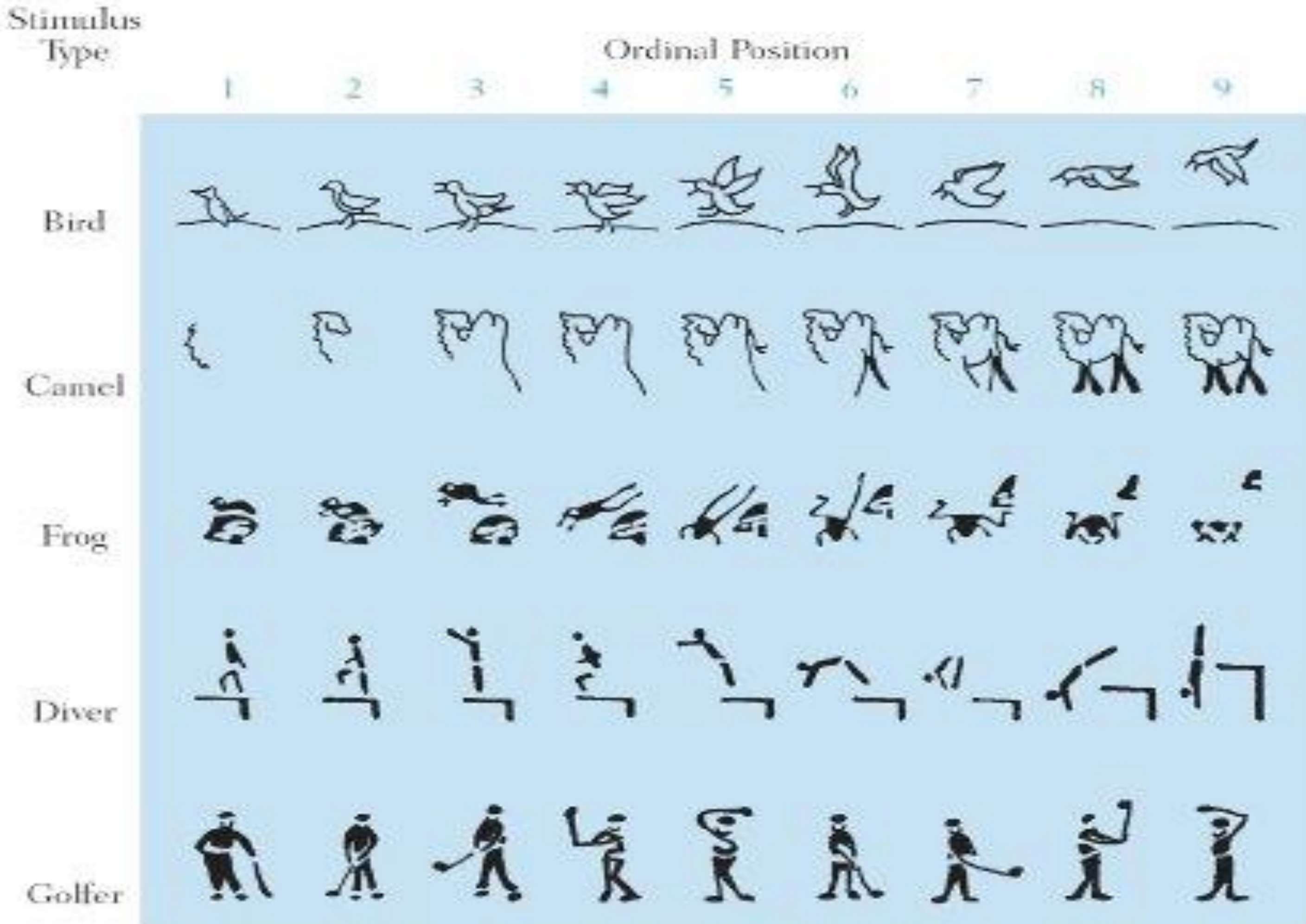
Similarly DeRosa and Tkacz (1976) demonstrated that with certain stimuli people apparently search STM in a parallel way.

De Rosa stimuli consisted of ***ordered sequences of pictures****. It became clear from further research on De Rosa's stimuli that*

a) if the memory set consisted of some ***randomly selected subset*** *of the nine picture – 1, 4, 6, 8 & 9 – from any of the sets the* ***results were similar to Sternberg's result***

b) If memory set consisted of an ***ordered subset of the original*** *sequence pictures – 2, 3, 4, 5 & 6 – then* ***it took participants no longer to search through five items than it did through two****.*

This result suggests that ***STM does treat organized material differently from unorganized material****. Also memory processes apparently work differently as function of the material (stimuli) to be remembered*



Stimulus Type
Ordinal Position
1
2
3
4
5
6
7
8
9
Bird
Camel
Frog
Diver
Golfer

Working Memory

The information processing model of Atkinson & Shiffrin (1968) describes information processing as being a two part process

a) the information representations being stored called either as "STM / LTM"

b) the structure storing it describes as "STS / LTS"

These authors conceived STS not only as a store for seven or fewer pieces of information for few seconds but found that information in STS somehow activates relevant information from LTS and gathers some of this information into STS.

*They equates STS with consciousness and saw it as the location of various **<u>control processes</u>** that govern the flow of information such as rehearsal, coding, integration and decision making.*

Baddeley & Hitch (1974) performed a series of experiments to test the model described above. The design was to have participants temporarily store a number of digits while simultaneously performing another task such as reasoning or language comprehension. The hypothesis was that if the STS capacity is taken up by stored digits fewer resources are available for other tasks so performance on other tasks suffer

Reasoning Task with Letter Recall

AB

‘A’ precedes ‘B’?	**T** or **F**
‘B’ is preceded by ‘A’ .	**T** or **F**
‘B’ does not precede ‘A’.	**T** or **F**

Reasoning Speed and Letter Recall

Experiment 1:

0, 1, 2 items preloaded

↓

reasoning task

↓

letter recall

Experiment 2:

0 or 6 items

↓

reasoning task

↓

letter recall

Reasoning Times & Letter Recall Results

Table 4-3 REASONING TIMES AND LETTER RECALL UNDER VARIOUS MEMORY LOAD CONDITIONS

Experiment 1

	Memory load (number of letters held in memory) 0	1	2
Reasoning times	3.20 sec	3.31 sec	3.31 sec
Letter recall	Essentially perfect		

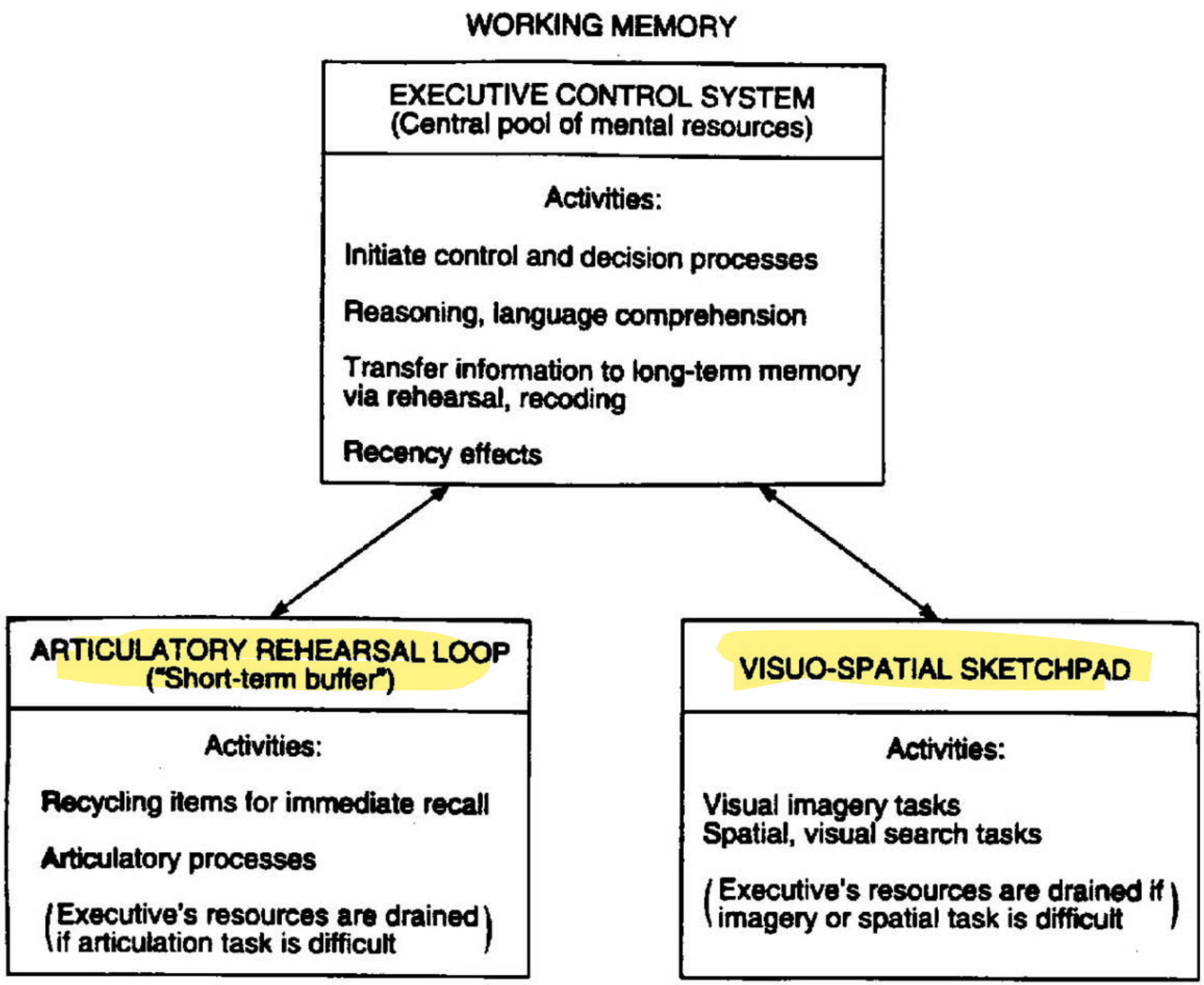
Experiment 2

	Memory load 0	6	
Reasoning times	3.27 sec	3.46 sec	"Equal stress"
Letter recall	5.5	3.7	
Reasoning times	2.73	4.73	"Memory stress"
Letter recall	5.8	5.0	

Note: In both experiments, a memory load of 0 was a control condition. In these conditions, subjects performed the reasoning task, and only then were they given the set of letters for the memory span task. Thus letter recall of 5.8 in the 0 Memory load condition means that 5.8 letters were recalled immediately after their presentation, where presentation followed the reasoning task.

Adapted from Baddeley & Hitch, 1974.

Baddeley Working Memory Model



***Working memory** consists of a limited capacity "workspace" that can be divided between storage and control processing. Baddeley (1981, 1986, 1990) conceived of WM as consisting of three components.*

*a) The first is **central executive** – this component directs the flow of information, choosing which information will be operated on when and how*

*b) The **phonological loop** – which is used to carry out sub vocal rehearsal to maintain verbal material*

*c) The **Visuospatial sketchpad** – which is used to maintain visual material through visualization.*

What about daydreams?

- Daydreams are stimulus-independent thoughts (SITs).
- Neither the phonological loop nor the visuospatial sketchpad is solely responsible for SITs.
- Producing SITs appears to involve the central executive.

Long Term Memory: Elephants Remember for Lifetime

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Retrieval and Encoding in Long Term Memory

The traditional view of long term memory

LTM or long term memory can be described as a place for storing large amounts of information for indefinite periods of time. LTM is often thought of as a *treasure chest* of memories or *scrape* book of memories

Capacity **-** What is the capacity of LTM?

Thomas Landauer (1986) has tried to provide the answer by making two estimates

a) The size of the human brain is equal to the no of synapses in the Cerebral Cortex = 10^{13}, which is the no of bits of information stored in the brain

b) Another estimate is 10^{20} bits of information which is the no is neuronal transmission made by average human lifetime

Coding in LTM

Errors made while recalling information from LTM are likely to be semantic confusion.

Baddeley (1966a)

Group A — Similar sounding words list 1 (map, mad, man)

Matched words from list 1 but not similar sounding (pen, day, rig)

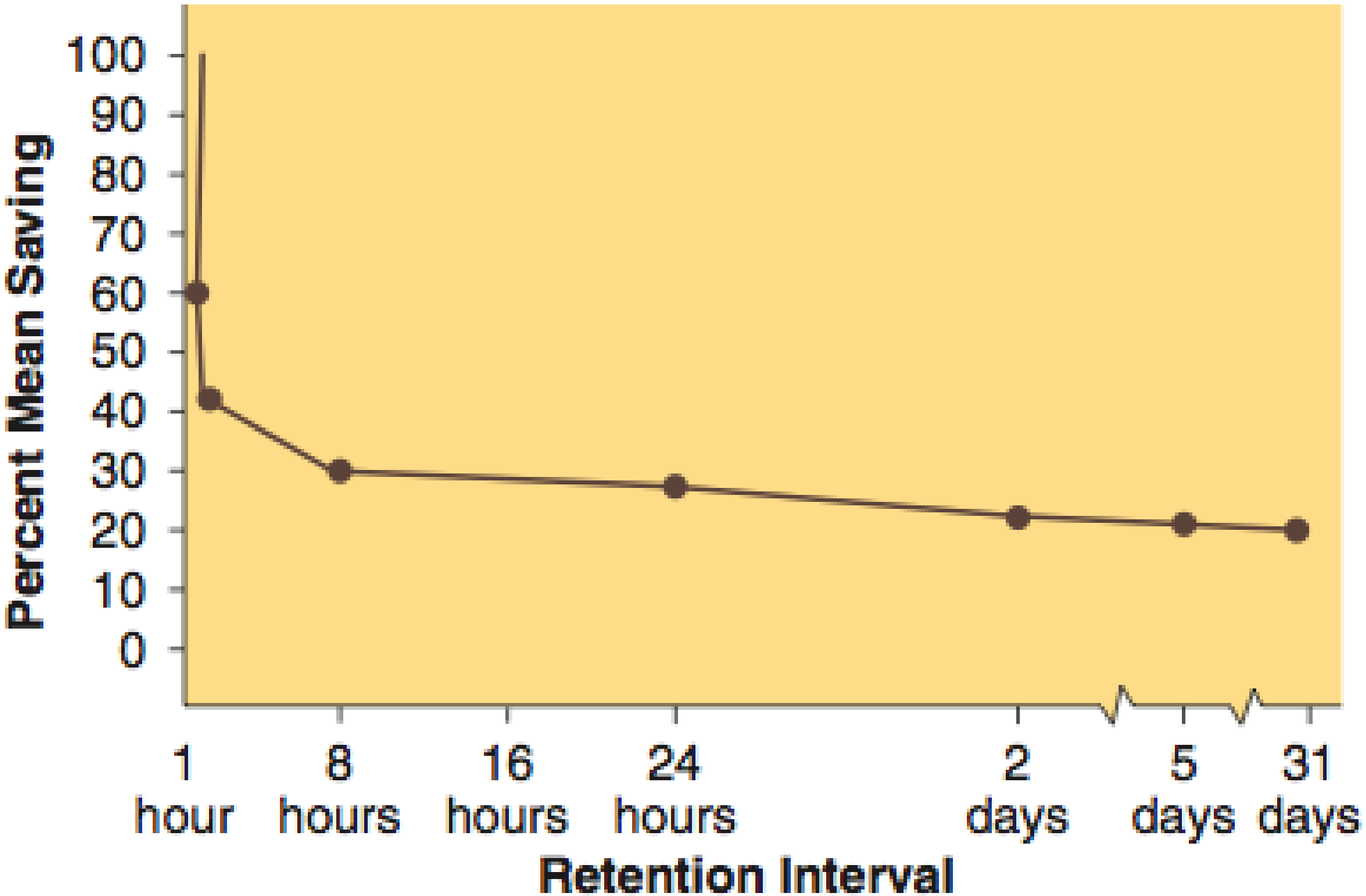
Group B — Similar meaning words list 2 (huge, big, great)

Matched words from list 2 but not similar meaning (foul, old, deep)

↓ Recall after 20 min / participants engaged in unrelated task

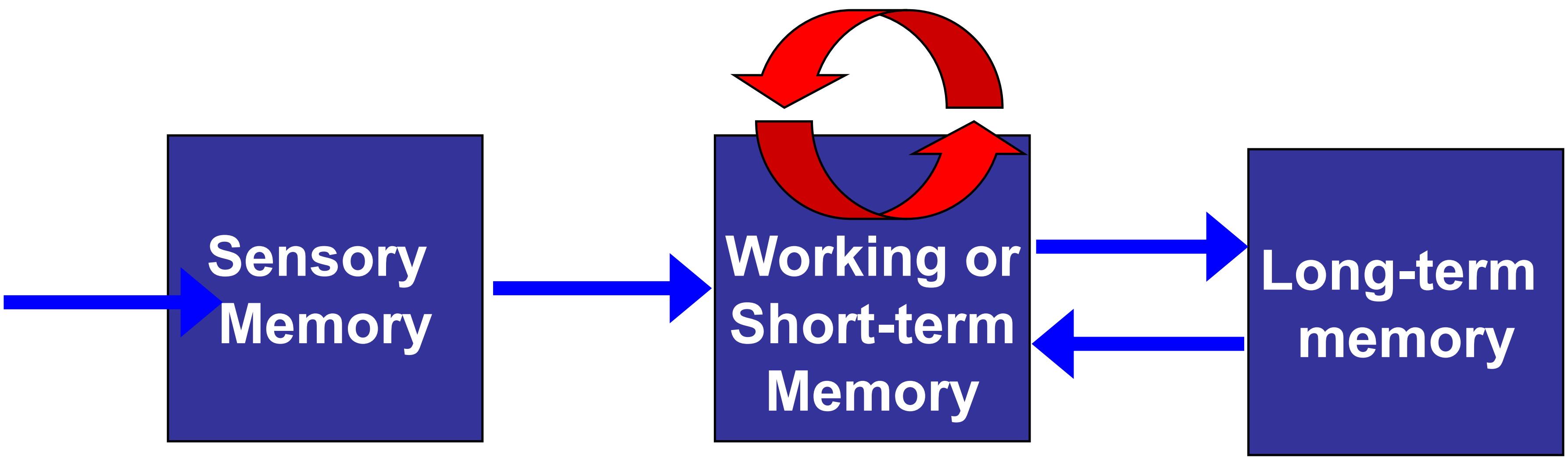
Acoustic similarity produced little effect on performance as compared to semantic similarity. Group 2 performed worse compared to group 1

Forgetting: Ebbinghaus's forgetting curve



Review of Long-term Memory

- Retrieval transfers info from LTM to STM
- Forgetting - inability to retrieve previously available information
- Why do people forget?



Forgetting theories

- Poor encoding theories
- Decay theories
- Interference theories
- Retrieval-cue theories

Forgetting as encoding failure

- Info never encoded into LTM

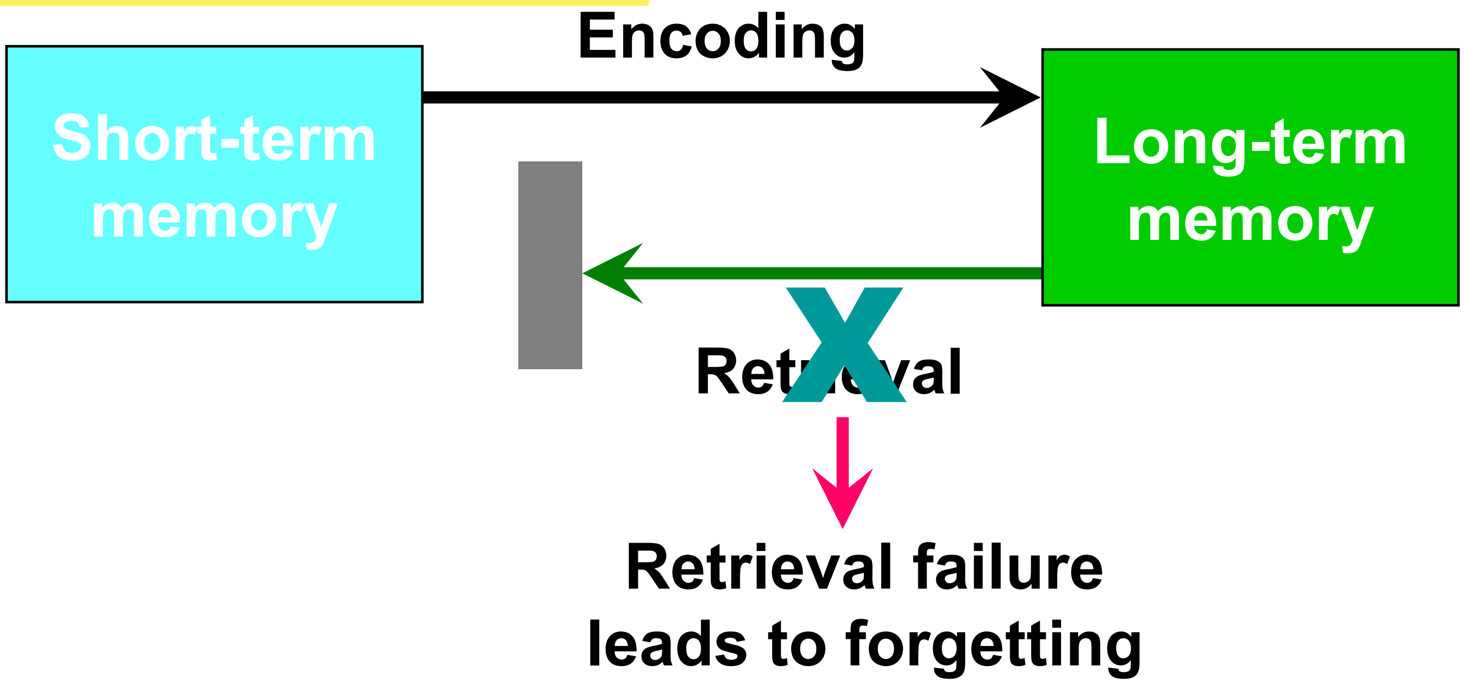
Encoding failure leads to forgetting

Some encoding failure demos

- What letters accompany the number 5 on your telephone?
- Where is the number 0 on your calculator?
- According to this theory, objects seen frequently, but info never encoded into LTM

Forgetting as retrieval failure

- Not all forgetting is due to encoding failures
- Sometimes info IS encoded into LTM, but we can't retrieve it



Tip of the tongue phenomenon

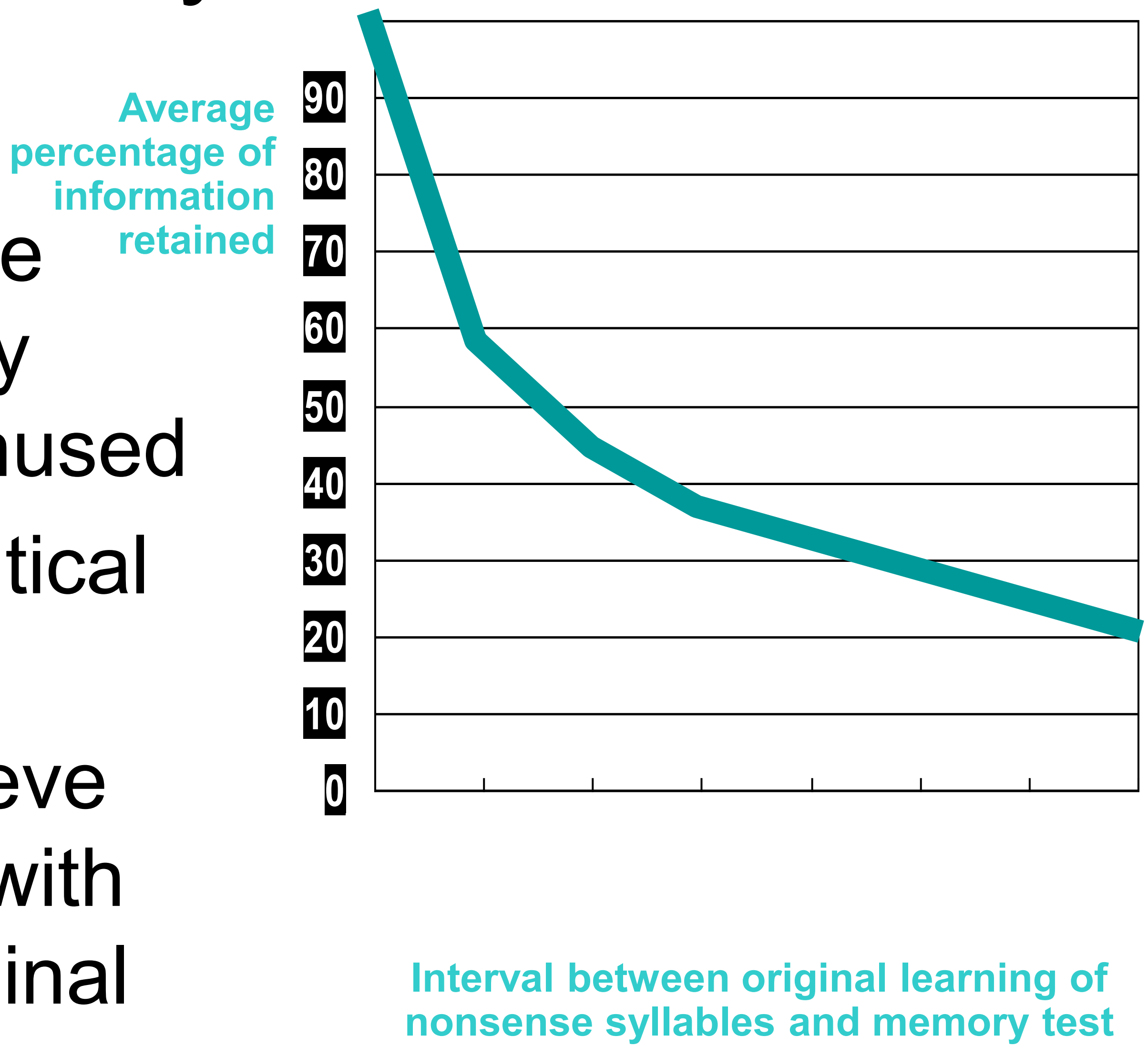
- a.k.a. TOT experience
- Can’t retrieve info that you absolutely know is stored in your LTM
- Example: ???
- Evidence of forgetting as an inability to retrieve info
- Why can’t we retrieve info?

Retrieval failure theories

- Decay theories
- Interference theories
- Retrieval cue theories

Decay theories

- Memories fade away or decay gradually if unused
- Time plays critical role
- Ability to retrieve info declines with time after original encoding



Decay theories

- Biology-based theory
- When new memory formed, it creates a *memory trace*
  - a change in brain structure or chemistry
- If unused, normal brain metabolic processes erode memory trace
- Theory not widely favored today
  - info CAN be remembered decades after original learning
    - even if unused since original learning

Interference theories

- "Memories interfering with memories"
- Forgetting NOT caused by mere passage of time
- Caused by one memory competing with or replacing another memory
- Two types of interference

Experimental Paradigm for Interference

Phase	Experimental Group	Control Group
Proactive Interference		
I	Learn List A-B	Unrelated Activity
II	Learn List A-C	Learn List A-C
Test	List A-C	List A-C
Retroactive Interference		
I	Learn List A-B	Learn List A-B
II	Learn List A-C	Unrelated Activity
Test	List A-B	List A-B

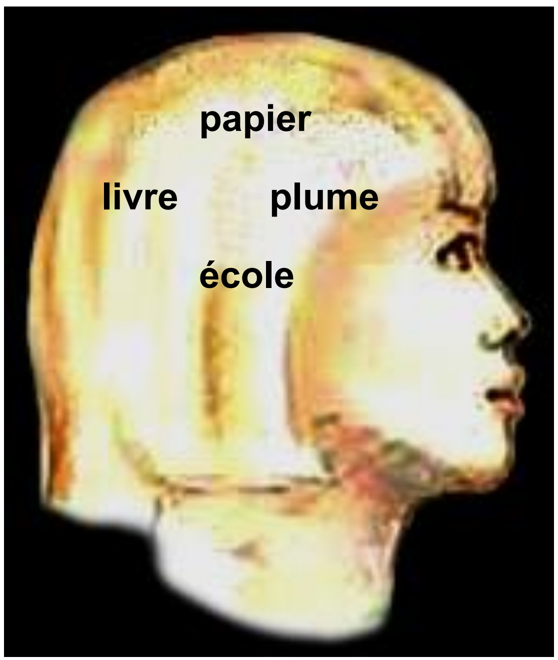
Retroactive interference

- When a NEW memory interferes with remembering OLD information
- Example: When new phone number interferes with ability to remember old phone number

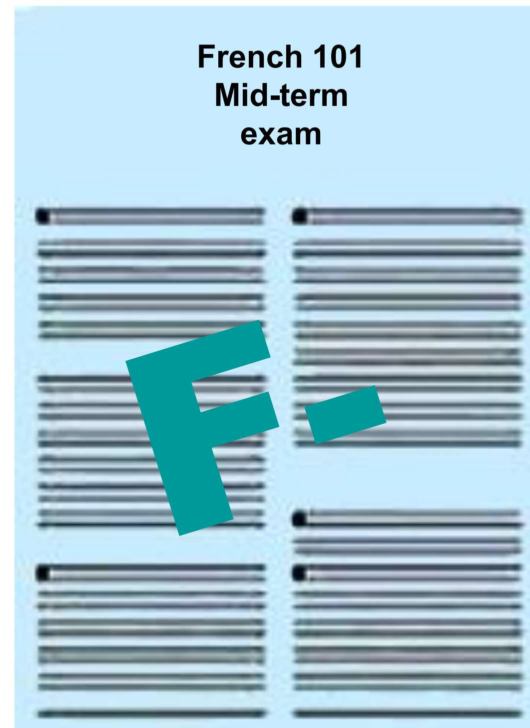
Retroactive interference

- Example: Learning a new language interferes with ability to remember old language

Study French



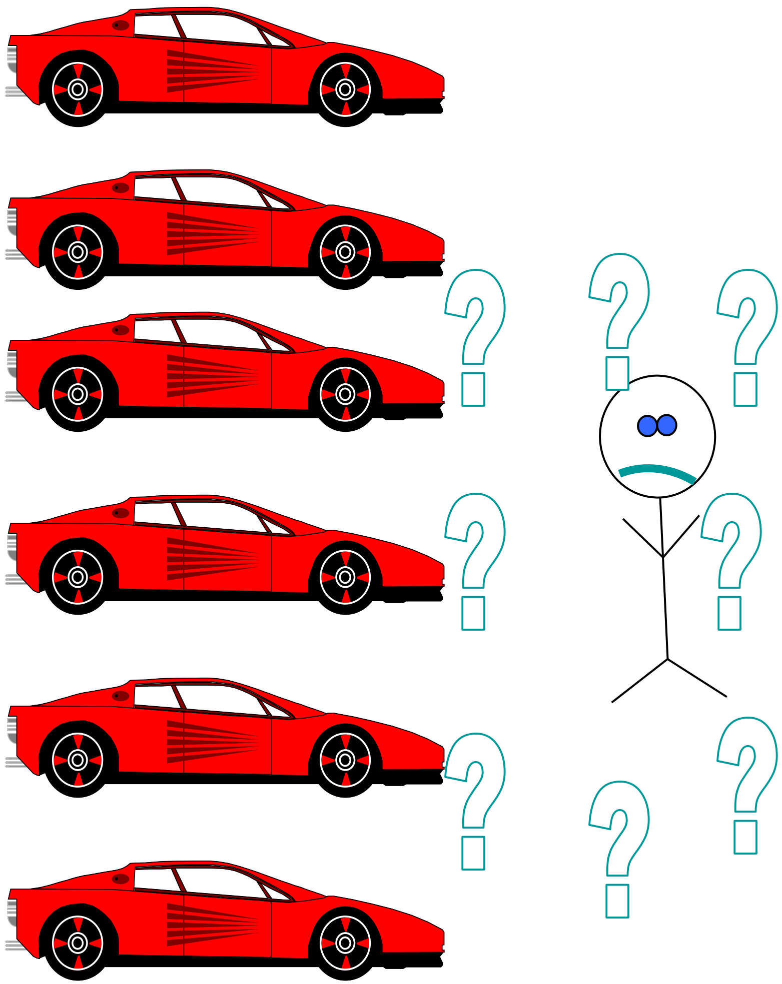
Study Spanish



retroactive interference

Proactive interference

- Opposite of retroactive interference
- When an OLD memory interferes with remembering NEW information
- Example: Memories of where you parked your car on campus the past week interferes with ability find car today



Retrieval cue theories

- Retrieval cue - a clue, prompt or hint that can help memory retrieval
- Forgetting the result of using improper retrieval cues

Recall vs. Recognition tests

- Importance of retrieval cues evident in recall vs. recognition tests
- Recall tests - must retrieve info learned earlier
  - Examples: Fill-in-the-blank test; essay exams
- Recognition tests - only need to identify the correct answer
  - Example: Multiple choice tests

What is the capital of Finland?

What is the capital of Finland?

- A. Uppsala
- B. Helsinki
- C. Tampere
- D. Amsterdam
- Which was easier: recall or recognition?
- For your psychology exam, would you rather have a fill-in-the-blank or a multiple choice test?

Which retrieval cues work best?

- Encoding specificity principle - cues used during initial learning more effective during later retrieval than novel cues

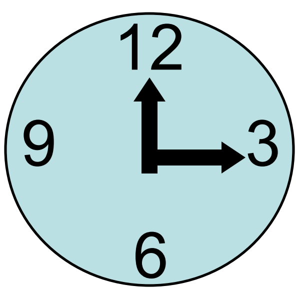
Which retrieval cues work best?

- Context-dependent memory - improved ability to remember if tested in the same environment as the initial learning environment
  - Better recall if tested in classroom where you initially learned info than if moved to a new classroom
  - If learning room smells of chocolate or mothballs, people will recall more info if tested in room with the same smell
    - compared to different smell or no smell at all

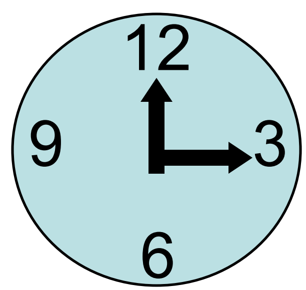
Context dependent effects

- Time of day is also important

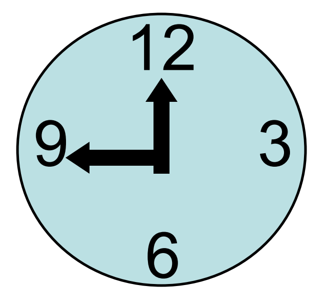
Learn at 3pm



Perform better at 3pm

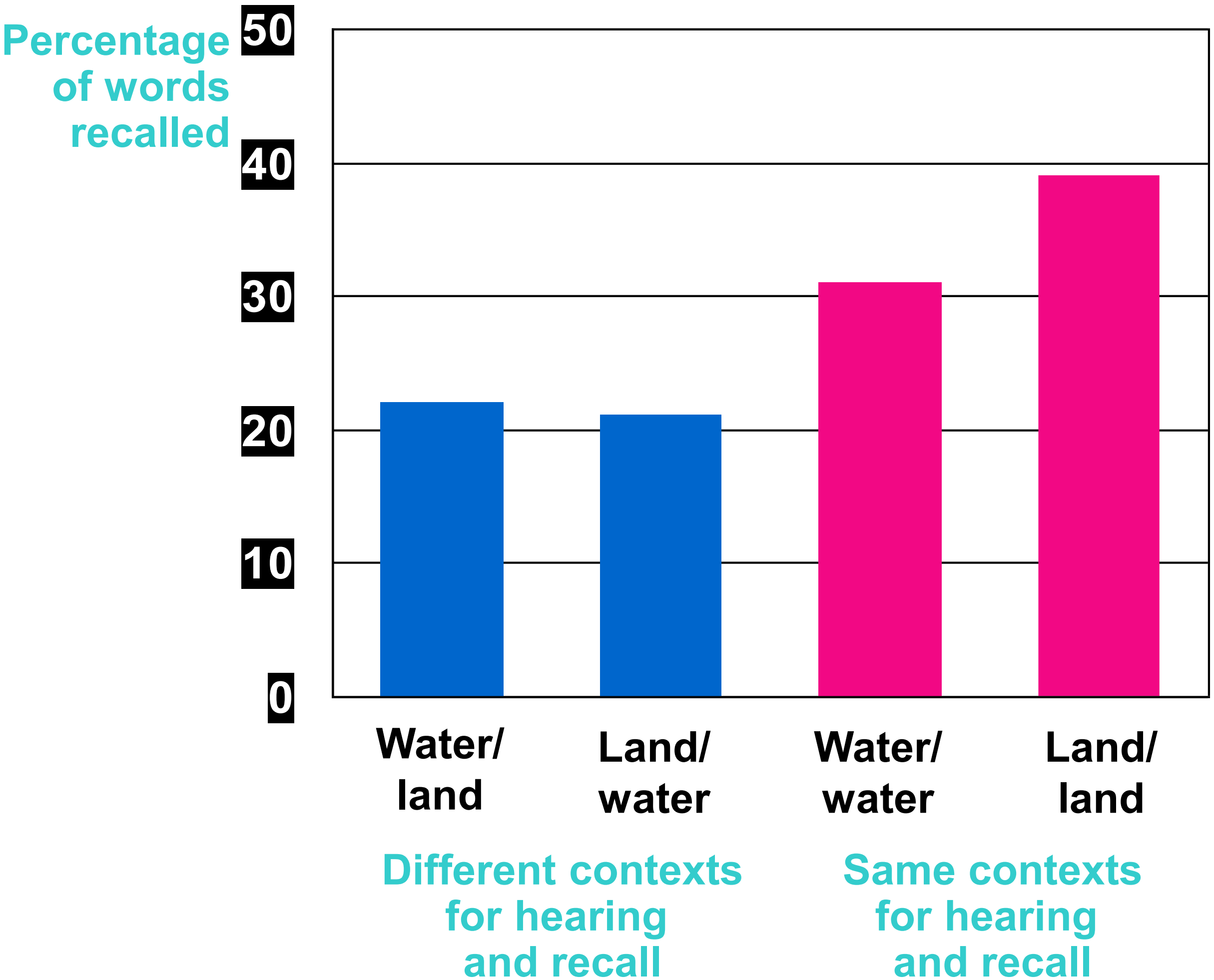


Than 9pm



Context-dependent effects

- Words heard underwater are best recalled underwater
- Words heard on land are best recalled on land



State-dependent effects

- Recall improved if internal physiological or emotional state is the same during testing and initial encoding
- Context-dependent - external, environmental factors
- State-dependent - internal, physiological factors

State-dependent effects

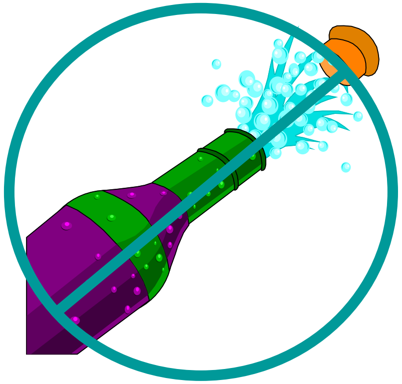
- Mood or emotions also a factor
- Bipolar depressives
  - Info learned in manic state, recall more if testing done during manic state
  - Info learned in depressed state, recall more if testing done during depressed state

State dependent effects

Drunk during learning

Recall better if drunk

Than if sober



The spacing effect

- Better to study for several shorter periods than for one longer period
- One hour per day for 8 days leads to better recall than 8 hours of cramming!
- Why? *Encoding variability*: best to encode in a variety of ways, to attach a wider variety of memory cues to the material. Spacing practice sessions allows for more variability.

Subdivisions of long-term memory

- Semantic memory: general knowledge
- Episodic memory: events in which you participated
- Explicit memory: consciously recollected
- Implicit memory: not consciously recollected, but shown in other ways

Declarative vs. procedural memory

- Procedural memory: how to do things
- Declarative memory: facts, information, ideas

Levels of processing

- Participants told to answer questions as quickly as possible about words on screen:

DOG

- “Is it in capital letters?”
- “Does it rhyme with FROG?”
- “Does it fit in this sentence: The _____ jumped up on the mailman”?

Levels of processing

- Later, on a surprise recall test, participants showed best memory for words that had been fit into sentences.
- Better recall because of DEEPER PROCESSING for these types of questions, which forced participants to think about the MEANING of the words on the screen

Reconstructive memory

- Retelling of stories leads to distortions in what is remembered.
- Eyewitness memory is subject to distortion when leading questions are asked.
  - “Did another car pass the red Datsun at the stop sign?”
  - The sign was actually a yield sign.
  - Participants later falsely recognized the stop sign 59% of the time.

Eyewitness testimony

- Recall not an exact replica of original events
- Recall a *construction* built and rebuilt from various sources
- Often fit memories into existing beliefs or schemas
- Schema - mental representation of an object, scene or event
  - Example: schema of a countryside may include green grass, hills, farms, a barn, cows etc.

Eyewitness testimony

- Scripts - type of schema
  - Mental organization of events in time
  - Example of a classroom script: Come into class, sit down, talk to friends, bell rings, instructor begins to speak, take notes, bell rings again; leave class etc.

Memory distortion

- Memory can be distorted as people try to fit new info into existing schemas
- Giving misleading information after an event causes subjects to unknowingly distort their memories to incorporate the new misleading information

Loftus experiment

- Subjects shown video of an accident between two cars
- Some subjects asked: How fast were the cars going when the smashed into each other?
- Others aksed: How fast were the cars going when the hit each other?

Accident

Leading question:

"About how fast were the cars going When they *smashed* into each other?"

Memory construction

Loftus results

Word Used in Question	Average Speed Estimate
smashed	41 m.p.h.
collided	39 m.p.h.
bumped	38 m.p.h.
hit	34 m.p.h.
contacted	32 m.p.h

Autobiographical memory

- Real-world memories are more durable than laboratory memories of word lists.
- Some items are forgotten because they are hard to distinguish from other, similar memories.
- Single-event memories are often combined into extended or summarized events.
- Rare actions are more likely to be recalled than frequent actions.

Flashbulb memories

False memory creation

- “You went on a shopping trip with your mom and your cousin. Somehow, you wandered away in the store and got lost. A security guard found you and you were reunited with your mom about an hour later.”
- This event never happened. But after repeated questioning, 29% of participants “recalled” details of the false event!

The Deese/Roediger-McDermott paradigm

- Study of list of words related to sleep:

Dark

Dream

Pillow

Nap

Night

Quiet

- 80% of participants false recognize “sleep” as having been on the list, although it wasn’t.

Amnesia

- Anterograde amnesia: inability to learn new information after the initial point of memory loss ("H.M.")
- Old memories in LTM remain intact.
- General knowledge and skills remain intact.

- Retrograde amnesia: loss of memory for information stored before the point of memory loss
- Spares "overlearned" information, and skills

Semantic Memory: Rules of the Game

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People hold on to information years after storing them

These contains knowledge relating to *definitions of words, arithmetic facts and procedures, historical, scientific and geographical knowledge to name a few*

The organization of the knowledge follows the metaphor of a book shelf

Information in memory consists of knowledge for specific events and *memory for general knowledge*

Endel Tulving (1972, 1983) argued that LTM contains two stores namely episodic and semantic which although are distinct but highly interactive.

Episodic – Semantic distinction

Episodic – enables people to *travel back in time* and become consciously aware of witnessing or participating in events in earlier time

Semantic – contains general and world knowledge, arithmetic rules, past tense of verbs etc

Episodic	Semantic
Personal Experience	Facts and Concepts
Remember "When"…	Remember "What"….
Temporally Organized	Meaning related Organization

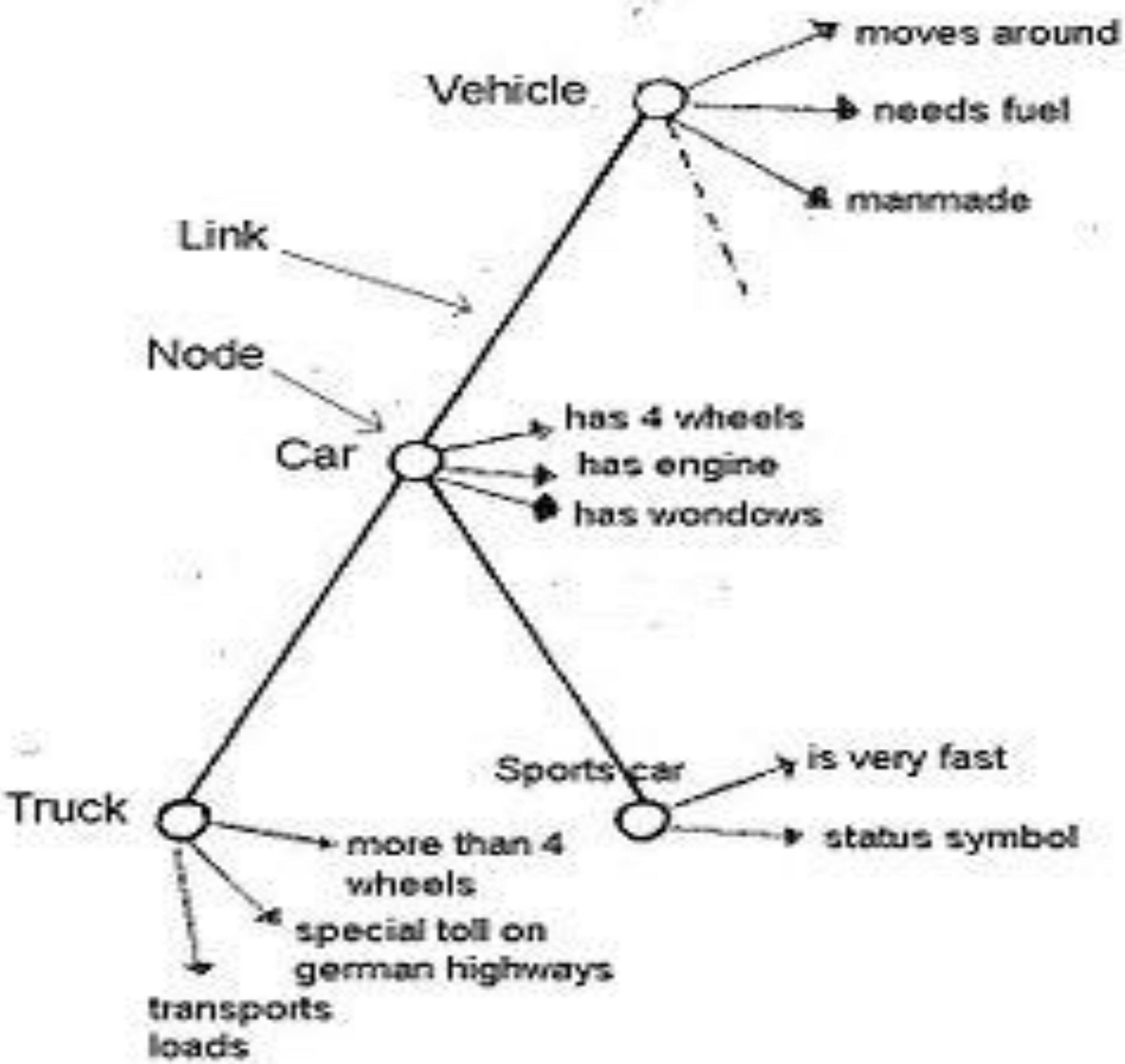
Semantic memory models

The Hierarchical Semantic Model

The model was proposed by ***Collins & Quillinan (1969).*** They tested the idea that semantic memory is analogous to a ***network of connected ideas.***

The Model consists of ***nodes*** (in this case words/concepts). Each node is ***connected to related nodes*** by means of ***pointers***.

*Thus the **node** that **corresponds to a given word/concept** together **with** the **pointers to other nodes** to which the **first node is connected**, constitutes the **semantic memory** for that **word/concept**. The **collection of nodes** associated with all the words & concepts is called **Semantic Network***


moves around
Vehicle
needs fuel
manmade
Link
Node
has 4 wheels
Car
has engine
has wondows
is very fast
Sports car
Truck
status symbol
more than 4
wheels
special toll on
german highways
transports
loads

Collins & Quillian (1969) tested the principle of cognitive economy with their model of semantic memory. They reasoned that the closer a fact is stored to a particular node, the less time it should take to verify the fact and property.

T*hey reported that people took **less time to respond** to sentences whose **representations should span two levels** (**A canary is a bird**) than for those whose **representation should span three** (**A canary is an animal**)*

This model was called the ***hierarchical semantic network model of semantic memory.*** The nodes in this model are ***organized in hierarchy*** and most nodes have ***super ordinate and subordinate nodes***. Super ordinate nodes correspond to the category name for which the thing corresponds to the subordinate node was a member.

Meyer & Schvaneveldt (1971) reasoned that ***if related words*** are ***stored close*** by one another and are ***connected to one another*** in a semantic network, then *when ever one node is activated* or energized, ***energy spreads to the related nodes***. One reason for such a fact could be the concept of ***spreading activation***, the idea that ***excitation spreads along the connection of nodes in a semantic network***

Limitations of HMSM

1) *Cognitive Economy*: Conrad (1972) found that people respond no faster to sentences such as “A shark can move” than to “A fish can move” or “An animal can move”.

2) *Hierarchical Structure*: Rips, Shoben & Smith (1973) showed participants were faster to verify “A pig is an animal” than to verify “A pig is a mammal” thus violating the hierarchical structure (animal-mammal-pig)

3) *Typicality Effect*: Rips (1973) found that responses to sentences such as “A robin is a bird” were faster than responses to “A turkey is a bird”. In general typical instances of a concept is responded to more quickly than atypical instances.

The Feature Comparison Model

Smith, Shoben & Rips (1974) proposed an alternative to the HMSM called the ***feature comparison model*** of semantic memory.

Assumption: ***The meaning of any word or concept consists of a set of elements called features. Features come in two types***

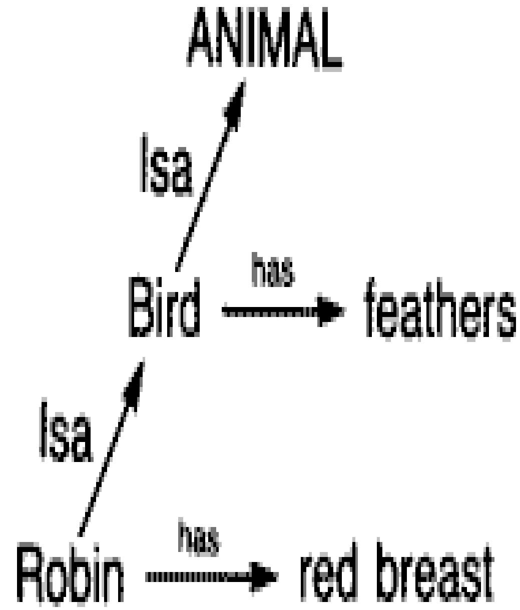
1) ***Defining*** *– meaning that the* ***features must be present*** *in* ***every example*** *of the concept and*

2) ***Characteristic*** *– meaning the* ***features is usually but not necessarily present.***

Attribute or feature list model

Robin	Bird
Physical object	Physical object
Living	Living
Animate	Animate
Feathered	Feathered
Red-breasted	

Hierarchical network model



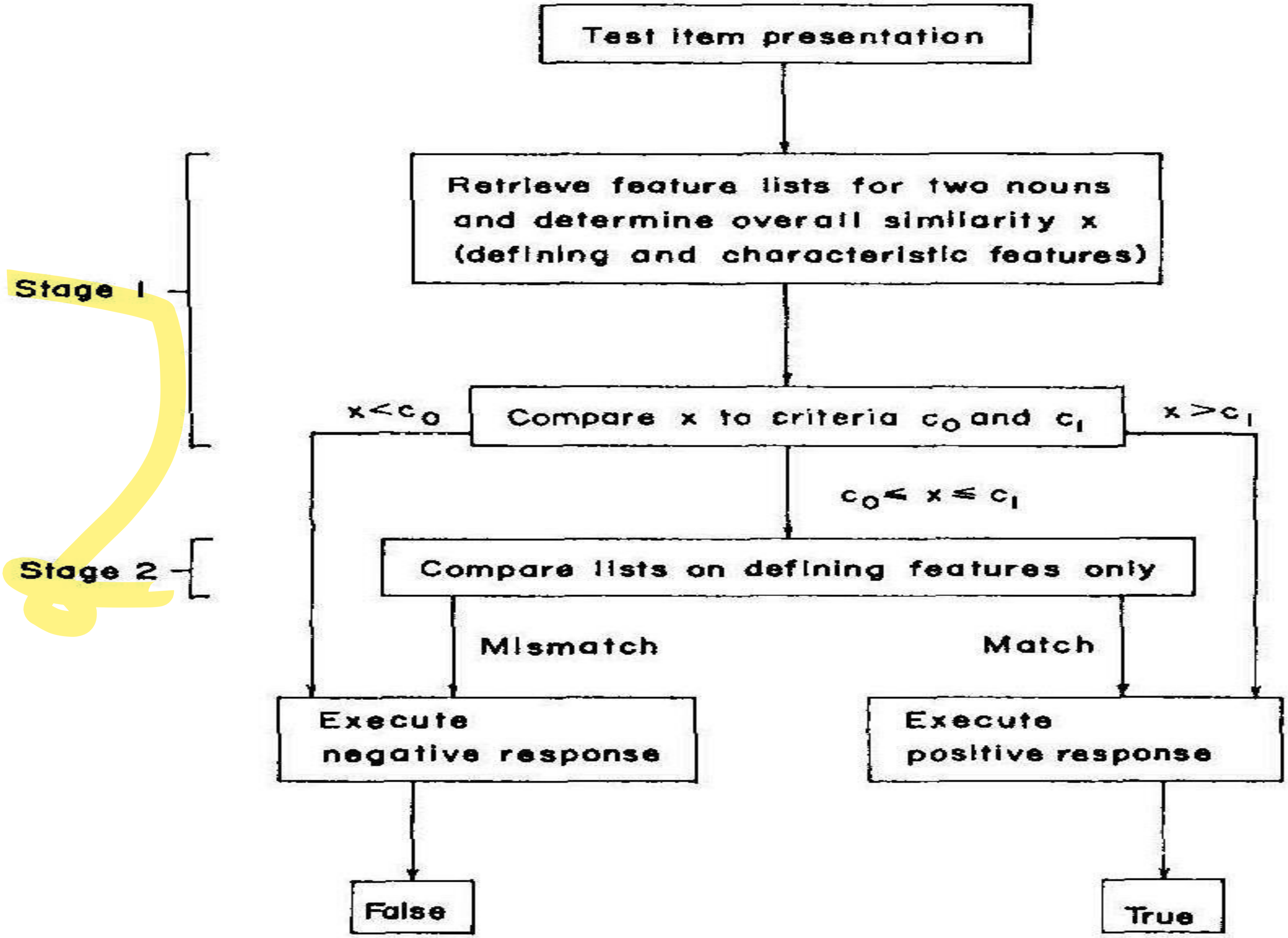


FIGURE 3. A two-stage, feature comparison model for semantic categorization tasks. (See text for explanation.)

Feature Comparison model can explain shortcomings of the HMSM

1) *<u>Typicality Effect</u>*: Sentences like “A robin is a bird” are verified more quickly than “A turkey is a bird” because robin being more typical examples of birds are thought to share more characteristics feature with “bird” than do turkeys

2) *<u>Category Size Effect</u>*: The feature comparison model assumes that as categories grow larger they also become more abstract which lead to lesser defining features.

<u>Criticisms:</u>

1) There is no existence of defining features (suppose a bird has clipped wings. Will it no longer be a bird?)

Other Network Models

Collins & Loftus (1975) presented an elaboration of the Collins & Quillian (1969) Hierarchical model that was the ***spreading activation model***

This model conceives of semantic memory as a ***network, with nodes in the network corresponding to concepts****. They also saw* ***related concepts as connected by paths in the network***

They further asserted that ***when one node is activated*** the ***excitation*** of the node ***spreads down the paths or links*** to related nodes.

They believed that ***as activation spreads*** down the paths or links to related nodes. ***When activation spreads outwards***, it ***decreases in strength***, activating very related concepts a great deal but *activating distantly related nodes* only a little bit.

ANIMAL
P
LEGS
Isa
SPARROW
Isa
FLY
P
P
BIRD
WINGS
WINGS
P
P
P
P
Isa
P
FEATHERS
FEATHERS
BREATHES
P
ROBIN
EYES
P
RED BREAST
P
P
P
P
P
EYES
P
P
EARS
EYES
FEET
BREATHES
FEET
Isa
CHICKEN
P
FEATHERS
P
P
EGGS
CLUCKS
P
P
PECKS
ANIMAL

In this model ***very similar concepts*** have ***many connecting links*** and are ***placed close to each other***. Each ***link/connection between two concepts*** is thought to have a certain ***weight or set of weights*** associated with it.

Criticism: The breadth of the model makes it difficult to make clear and strong predictions from the model regarding empirical findings.

Anderson’s ACT model

Proposed by ***John Anderson (1976, 83, 93)*** and called the ***adaptive control of thought*** model of memory (ACT, ACT-*, ACT-R). Based on ***analogies to computers***, ACT gives rise to ***several computer simulations*** of cognitive processing of different tasks.

Distinguishes among three types of memory systems:

- Declarative memory (information, facts)
- Working memory (information that is currently at a high level of activation)
- Procedural memory

Declarative Memory

Anderson (1983) believed ***declarative memory stores information in networks that contain nodes***.

There are different types of ***nodes***, including those corresponding to ***spatial images or to abstract propositions***.

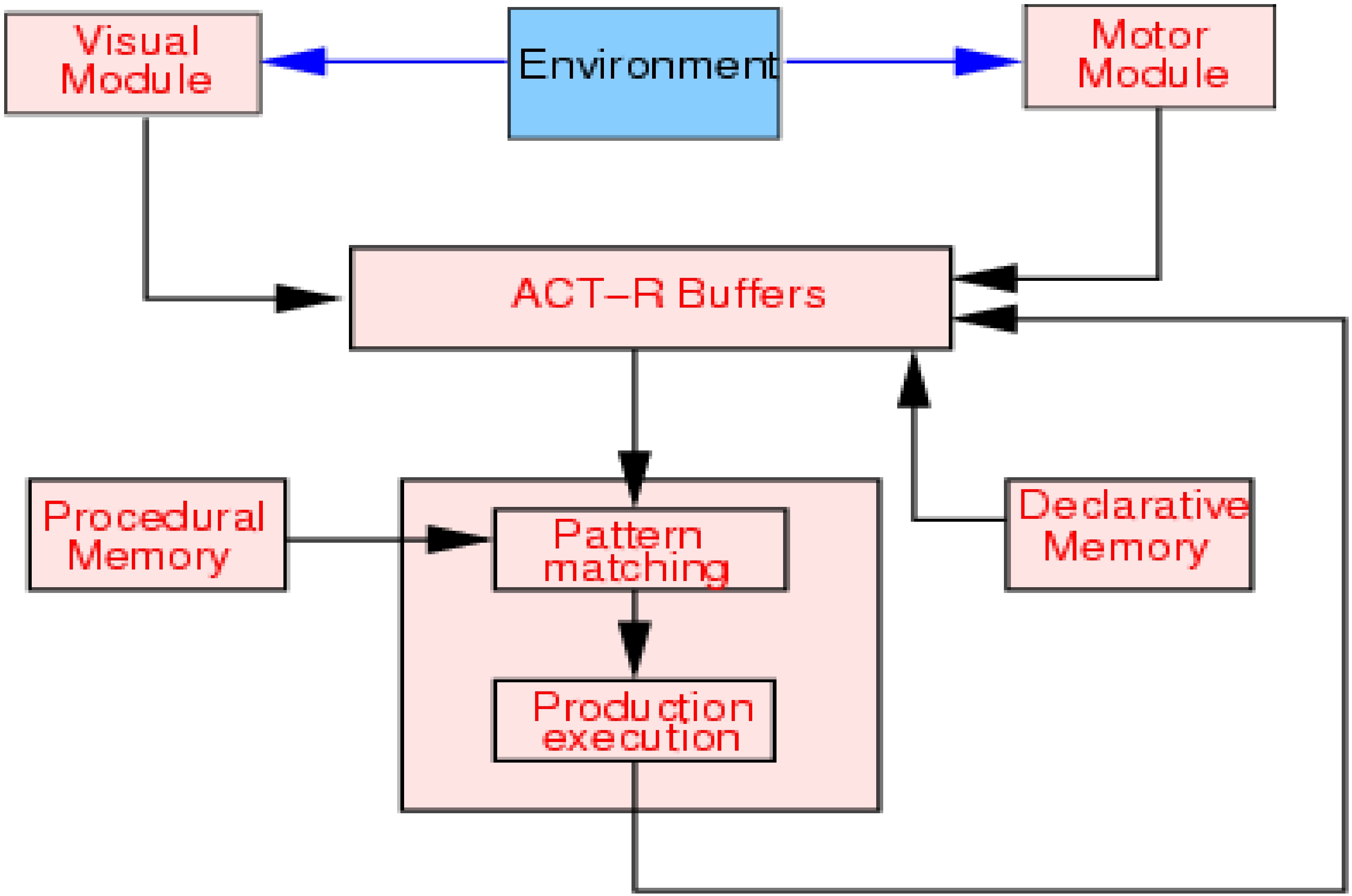
ACT model allows ***both for activation*** of any node and for ***spreading activation*** to connected nodes

Procedural Memory

Representation is as a series of ***"production rules."***

If–then statements that tell ***how to perform*** a particular action

Production rules specify ***a goal to achieve***, one or ***more conditions*** that must be true for the rule to apply, and ***one or more actions*** that result from applying the rule



Visual Module
Environment
Motor Module
ACT–R Buffers
Procedural Memory
Pattern matching
Production execution
Declarative Memory

Connectionist models

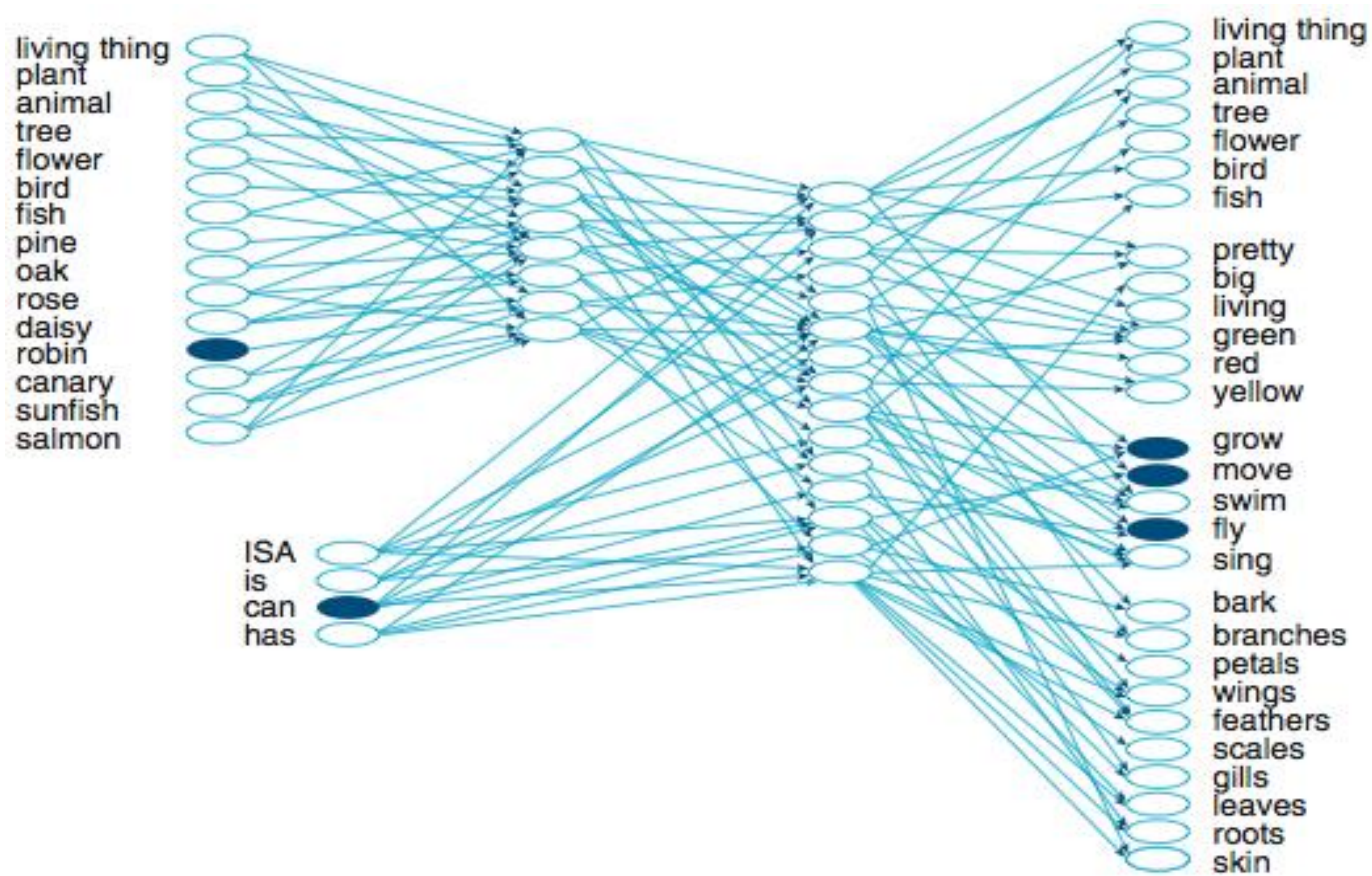
Model ***“learns”*** to develop patterns of activation through ***many trials*** with ***training examples (back propogation)***

Initially, connections between nodes are set at ***random strengths*** (weights); ***experience*** leads these connections to be activated more or less strongly.

Training occurs by presenting a specific example to the network which then generates a particular output.

Training takes places in ‘epochs’. Each epoch produces an output activation which is compared with correct target activation.

A connectionist model for “robin”



Schemata

Represents knowledge in Semantic Memory (Bartlett, 1932)

Schemata contains: *General Knowledge about world and Information about particular events*

Schema – *are large units of organized information which are used for representing concepts, situations, events actions in memory*

Rumelhart and Ortony (1977) – *fundamental building blocks of cognition, units or organized knowledge analogous to theories*

Schemata – *packets of information that contain both variable and fixed part.*

DOG Schemata

Mammal, four legs
(fixed part)

Breed, Size, Color, Temperament
(variable part)

Schemata – *indicated relationship among various pieces of information*

Schemata – *connected to other schemata in a variety of ways*

Schemata – *fills in default values of certain aspects of the situations which help us in making assumptions*

Schemata – *exists at all levels of abstraction; thus they can exist for small parts of knowledge and for very large parts*

Scripts – are schema for routine events (for example going to a restaurant)

Scripts – are used across variety of situations for figuring out unknowns (new city visit)

Scripts – *help us make a number of inferences*

Scripts – *help us for order.*

Bower, Black and Turner (1979) showed that when information from a story is presented in jumbled up sequences people tended to recall the story in scripted order.

Concepts and Categories: Let me Organize….

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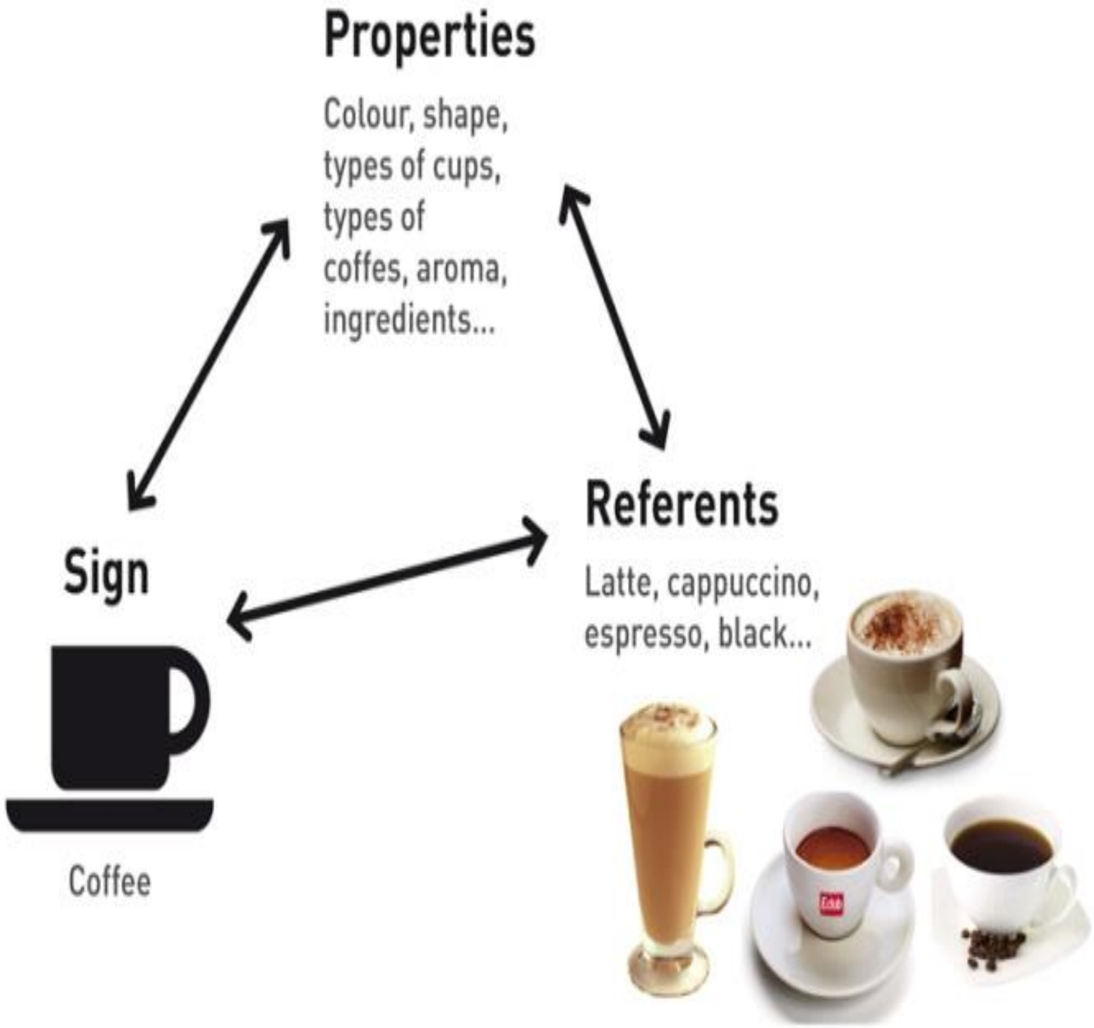
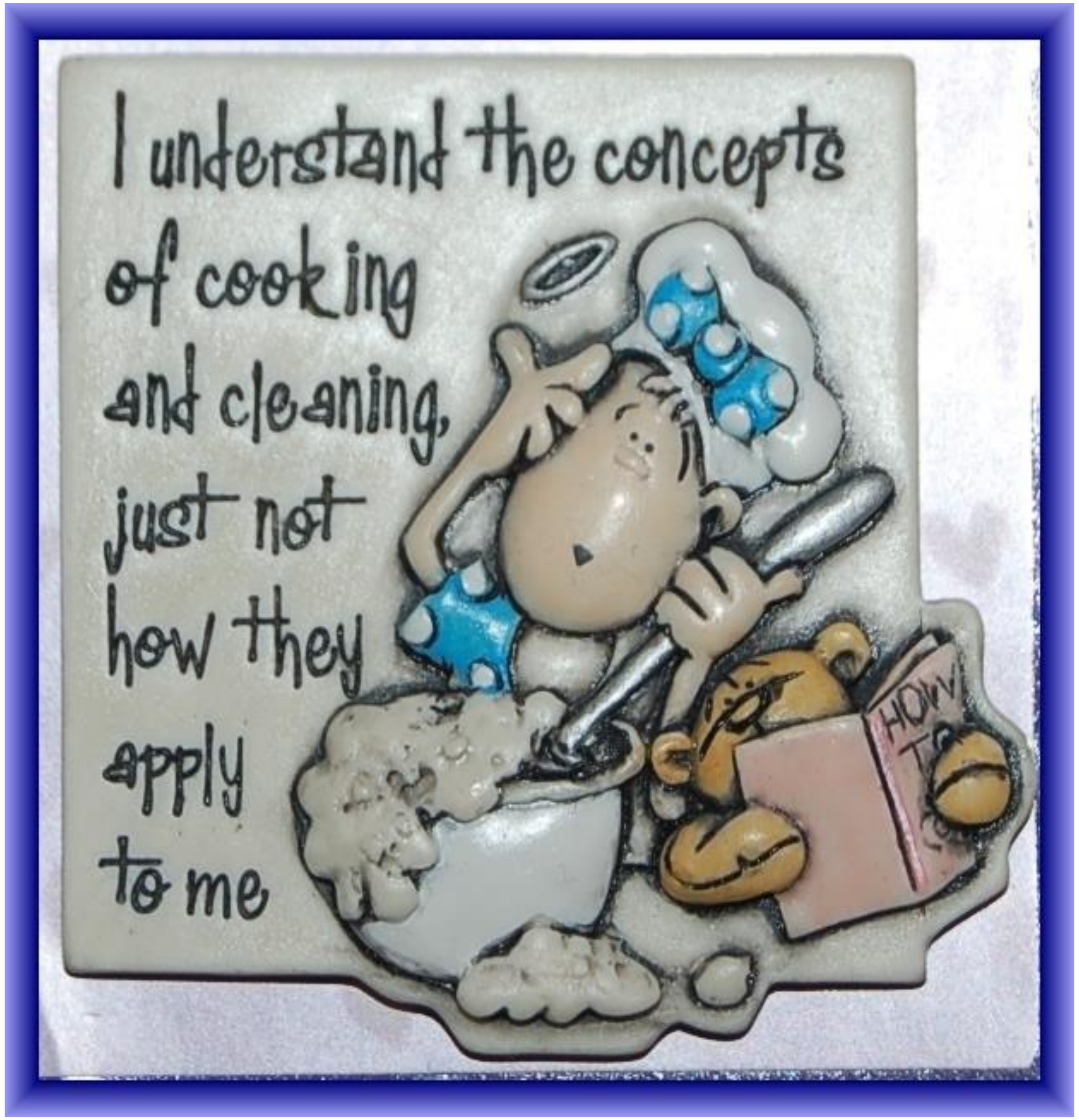

Properties
Colour, shape, types of cups, types of coffes, aroma, ingredients...
Sign
Coffee
Referents
Latte, cappuccino, espresso, black...


I understand the concepts of cooking and cleaning, just not how they apply to me

What do humans process by cognitive processes?

In general, cognitive psychologists believe that humans ***form mental representations*** and it is these that are processed by cognitive processes. Thus all ***knowledge*** in humans are stored as ***mental representations***, and they in turn guide our behavior. Mental representation are stored ***as concepts & categories.***

What is a concept?

A concept is a ***mental representation of some object, event, or pattern*** that stores in it much of the ***knowledge*** typically thought ***relevant to that object, event or pattern***.

e.g., dog (concept) = animal, 4 legs & tail, man’s best friend (knowledge)

What is a category?

A category can be defined as a ***class of similar things (objects/entities)*** that ***share one or two things***: either ***an essential core*** (e.g., why all sciences courses are considered “science”) ***or some similarity in perceptual, biological, or functional properties***

Nature of Concepts

The Classical View

It dates back to Aristotle and dominated psychology till 1970's. This view believe that ***all examples/instances of concept share fundamental characteristics/ features*****.** In particular *the classical view of concepts* holds that the ***features represented are individually necessary and collectively sufficient*** (Medin, 1989).

Concept	Feature(s)
Bachelor	Male Adult Unmarried Human
Even number	Integer Divisible by 2
Triangle	Planar figure Closed geometric figure Three sided

Implications of classical view

-It assumes that ***concepts mentally represent lists of features***

- It assumes ***membership in a category is clear cut***

- It implies that ***all members within a category are created equal***

Critics of classical view

-Rosch found that ***people judge different members of a category differently***

-The idea that ***people store and refer to a list of necessary features*** when judging category membership ***is doubtful***

-Most people ***cannot generate lists of features that are individually necessary and collectively sufficient*** to specify membership in a category

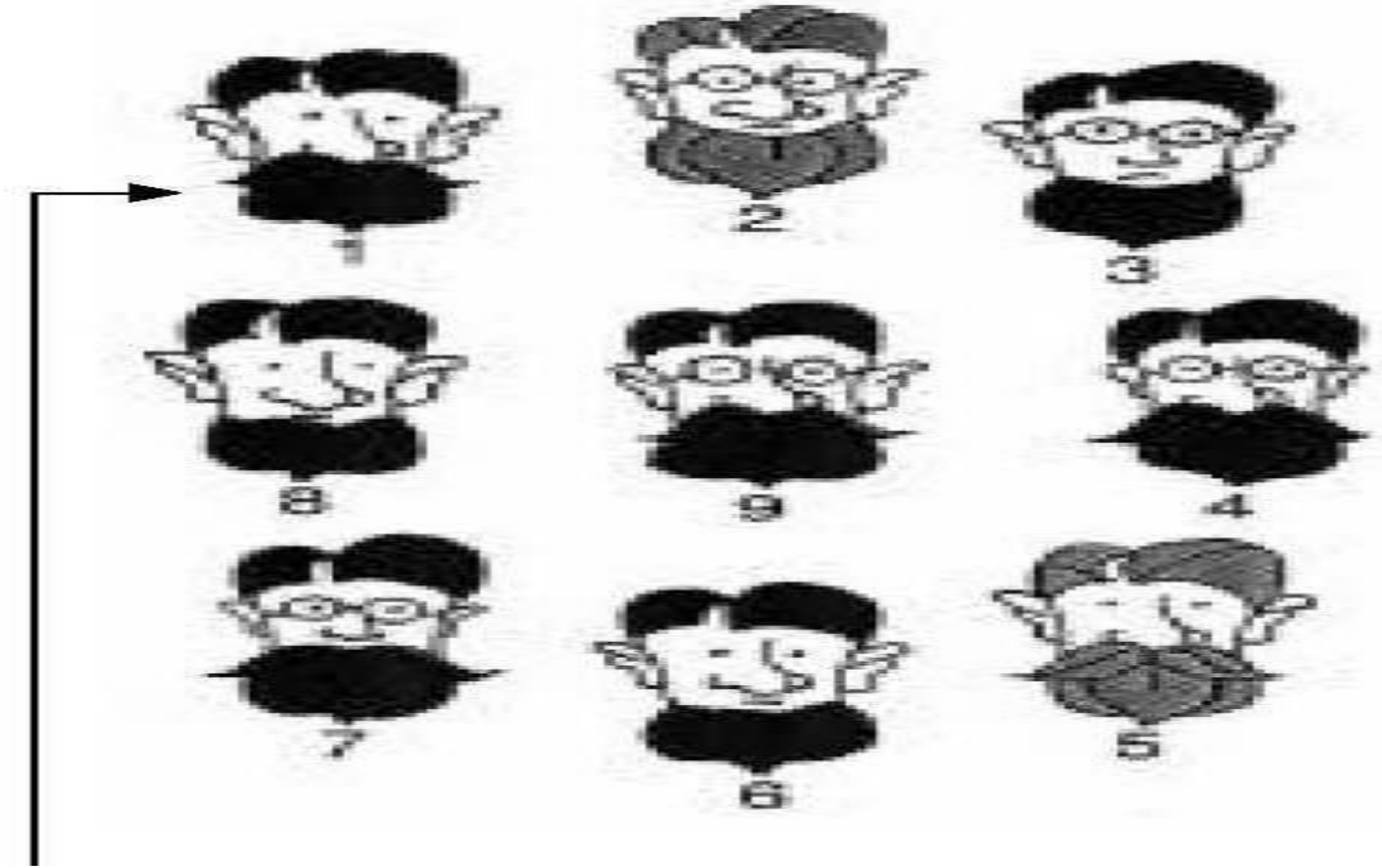
The Prototype View

Like perceptual researchers, conceptual researches believe in the existence of ***mental prototypes***, - ***idealized representations of some class of objects or events***.

Prototypes of concepts are ***features or aspects*** that are ***characteristics*** – that is typical - ***of members of the category*** rather than necessary and sufficient.

No individual feature or aspect ***need be present*** in the instance for it to ***count as a member of the category***, but the ***more characteristic features*** or aspect an instance has, the ***more likely*** it is to be regarded as a ***member of the category***.

- The prototype view of category and concepts ***refers to the family resemblance*** structure of concepts, ***a structure*** in which ***each member*** has a ***number of features***, ***sharing different features with different members.***


1
2
3
8
9
4
7
6
5

-A prototype is some sort of ***abstraction that include all the characteristics of a category*** and ***may/may not be actual instance of category***. Prototypes are often thought of as ***mental "summaries" or "averages"*** of all the instances.

-Concepts exists at many ***different level of a hierarchy*** but one level of abstraction appears ***psychologically fundamental***. This is the ***"basic level" and different from both higher level (super-ordinate) and lower level (sub-ordinate) concepts.***

Critics of Prototype View

-It fails to capture people's knowledge about the ***limits of conceptual boundaries.***

- A second problem from the prototype view has to do with ***typicality ratings***

The Exemplar View

concepts include ***representations of at least some actual individual instances***

categorize new instances by ***comparing to representations*** of previously stored instances, called ***exemplars****.*

difficulty categorizing unclear, atypical instances because such instances are ***similar to exemplars of different categories***

Critics of Exemplar View

- like prototype view it is ***too unconstrained*** and fails to specify ***which instances will eventually be stored*** as exemplars

- how ***different exemplars are "called to mind"*** at the time of categorization.

THE NINE TAXONOMIES USED AS STIMULI

Superordinate	Basic level	Subordinates	
		Nonbiological taxonomies	
Musical instrument	Guitar	Folk guitar	Classical guitar
	Piano	Grand piano	Upright piano
	Drum	Kettle drum	Base drum
Fruit[a]	Apple	Delicious apple	Mackintosh apple
	Peach	Freestone peach	Cling peach
	Grapes	Concord grapes	Green seedless grapes
Tool	Hammer	Ball-peen hammer	Claw hammer
	Saw	Hack hand saw	Cross-cutting hand saw
	Screwdriver	Phillips screwdriver	Regular screwdriver
Clothing	Pants	Levis	Double knit pants
	Socks	Knee socks	Ankle socks
	Shirt	Dress shirt	Knit shirt
Furniture	Table	Kitchen table	Dining room table
	Lamp	Floor lamp	Desk lamp
	Chair	Kitchen chair	Living room chair
Vehicle	Car	Sports car	Four door sedan car
	Bus	City bus	Cross country bus
	Truck	Pick up truck	Tractor-trailer truck
		Biological taxonomies	
Tree	Maple	Silver maple	Sugar maple
	Birch	River birch	White birch
	Oak	White oak	Red oak
Fish	Bass	Sea bass	Striped bass
	Trout	Rainbow trout	Steelhead trout
	Salmon	Blueback salmon	Chinook salmon
Bird	Cardinal	Easter cardinal	Grey tailed cardinal
	Eagle	Bald eagle	Golden eagle
	Sparrow	Song sparrow	Field sparrow

[a] Fruit is not considered a biological taxonomy by the criteria in Berlin (1972).

or greater from the Kučera and Francis (1967) sample of written English. A superordinate category was considered in common use if at least four of its members met this criterion. Categories were eliminated if: (a) all of the items bore a part–whole relationship to the only reasonable superordinate (e.g., parts of the body, parts of buildings), (b) if there was linguistic ambiguity amongst possible superordinates (e.g., *animal* is commonly used as a synonym for *mammal*), and (c) if the superordinate cross-cut a large number of other taxonomic structures (e.g., *food*).

By these criteria, only one biological category, *bird*, could be included in the study. Because biological taxonomies were the only ones in which hypotheses concerning basic objects based on independent linguistic evolutionary data existed, it was necessary to amend the inclusion criteria. A biological category was included if at least one member of the category (or the superordinate noun itself) achieved a Kučera and Francis frequency

The Schemata View

This view ***shares features with both the prototype view*** (in that both schemata and prototypes store information that is abstracted across instances) ***and the exemplar view*** (both schemata and exemplar store information about actual instances).

Critics of schemata view

-It does not ***specify clear enough boundaries*** among individual schemata

- The schemata framework, in the present view, ***is not sufficiently delineated*** to be ***empirically testable***

- Also question like ***what information leads to schemata*** and ***how are they modified*** plus the ***process of using appropriate schemata*** is not known.

The Knowledge Based View

The idea of knowledge-based view is that a person classifying objects and events ***doesn’t just compare features or physical aspects*** of the objects and events ***to features or aspects of stored representations***. Instead, the person ***uses his/her knowledge of how the concept is organized, to justify the classification*** and to explain why certain instances happen to go together in the same category.

Most previous views of concepts ***fail to answer satisfactorily how things in the same category go together***. The knowledge based view proposed that ***people's theories or mental explanations about the world are intertwined with their concepts and provide the basis for categorization***

The Five approaches to conceptual structure has been categorized into two subtypes (Komatsu, 1992).

Similarity based category

- The *similarity based* category consists of classical, prototype, exemplar & parts of schemata views.

- It includes approaches in which categorization is assumed to be based on the similarity of an instance to some abstract specification of the category

- The key critic of this view is that similarity is meaningful only in certain respects

***Explanation based* category**

- Comprises of the schemata view and knowledge based view.

- People using this view base classification on meaningful relationships among instances and categories.

Forming New Concepts and Classifying New Instances

Concept formation requires some basis of generalization, for grouping certain things but not others together. This process requires figuring out what features are relevant / irrelevant with little feedback.

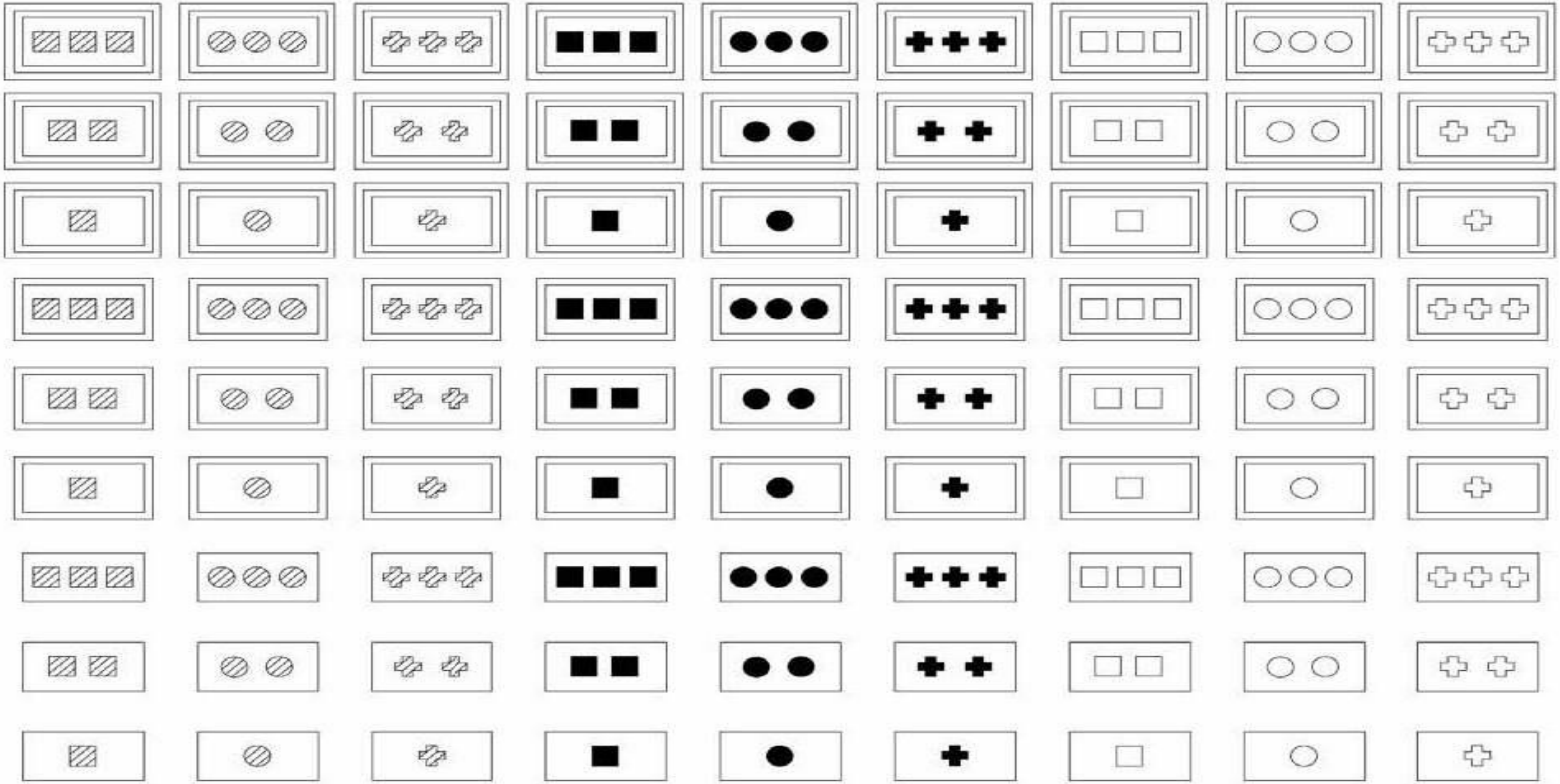
Concept Attainment Strategies

The process of acquiring concepts involve – *acquiring the information* necessary to isolate and learn a concept, *retaining the information* for later use and *transforming the information* to make it usable when testing ideas about new possible instances. The possible strategies for concept formation involve

- *Simultaneous Scanning*

- *Successive Scanning*

- *Conservative Focusing*



Bruner et.al. (1956) found that the effectiveness of each of their strategies depend to some extent on the task conditions

Acquiring Prototypes

- People do form and use prototypes, even when given distorted instances during the learning

- Learning about category variability may be at-least as important as learning about prototypes, especially if categorizations are to be made later for new instances that vary a great deal from the prototype

Implicit Concept Learning

Brooks (1978) defined *Non analytical concept formation (in contrast to logical, scientific and focused),* also called *Implicit Learning*, require that people pay attention to individual exemplars, storing information about the representations of them in memory. Later classifications are done by comparing new instances to the representations, drawing analogies between new and old.

Brooks describes five factors that encourage people to store information about individual exemplars

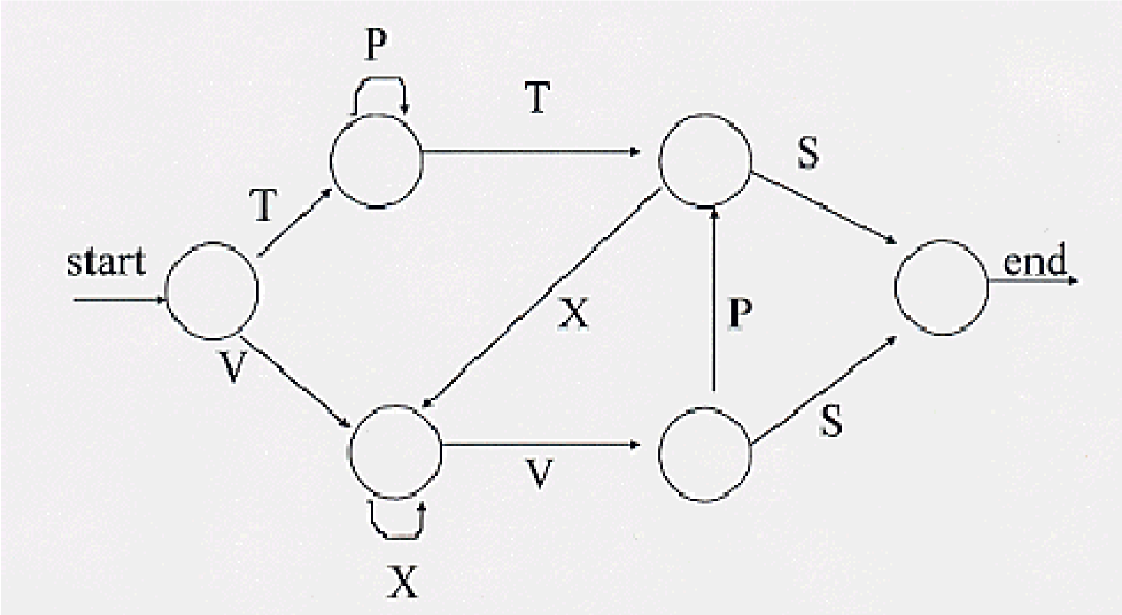
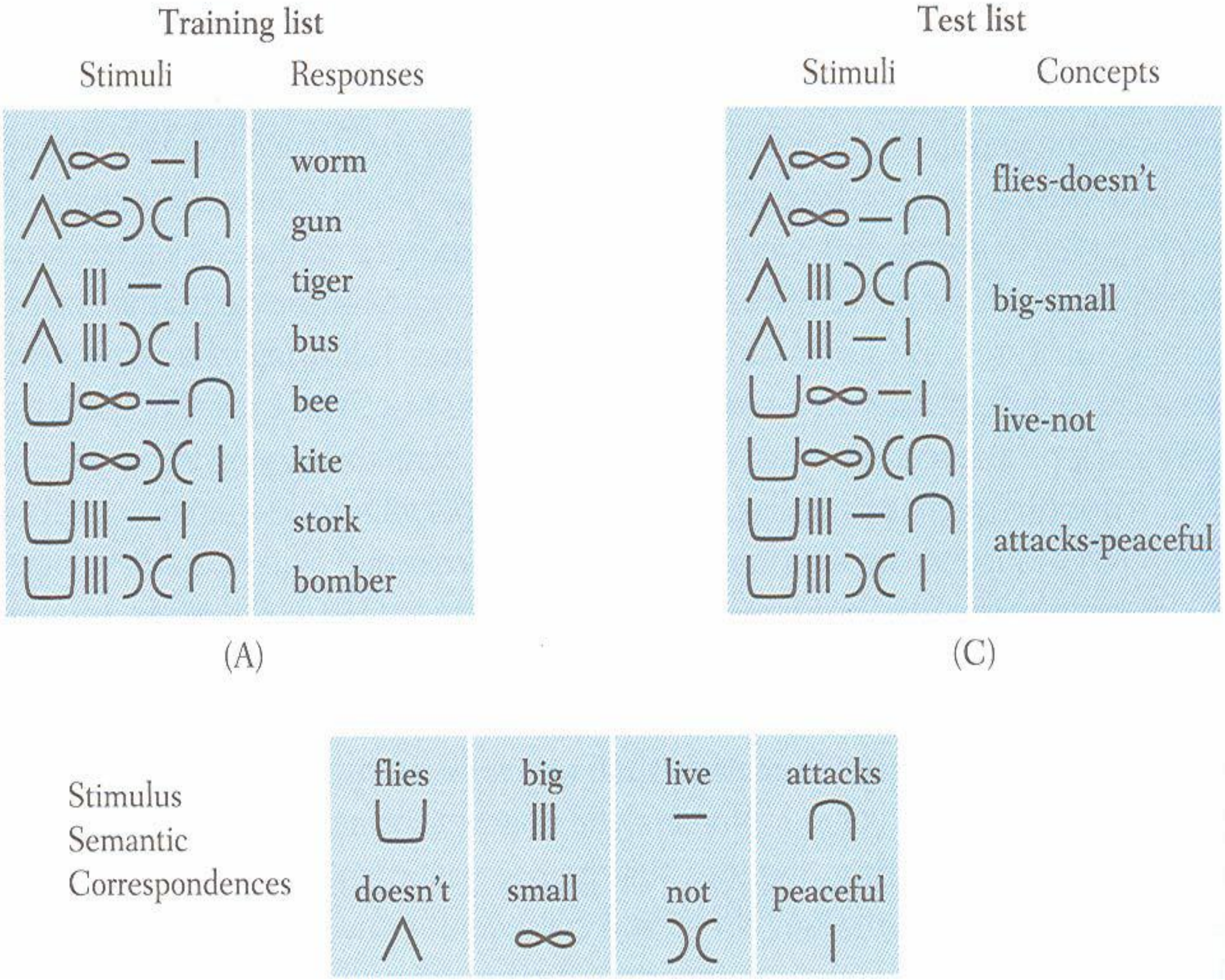


Figure 1: The finite-state artificial grammar created by Reber (1967)

- Examples of ruleful & unruleful strings:

VXVS	VXXXS
TPTXVS	TPTPS


Training list
Stimuli
Responses
worm
gun
tiger
bus
bee
kite
stork
bomber
(A)
Test list
Stimuli
Concepts
flies-doesn't
big-small
live-not
attacks-peaceful
(C)
Stimulus
Semantic
Correspondences
flies
big
live
attacks
doesn't
small
not
peaceful

- The first factor involves task requirements to learn information that distinguishes among individual instances

- A second factor involves the original learning situation

- Third, some stimuli lend themselves to hypothesis testing better than others

- A fourth factor is that in real-life concept learning, instances may belong to a number of categories all at the same time.

- Fifth, in natural settings we learn about instances without knowing how we will be called on to use the information later.

Visual Memory: Imagine That ....

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Visual Imagery

Visual imagery is information which passes through the brain as though something is being perceived, when nothing is actually happening. Someone may experience sight, smell, sound, and touch as a result of visual imagery when none of these stimuli are present. Visual imagery involve the use of mnemonics


RELAX

Mnemonics and mental codes

Mnemonics involve the construction of mental pictures or images which helps us in increasing our chances of remembering information. There are several techniques of mnemonics.

1) *Method of Loci – requires the learner to imagine a series of places (locations) that have some sort of order to them.*

e.g., suppose you want to remember a list of 10 item to shop.

Try to imagine your front door but with a huge banana instead of the usual handle. When you open the door and walk into the entrance the floor is covered in eggs and you have to walk over the eggs to get to the living room. Imagine the eggs cracking under your feet and the mess! Anyway it gets much messier because when you open the living room door you are almost knocked off your feet by the river of milk that comes gushing out. You stagger over to the window to pull the curtains which have turned into two giant slices of bread. You try to turn on the TV but fail because that has been replaced by a very large packet of cereal. Time to have a sit down, but when you collapse on the sofa you sink down into a sofa sized ginger cake. Go to the kitchen for a drink. Walking across the kitchen floor is a bit difficult as it is knee deep in sugar and when you have reached the kettle you find it has turned into a bottle of wine. I prefer white but you can visualise red if you want. Give up and go for a mug of water. Unfortunately when you reach down a mug from the cupboard it is filled with a bouquet of flowers and when you turn the tap on it is chocolate not water that comes out.

Shopping list

Bananas
Eggs
Milk
Bread
Cereal
Cake
Sugar
Wine
Flowers
Chocolates

2) **Technique of interacting images** – states that recall of concrete nouns on a list improved when participants will told to form images of the words,   in comparison to when they were not given such instructions.

e.g., In a pair word recall test of the pairs dog/pipe, image of a dog smoking pipe will make better recall than the images of dog and pipe kept together

3) *Peg word method – it involves picturing the item with another set of ordered "cues" – pegging them on the cue. In this case the cues are not locations but rather nouns that come from a memorized rhyming list.*

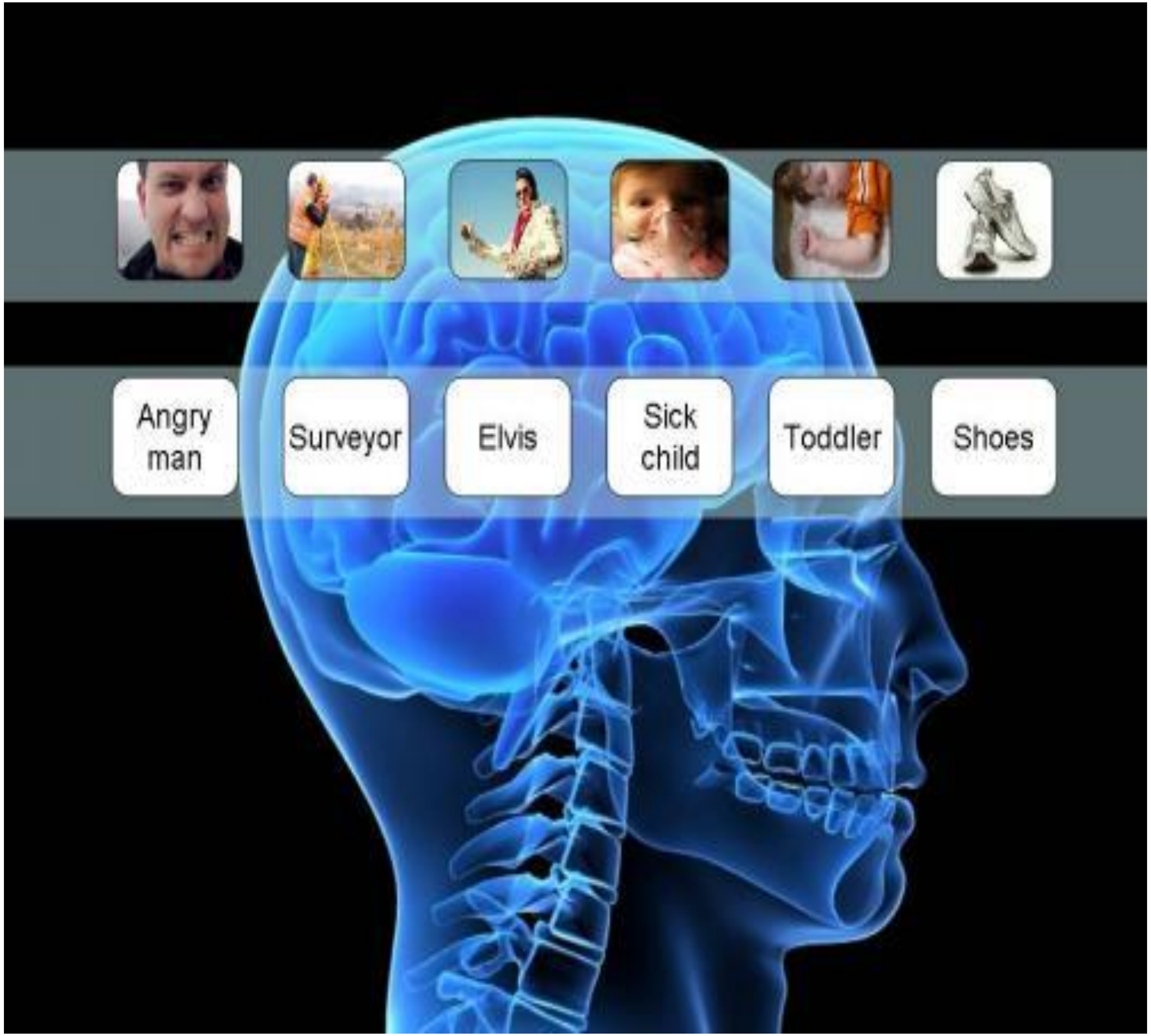
Number	Pegword	Number	Pegword
One	Bun, gun, sun	Eleven	Lever
Two	Shoe	Twelve	Elf
Three	Tree	Thirteen	Thirsting
Four	Door, floor	Fourteen	Forking
Twenty	Twinty, Plenty	Sixty	Witchy
Thirty	Dirty	Seventy	Heavenly
Forty	Warty	Eighty	Weighty

In order to study my mnemonics generally used visual imagery and how visual imagery functions two lines of explanation exists

<u>The Dual – Coding Hypothesis</u>

Alan Paivio (1969, 71, 83) originated the dual-coding hypothesis of memory, According to Paivio

LTM contains ***two distinct coding systems*** *(or codes) for representing information to be stored. One is* ***verbal****, containing information about an item's abstract, linguistic meaning. The other involves* ***imagery****: mental pictures of some sort that represents what the items look like. Paivio's idea is that pictures and concrete words give rise to both verbal labels and visual images.*


Angry man
Surveyor
Elvis
Sick child
Toddler
Shoes

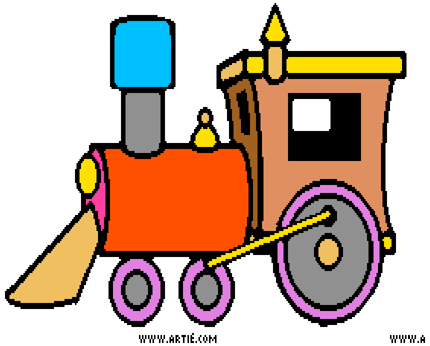
The Relational – Organizational Hypothesis

Bower (1970b) proposed the relational-organizational hypothesis.

The theory states that imagery improved memory, not because images are necessarily richer than verbal labels, but because imagery produces more associations between the item to be recalled.

Forming an image typically requires a person to create a number of links or hooks between the information to remember and other information.

Bower (1970) experiment to distinguish dual coding hypothesis from the relational organizational hypothesis

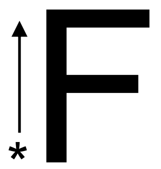
Learn Pair words	train / wall		Recall %
Group 1	Overt rote repetition	train / wall	30%
Group 2	Image	 	27%
Group 3	Image		53%

Evidences for the existence of Imagery

Studies by Lee Brooks (1968) yield some of the best evidence that images are distinct from verbal materials or at least use different process from those used by verbal materials

*Move clockwise mentally from * to mark each corner as top most/bottom most*

Indicate for each word whether it is a concrete noun or not



A BIRD IN THE HAND IS NOT IN THE BUSH

Indicate Response As

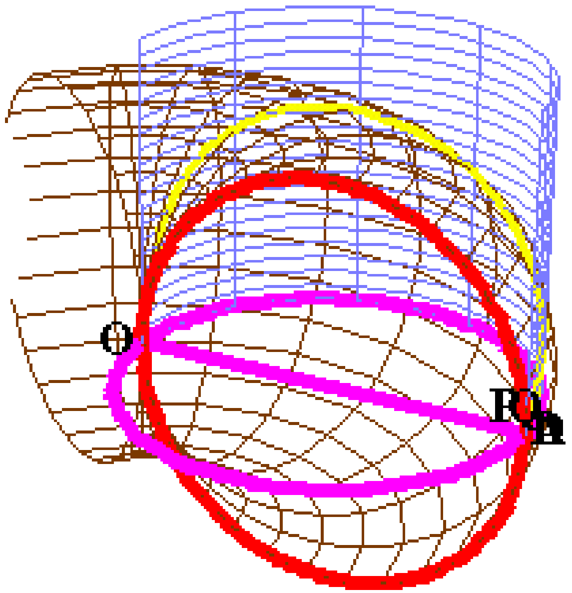
1)Verbally saying yes or no for each movement

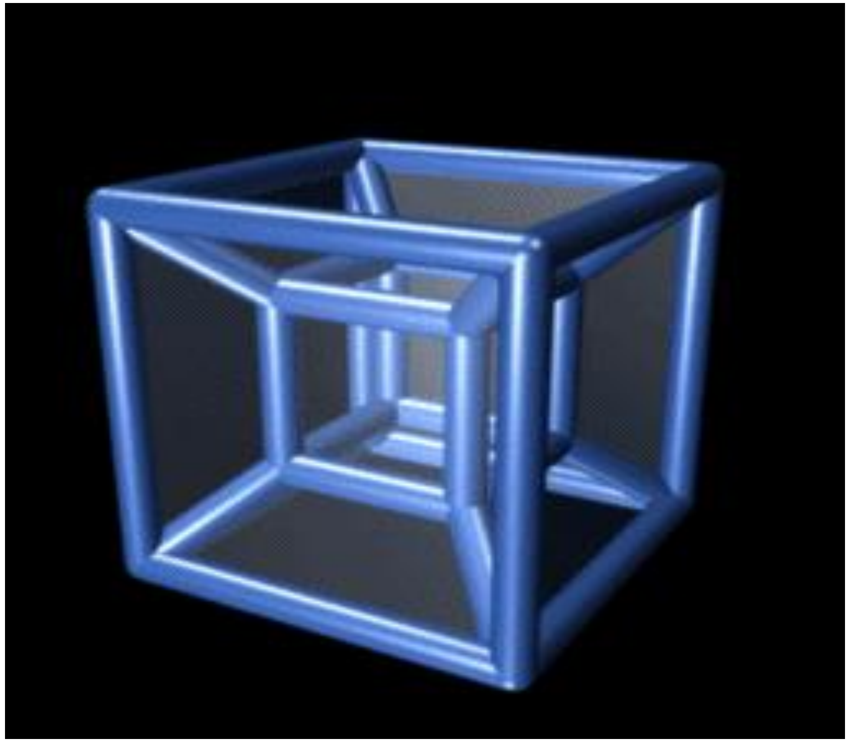
2)Mark on list your responses as

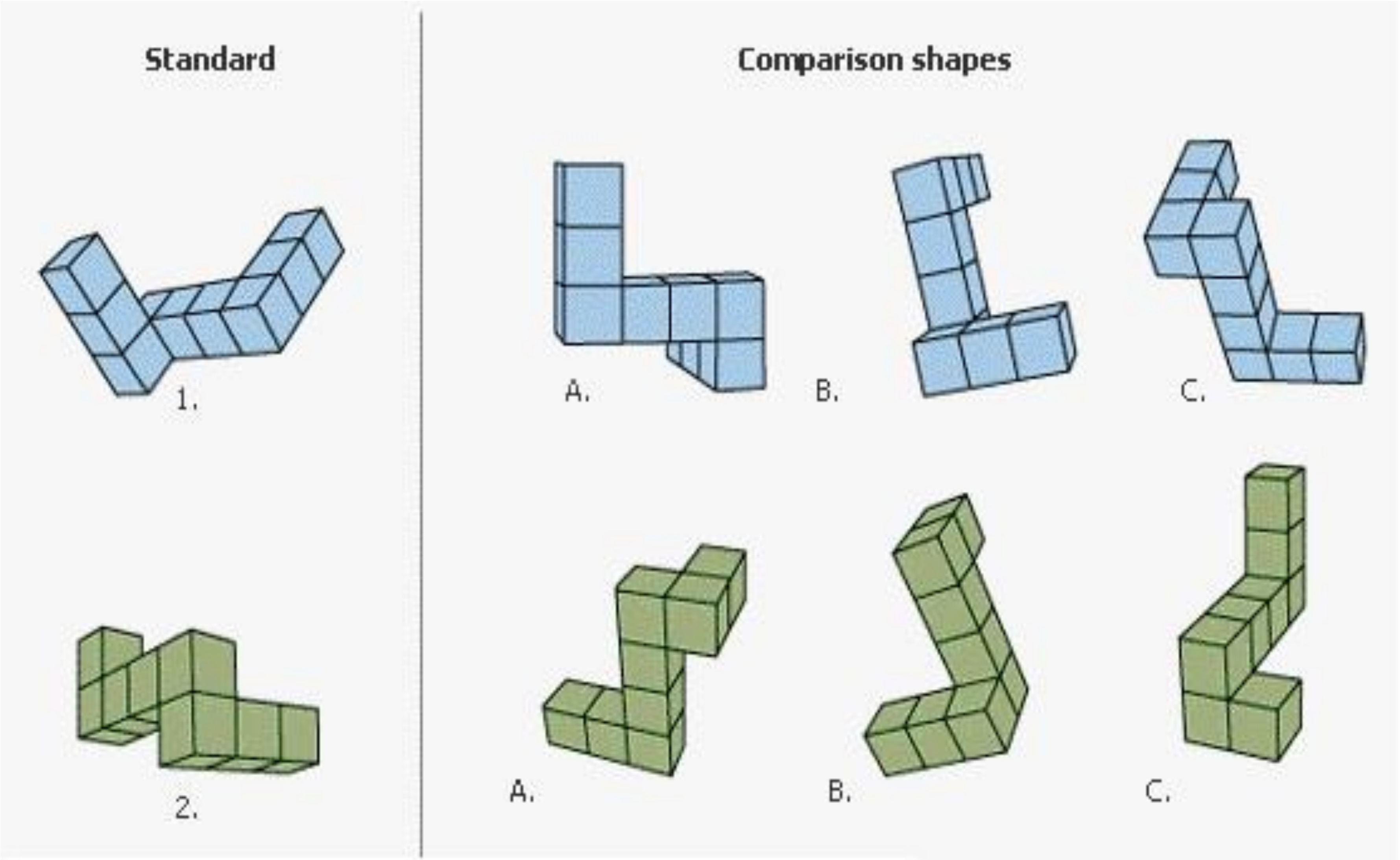
Y	Y	N
N	N	Y

Mental Rotation of Images

One important finding for visual imagery was that people can do more than simply create images mentally, they could also mentally transform them







Mental rotation test

Shepard & Matzler (1971) in their experiments showed participants line drawings of three dimensional object. On each trial subjects would see two drawings

1) same object with one rotated by some degree

2) mirror image reversals with/without rotation

The result of the experiment showed that the amount of time it took participants to decide if the two drawings depicted the same object or a mirror-image reversal was directly proportional to the angle of rotation between the drawings

The close relation between the angle of rotation of the drawings and participants reaction times strongly suggest that they performed the task by ***mental rotation*** of the drawing

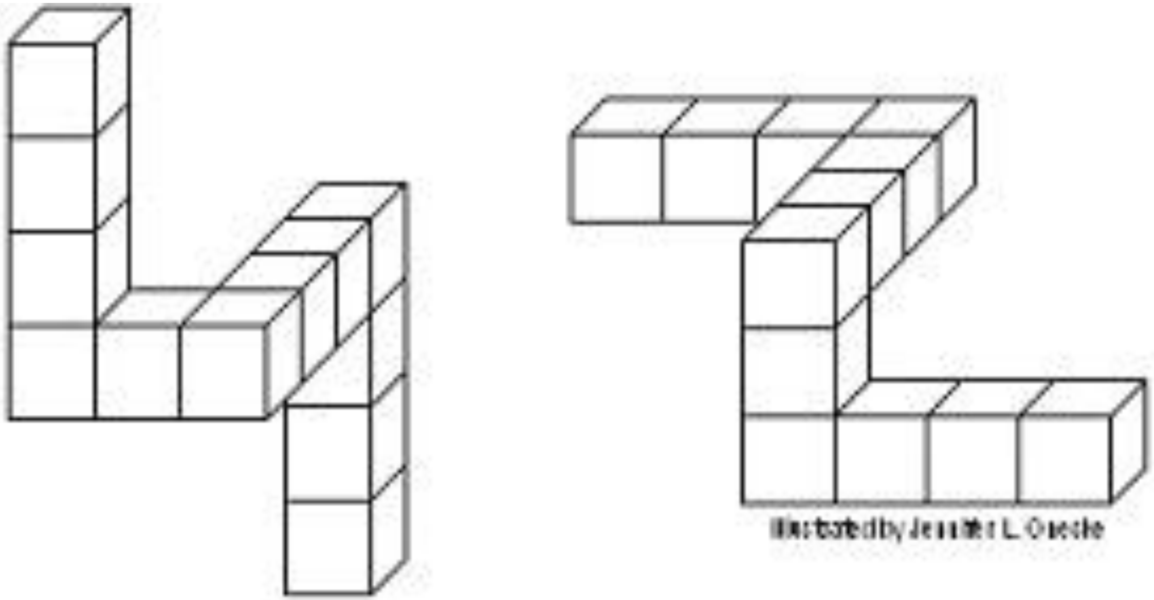


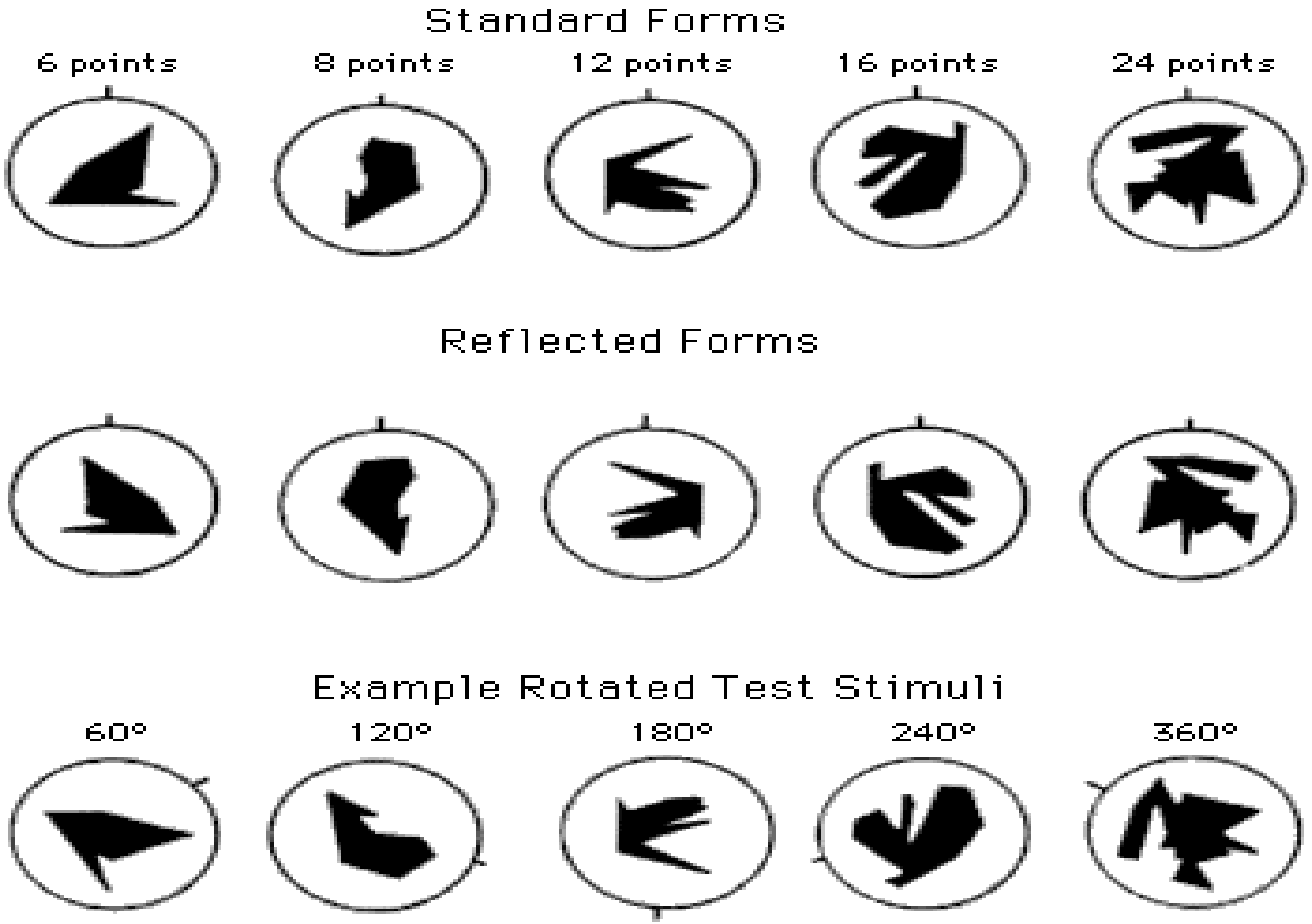
Figure 1: Based on Shepard & Metzlar's 'Mental Rotation Task'

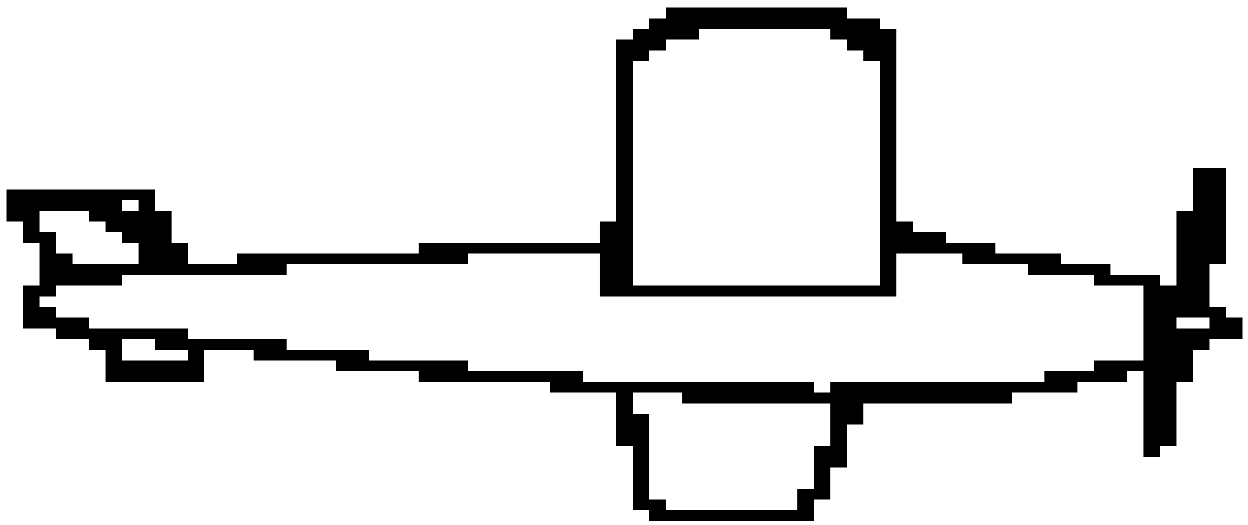
Figure 2: Mental Rotation Task Based on Canonical Orientations

Another question that puzzled researchers was – whether people mentally rotate the whole/part of the image in the mental rotation task. Lynn & Cooper (1975) using the irregular polygon task reaction time increased linearly with the angle of rotation and the rate of rotation was same for all the polygons regardless of their complexity.

In another study Cooper (1976) showed that mental rotations like physical rotations are continuous in nature

Cognitive psychologists also started searching how people recognize objects presented in unusual angle. One possibility is to mentally rotate the image till it reaches the orientation of depiction (Pinker & Tarr 1989) or that distinctive geons of the object remain visible we can recognize them with rotation (Biederman & Gerhardestein, 1993)


Standard Forms
6 points
8 points
12 points
16 points
24 points
Reflected Forms
Example Rotated Test Stimuli
60°
120°
180°
240°
360°



The Nature of Mental Imagery

Visual images share some properties with pictures. But what are images, what kind of properties do images have and how are these like and unlike the properties that real pictures have?

Ronald Finke (1989) proposed some fundamental principles of visual imagery. They are

1) *Implicit Encoding*: Mental imagery is instrumental in retrieving information about the physical properties of objects or about physical relationships among objects that was not explicitly encoded at previous time

2) *Perceptual Equivalence*: Imagery is functionally equivalent to perception to the extent that similar mechanisms in the visual system are activated when objects or events are imagined as when the same objects or events are actually perceived. (e.g. Perky 1910)

3) *Spatial Equivalence*: The ***spatial arrangement*** of the elements of ***a mental image*** corresponds to the way objects or their parts are arranged on ***actual physical surface*** or in an actual physical space (e.g., Kosslyn, 1978)

4) *Transformational Equivalence*: ***Imagined transformations*** and ***physical transformations*** exhibit corresponding dynamic characteristic and are governed by the same laws of motion (e.g., Cooper, 1976)

5) *Structural Equivalence*: The ***structure of mental images correspond*** to that of ***actual perceived objects***, in the sense that the structure is coherent, well organized, and can be recognized and reinterpreted (e.g., Kosslyn, Farah & Fliegel 1983)

Critiques of Mental Imagery

There exists many critiques to mental imagery. Some of the main themes of debate are

1) Tacit knowledge & demand characteristics

2) Picture metaphor

3) Propositional theory

Tacit Knowledge and demand characteristics

Pylyshyn (1981) argued that the result from many imagery studies reflect participants underlying and implicit, *tacit knowledge*, and beliefs about the task rather than their construction and manipulation of visual images.

Finke (1989) with his example of moving the coffee cup provided evidence to Pylyshyn’s claim

Pylyshyn (1981) states that tasks that are affected by people's beliefs and expectations are termed *cognitive penetrable*. Such tasks make it obvious to participants how they ought to perform and are said to have *demand characteristics (Orne, 1962)*

Sometimes experimenters unconsciously give subtle cues to participants. Intons & Peterson (1983) called such cues as *experimenter expectancy effects.*

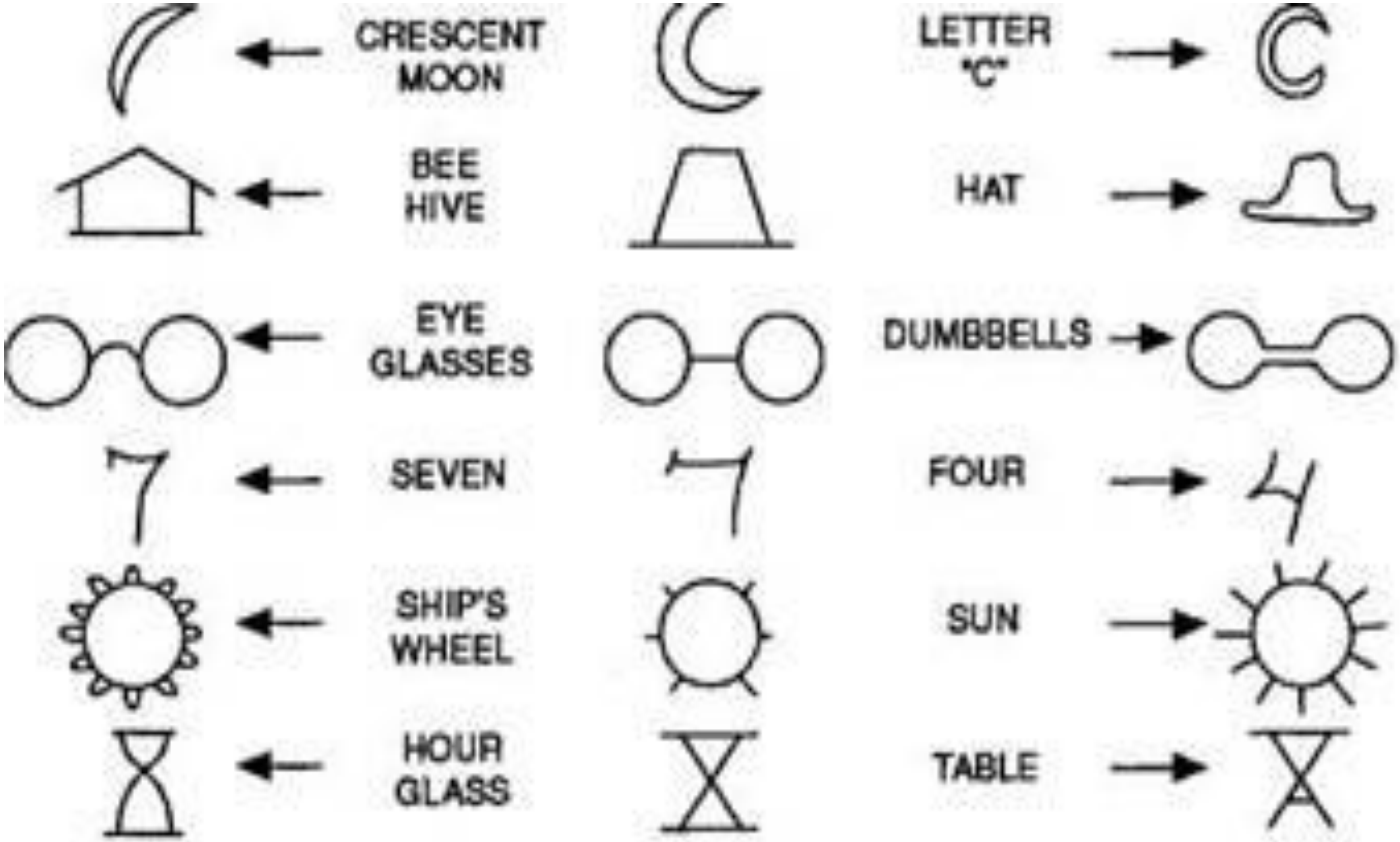
The Picture Metaphor

Visual images are casually spoken as mental pictures, how far is the statement true. Pylyshyn (1973) pointed out that pictures and images differ in several ways

1) Pictures can be physically looked at without knowing what it’s a picture of but images cannot be looked at unless you know what it is

2) Pictures and images are disrupted & disruptable in different ways

3) Images are more easily distorted by the viewers interpretation


CRESCENT MOON
LETTER "C"
BEE HIVE
HAT
EYE GLASSES
DUMBBELLS
SEVEN
FOUR
SHIP'S WHEEL
SUN
HOUR GLASS
TABLE

Propositional Theory

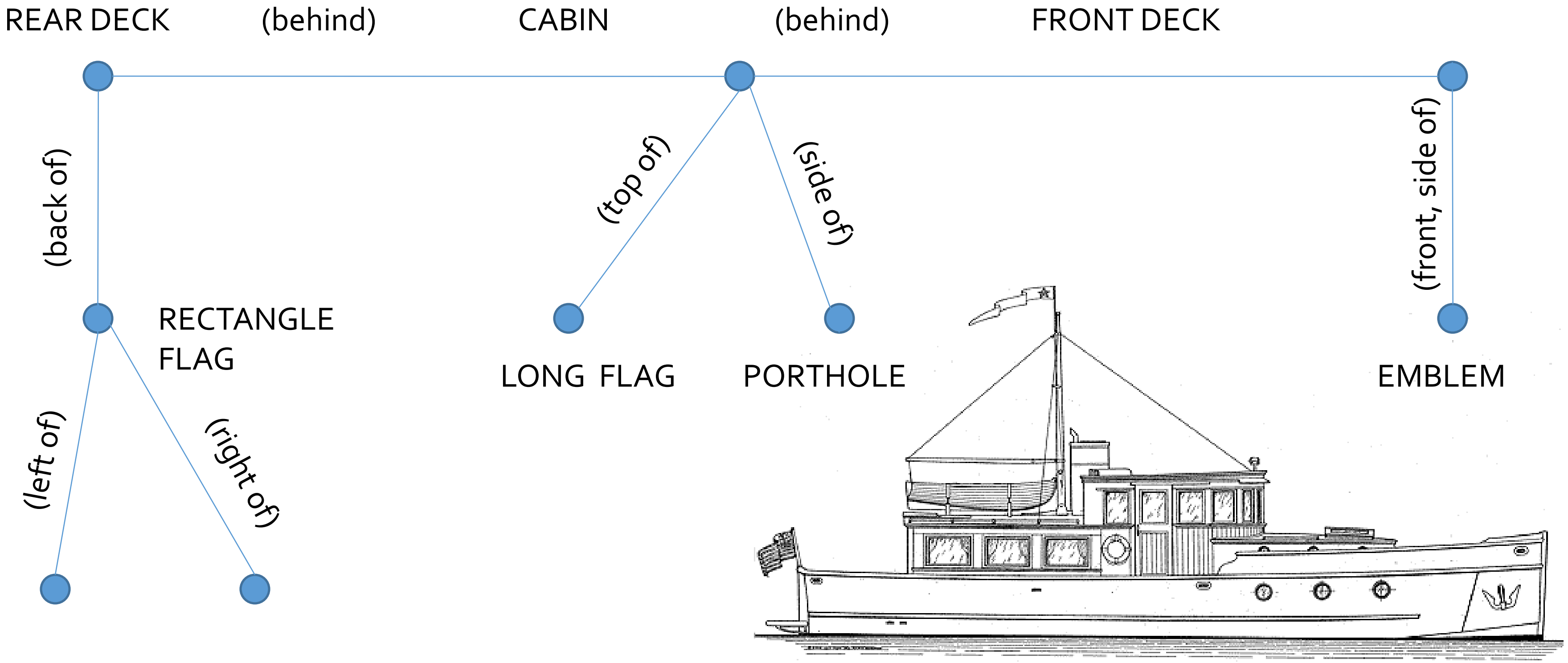
Propositional Theory – ***original mental imagery idea is that mental images are a special type of encoding***; propositional theory says this is not true, ***that there is only one kind of encoding, which is neither visual nor verbal***. Pylyshyn suggested that ***the experience of having a mental image is really just an epiphenomenon*** (something that happens with a process, but that does not cause the process, instead is just a by-product – without the epiphen. The process would go on just like normal – not necessary for process to occur)

Ex. when computer is calculating something, it often has a flashing light, but flashing light has nothing to do with the actual computation; if light blew out, computation will still happen, so trying to understand how and why the light comes on and flashes will not tell us anything about how the computations are occurring

Instead, the encoding is propositional – concepts are stored as symbols, and what is stored is not a physical relationship, but a conceptual one, like the network models of memory

So it would make sense that trying to scan a path from the flag at the back of the boat to the cabin would take less time than scanning from the flag to the emblem, since you would have more nodes to go thru (2 vs. 4)

So it is possible to explain scanning times without having to use a mental image



Spatial cognition

- Space of the body: Where are the parts of your body located at any particular time?
- Space around the body: the area immediately around you
- Space of navigation: larger spaces that we walk through, travel to, and explore
- Our mental representations of these spaces may be distorted, made “neater,” and more regular.

Language: Entschuldigen Sprechen Sie Englisch

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"Waiter, this soup is fly."

Language

What is language and how is it different from communication?

Although language is often used as a communication system, there are other communication systems that do not form a true language like (Honey bee dance, smoke from mountains & bird song)

A natural language has two necessary characteristics:

a) it is regular (governed by a system of rules called grammar)

b) It is productive (infinite combination of things can be expressed)

c) arbitrariness (lack of a necessary resemblances between a word or sentence and what it refers to)

d) discreteness (the system can be sub-divided into recognizable parts e.g., sentences into words, words into sounds)

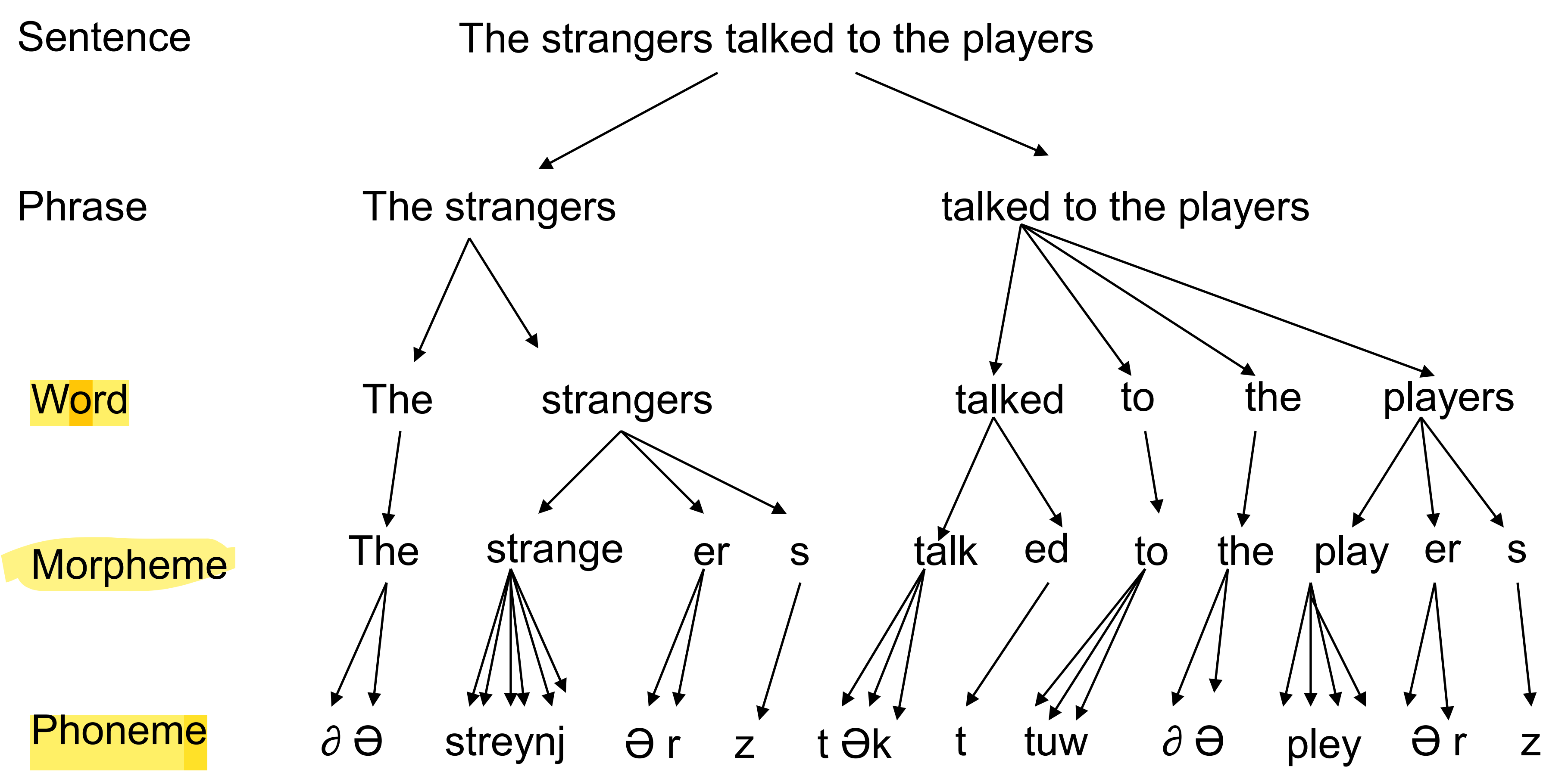
The structure of language

Language comprises of a number of system working together. Evaluating the structure of a language requires the study of a conversation

Conversation demands that we listen to & perceive the sounds of the speaker. Different language have different sounds (***called phonemes***). The study of the way in which phonemes can be combined in any given language constitutes the study of ***phonology.***

The various phonemes are combined together to yield meaningful units of language (***called morphology).*** Word endings, prefixes, tense markers are the critical part of each sentence. Some of the ***morphemes (smallest meaningful units of language)*** are words and needs to be identified in order to study the role played by each word in a sentence. This is done by determining the ***syntax (structure)*** of a sentence

A syntactically correct sentence does not by itself make a good conversation. The sentence must mean something to the listener. Semantics is the branch of psycholinguistics devoted to the study of meanings.



Sentence
The strangers talked to the players
Phrase
The strangers
talked to the players
Word
The
strangers
talked
to
the
players
Morpheme
The
strange
er
s
talk
ed
to
the
play
er
s
Phoneme
∂ ə
streynj
ə r
z
t ək
t
tuw
∂ ə
pley
ə r
z

For conversations to work there must be some flow. Listeners must pay attention and make certain assumptions, and speakers must craft their contribution in ways that will make the listeners job feasible. This aspect of language is called ***pragmatics***

Grammar is the set of rules for a language. Psychologists distinguish between the explicit and implicit knowledge of linguistic rules between people. Although most of us cannot state with accuracy the rules for English syntax, we can however almost immediately detect violation of the rules

Ran the dog street down cat after yellow the very the

The dog ran down the street after the very yellow cat

Our knowledge of rules is therefore not explicit. We often articulate the so-called *prescriptive rules (don’t say ain’t),* which tell us how we should talk or write even though we may violate them. In contrast the articulation of *descriptive rule (characterizing which sentences are legal or not)* is hard

Phonology

The sound of German is different from English. Part of what distinguishes language are their idiosyncratic sounds. ***Phonetics*** the study of speech sound and how they are produced and ***Phonology*** the study of the systematic ways in which speech sounds are combined & altered in language help us in studying the sounds of language

The English language has 40 phonetic segments (phones). Phoneme refers to the smallest unit of sound that makes a meaningful difference in a given language. If one phoneme of a word is exchanged for another, the word itself gets changed.

thus if \d\ is replaced with \t\ then *duck* becomes *tuck* vowels

IPA	examples
ʌ	cup, luck
a:	arm, father
æ	cat, black
ə	away, cinema
e	met, bed
ɜ:	turn, learn
ɪ	hit, sitting
i:	see, heat
ɒ	hot, rock
ɔ:	call, four
ʊ	put, could
u:	blue, food
aɪ	five, eye
aʊ	now, out
əʊ	go, home
eə	where, air
eɪ	say, eight
ɪə	near, here
ɔɪ	boy, join
ʊə	pure, tourist

consonants

IPA	examples
b	bad, lab
d	did, lady
f	find, if
g	give, flag
h	how, hello
j	yes, yellow
k	cat, back
l	leg, little
m	man, lemon
n	no, ten
ŋ	sing, finger
p	pet, map
r	red, try
s	sun, miss
ʃ	she, crash
t	tea, getting
tʃ	check, church
θ	think, both
ð	this, mother
v	voice, five
w	wet, window
z	zoo, lazy
ʒ	pleasure, vision
dʒ	just, large

Psycholinguists distinguish between consonants and vowels.

Vowels work without obstructing the airflow, simply depending on the shape and position of the tongue and lips (a, e, o) [Halle, 1990]

Consonants are phonemes made by closing or at least almost closing part of the mouth. They differ in

a) place of articulation – where the obstruction of airflow occurs

\b\ & \p\ sounds appear by closing the lips

\s\ & \z\ sounds made by placing the tongue against the hard pallet of the roof of the mouth just behind the ridge of the gums

b) manner of articulation – mechanism of how the airflow is obstructed

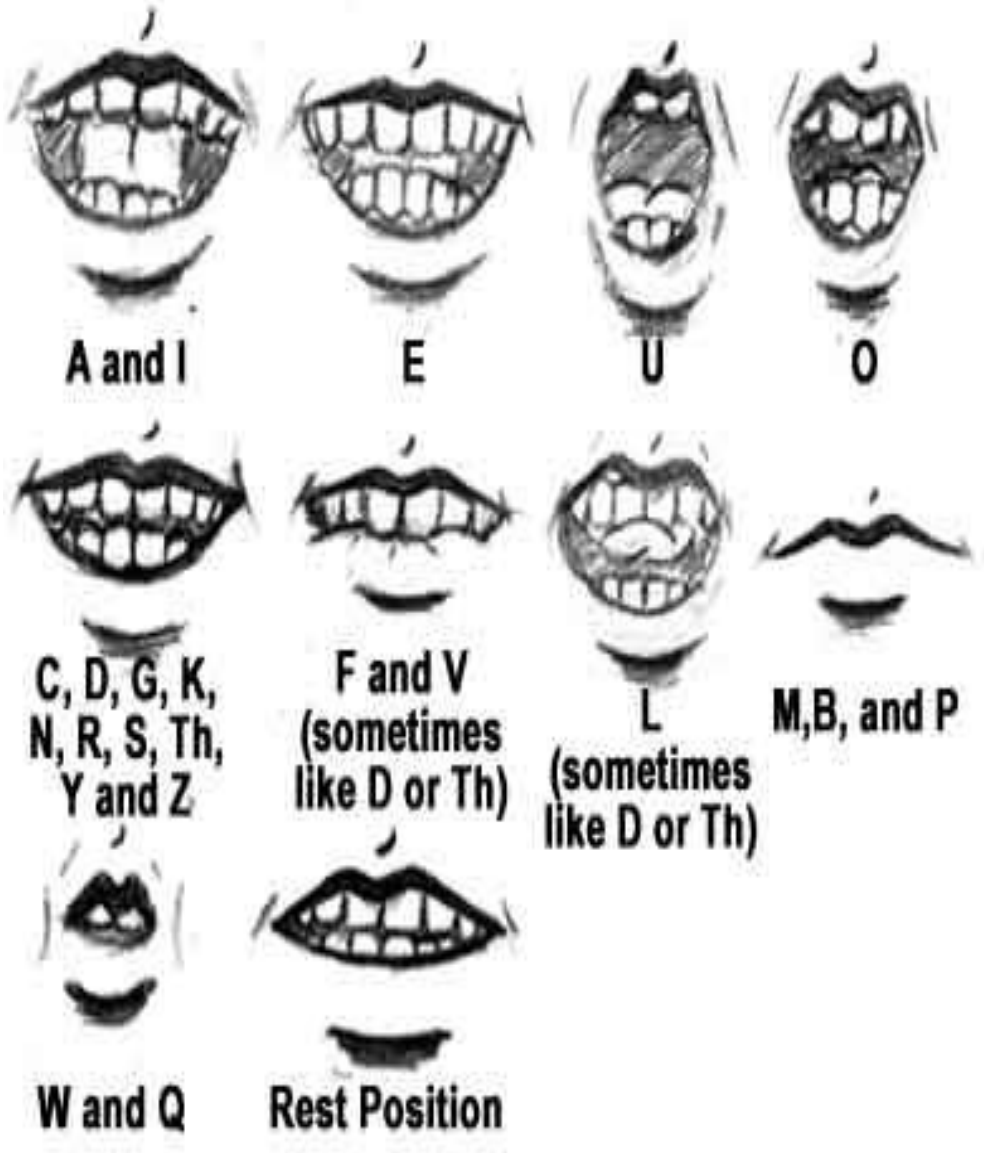
\m\ sound closing the mouth while opening the nasal cavity

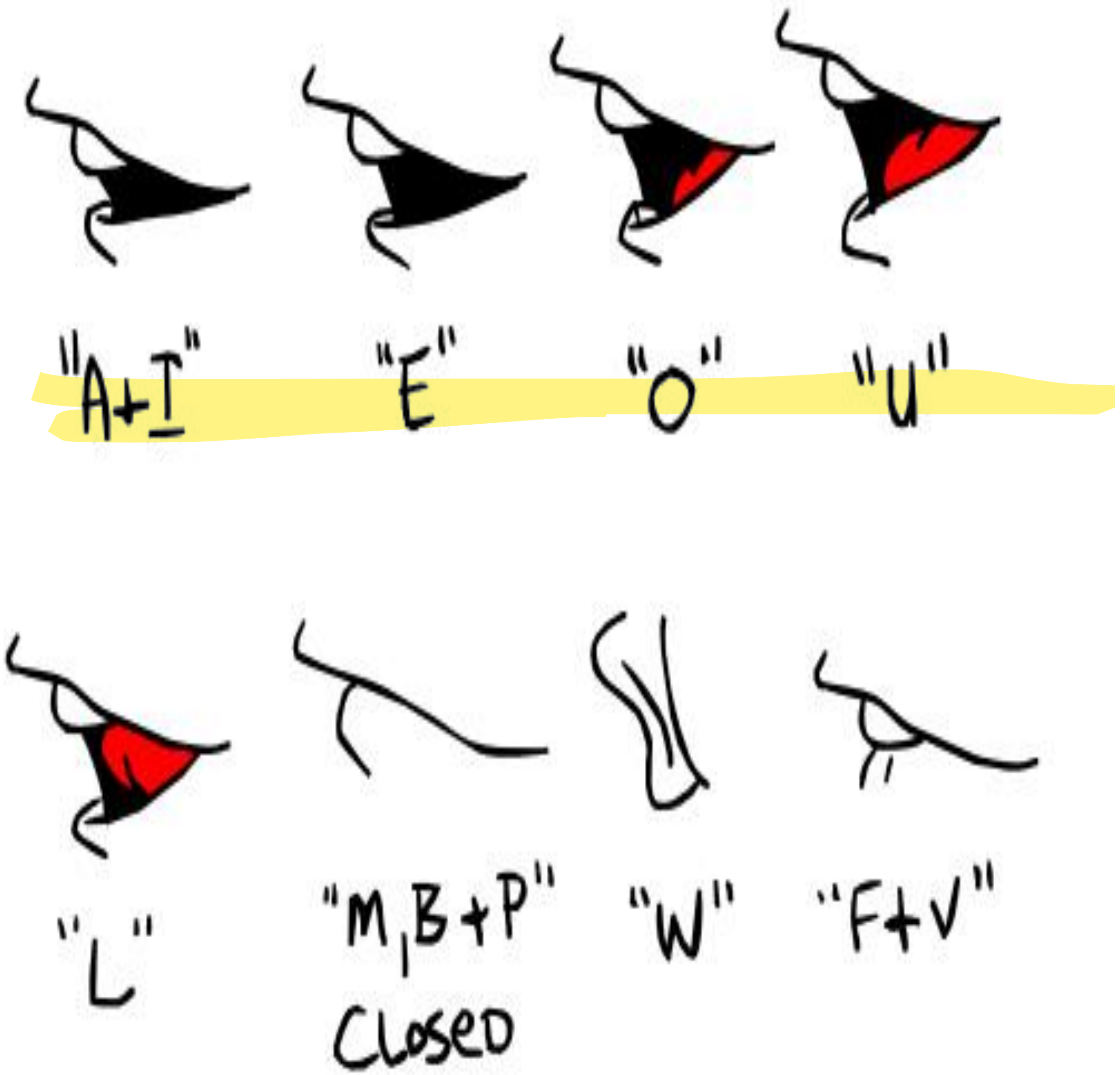
\f\ sound obstruction of the airflow producing a hissing sound

c) voicing – vibration of vocal cords

\s\ in “sa” does not require vocal cord to vibrate

\z\ in “za” requires vocal cord to vibrate


A and I
E
U
O
C, D, G, K, N, R, S, Th, Y and Z
F and V (sometimes like D or Th)
L (sometimes like D or Th)
M,B, and P
W and Q
Rest Position


"A+I"
"E"
"O"
"U"
"L"
"M,B+P" Closed
"W"
"F+V"


Snake, you live in the consonant section with the sun - and the dress, horse, city and ice.
Ant, you live in the vowel section.
THRASS PICTURECHART

Features of phonemes are involved in certain *phonological rules* that govern the ways in which phonemes can be combined

a) if two true consonants are at the beginning of an English word then the first must be an \s\. This rule prevents words such as *dtop and mkeech* from being legal words.

b) how to pronounce the plurals for an English word

If word ends with	Plural ending of word	example
\s z c j s z\	\z\	Places, porches
\p t k f\	\s\	Lips, lists, telegraphs
Anything else	\z\	Clubs, herd

Why do different languages sound different?

a) they contain different sounds (phonemes)

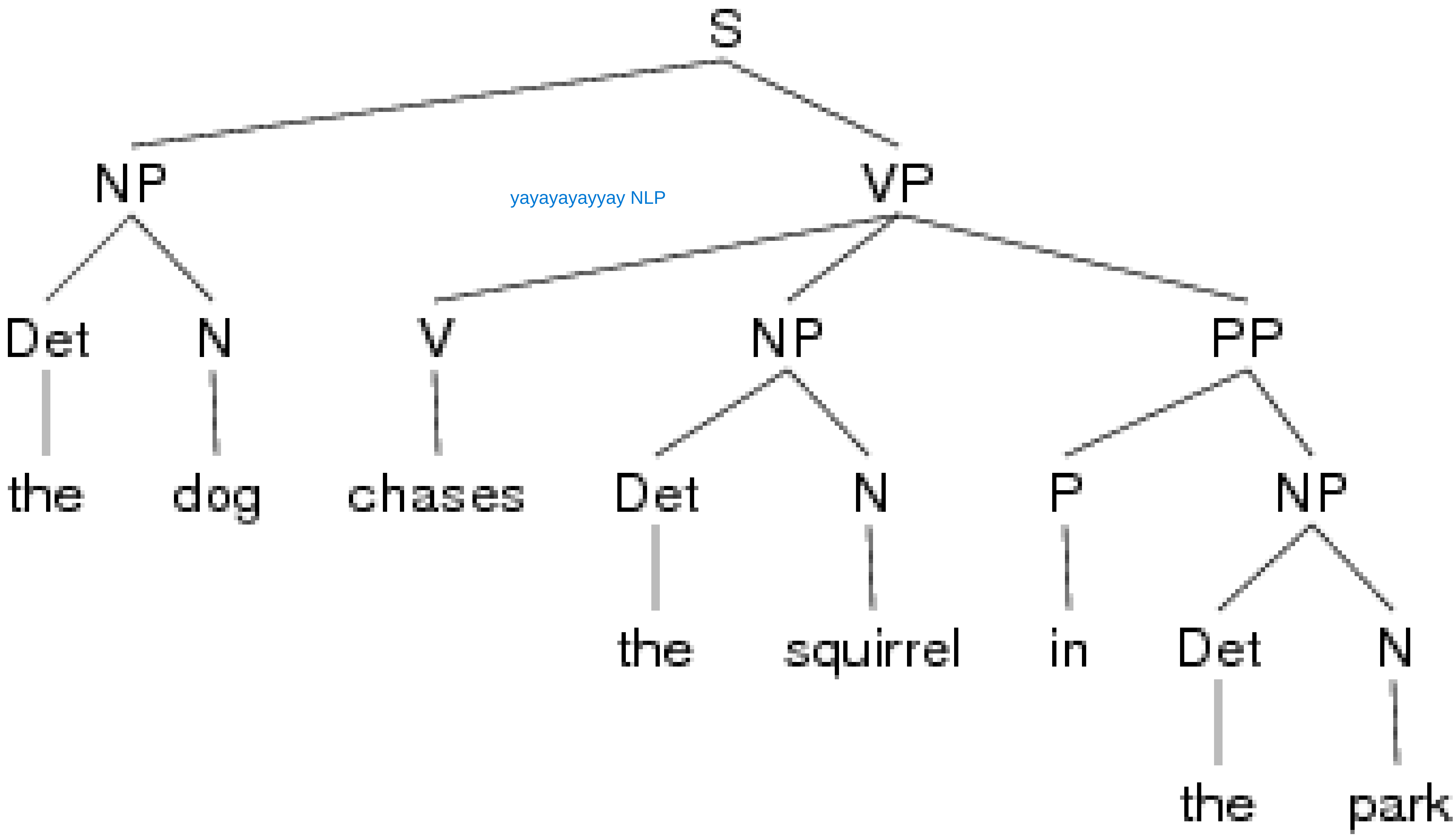
b) they have different rules for combining these sounds (phonology)

Syntax

Syntax refers to arrangement of words within sentences or to the structure of the sentence, their parts and the way the parts are put together. Syntactic rules govern the ways in which different words or larger phrases can be combined to form “legal” sentences in the language.

To explain what does structure of a sentence mean consider the following

“The Dog Chase the squirrel in the park”


S
NP
VP
yayayayayyay NLP
Det
N
V
NP
PP
the
dog
chases
Det
N
P
NP
the
squirrel
in
Det
N
the
park

The diagram shows a *labeled diagram tree* and depicts what is called the *categorical constituent structure* of a sentence. These changes help us explain why certain changes can be made in a sentence and others can't. For example *preposing – taking a certain part of sentence an moving it to the front usually for emphasis.*

My naughty dog, I'm mad at. Naughty dog, I'm mad at my

That inflated price, I will not pay Price, I will not pay that inflated

How can we concisely summarize of what can and what can’t be legally proposed structure of a sentence.?

1) Only constituents labeled as being whole phrases (NP/VP node) can undergo movement from one position in a sentence to another.

2) Phrase structure rule / rewrite rule – describes the ways in which certain symbols can be rewritten as other symbols (S==NP VP)

3) Transformational rule – turn structure such as those depicted in tree diagrams into other structures. (e.g., preposing)


will work as food
due to his grammar mistakes, Porky found a postition. It just wasn't the one he wanted.

Semantics

Semantics is the study of meaning and plays an important in language use. The task of designing a complete theory of meaning is currently unfinished but the question that such a theory should explain can be reviewed

Theory of meaning have to explain several things at a minimum (Bierwisch, 1970)

1) Anomaly (why cant one say “coffee ice-cream can take dictation”

2) Self-contradiction (Why is contradictory to say “my dog is not an animal”)

3) Ambiguity (why isn’t it clear when where one intends to go in “I need to go to the bank”)

4) Synonymy (why does “the rabbit is not old enough” mean the same as “the rabbit is too young”)

5) Entailment (what does “Pat is my uncle” mean that Pat is a man)

When listeners figure out the meaning of a sentence, they need to pay attention to more than just the meaning of individual words. e.g.,

the professor failed the student

the student failed the professor

The study of semantics also involves the study of *truth conditions* of sentences and of the relationships between sentences. Truth conditions – are simply circumstances that make something true (e.g., The dog chased the cat).

Hence our understanding of the meaning of sentence requires

1) an understanding of the meaning of each word of the sentence

2) an understanding of the syntax of the sentence

3) an understanding of the truth condition of the sentence

Pragmatics

pragmatics is the study concerning the social rules of language, which include certain etiquette conventions, such as not interrupting another speaker and beginning conversations with certain conventional greetings (Hi, How are you?)

Searle (1979) points that in listening to another person we must understand the kinds of utterances as they demand different responses from us

1) in *assertive* the speaker asserts his/her believes in some propositions

("It hot in here" or "I am a Gemini"")

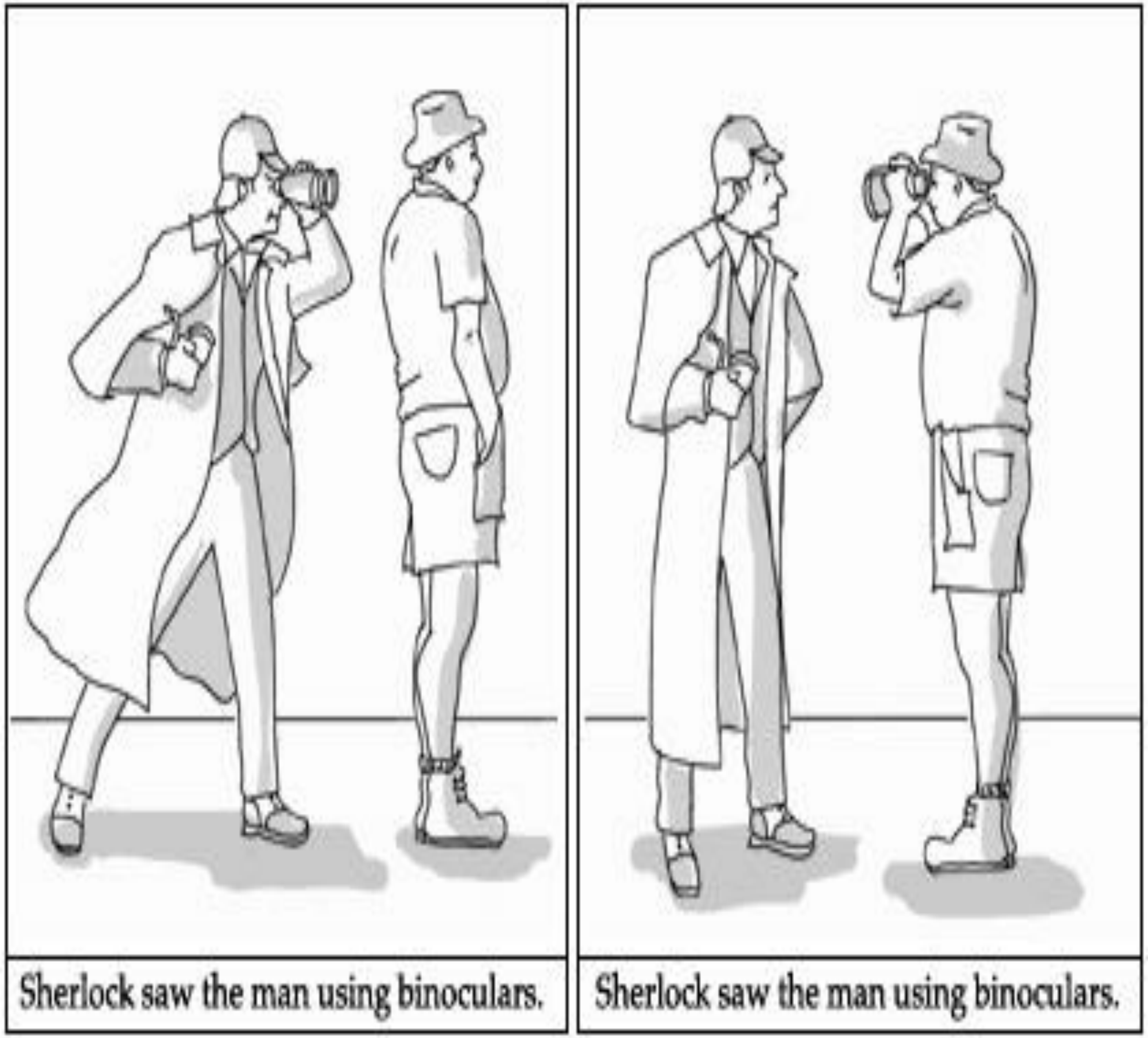
2) *Directives* are instructions from the speaker to the listener ("Close the door" or "Don't trust him")

3) *Commissives* are utterances that commit the speaker to some later action ("I promise to be good" or "I will be your wingman")

4) *Expressives* describe psychological state of the speaker ("I thank you for the favor you did for me" or "Thank for nothing")

5) *Declarations* are speech acts in which the utterances itself are the actions ("I now pronounce you husband and wife" or "You are so dead")

According to Searle’s *speech act theory* part of our job as listeners' is to figure out which of the five types a particular utterance is and to respond appropriately.


Sherlock saw the man using binoculars.
Sherlock saw the man using binoculars.


That's not what I meant when I asked you to carve it.
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Language comprehension and production

language like any other information is transformed from raw input to meaningful representation. The steps in undergoing such transformation are

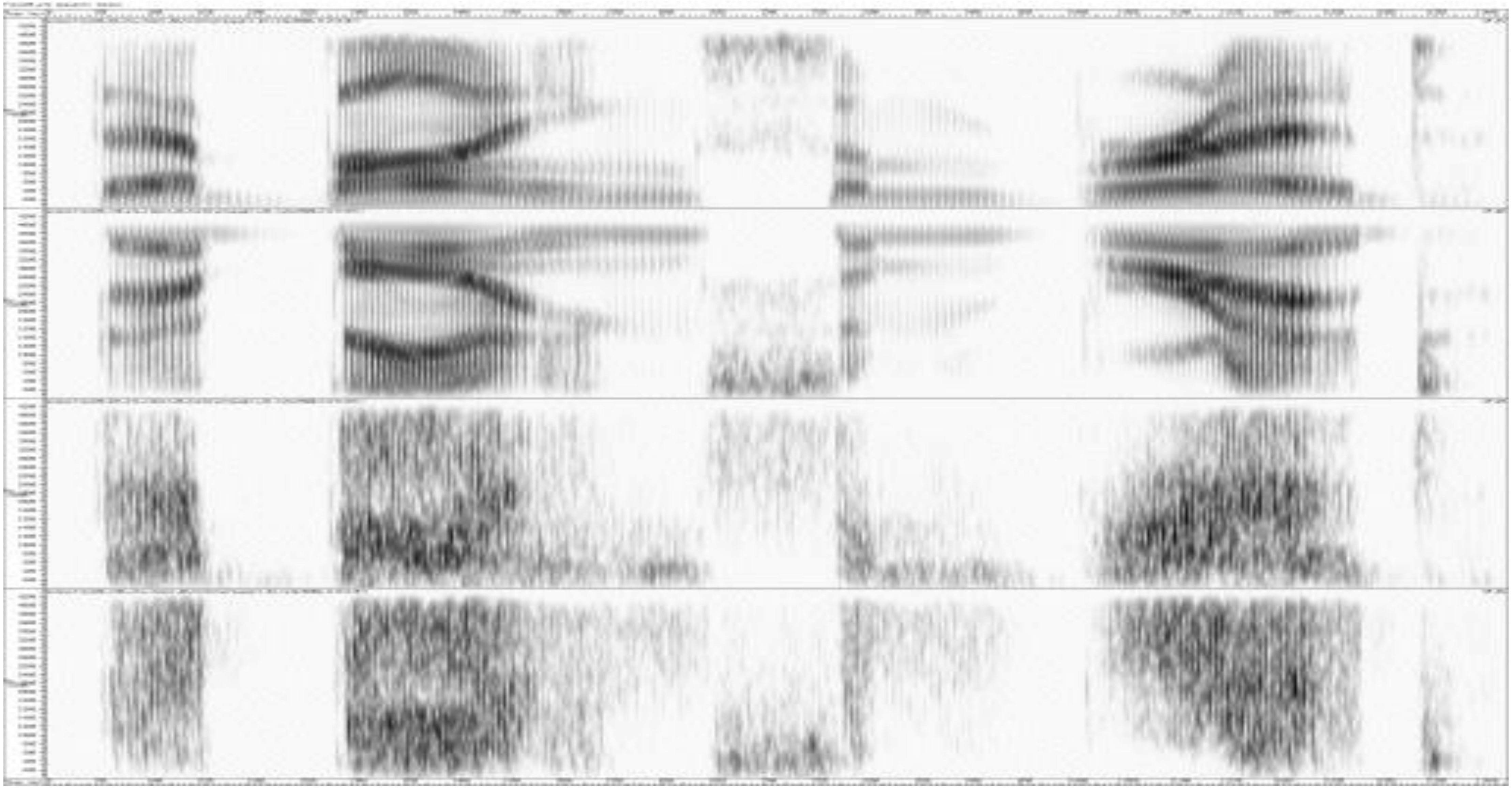
Speech Perception: The simplest way to assume speech perception would be like text perception i.e., one sound at a time using the pauses between sounds to identify when one word ends and the other begin

However Milner (1990) described two problems to such a theory

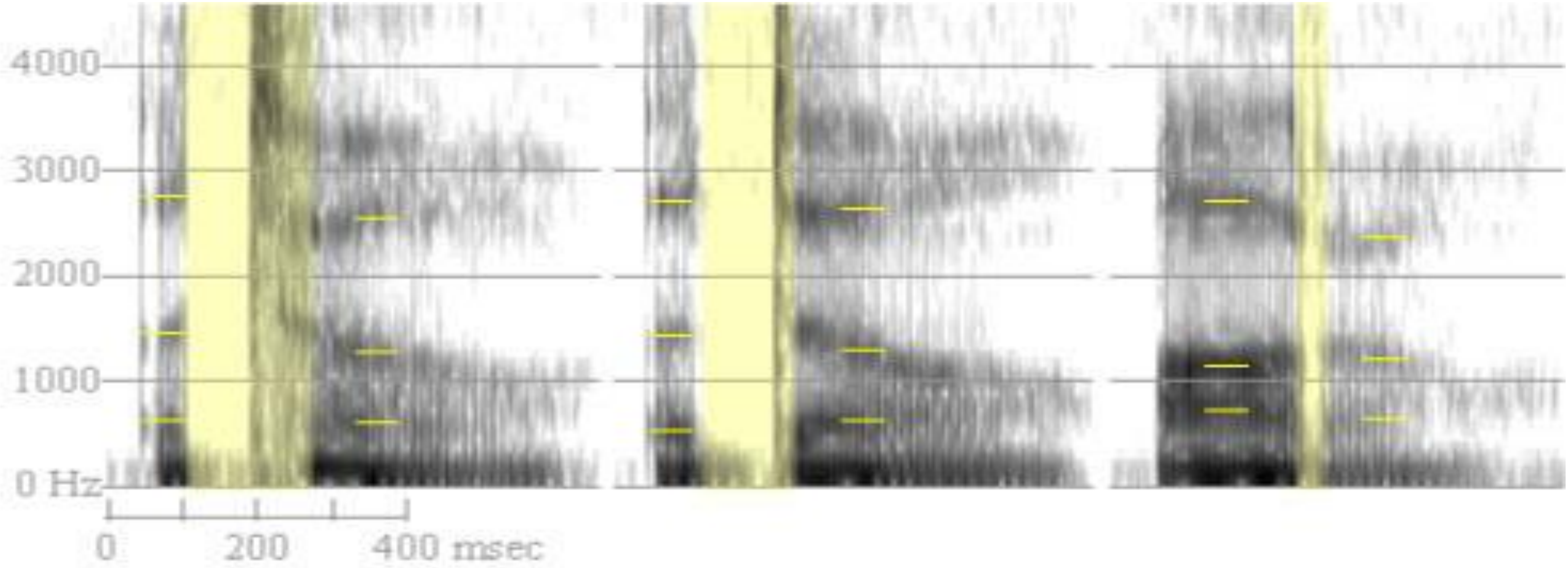
a) speech is continuous
For example refer to the spectrogram of the sentence

“they are buying some bread”.
Y axis = sound in Hz
X axis = time in sec

Spectrogram indicated that rarely there are pauses around each sound, rather different sounds from the same word blend into each other



b) a second problem in speech perception is that a single phoneme sounds different depending on context. e.g., “a toe, a doe & otto”



Also important here is to note that man / women speak with different frequencies, different accents and across situations (whispering. lecturing etc).

“*how do people then perceive speech*”

the answer lies in the truth that we come specially equipped to perceive speech in efficient ways. Our perception of speech is categorical – in processing speech sounds we automatically without awareness / intention force the sounds into different categories. Thus we pay attention to certain acoustic properties of speech and ignore others

Perception of speech are also affected by visual cues. This is referred to as context effect. Warren (1970) presented subjects with a sentence “The state governors met with their respective legi**latures convening in the capital city”, in which a 120 millisecond portion has been replaced by a coughing sound. 1/20 people listening to the sentence would identify the cough sound. This restoration of the missing phoneme is called the *phoneme restoration effect*

People are capable of using a great deal of information to "predict" what the correct sound of a missing segment should be. Warren & Warren (1970) demonstrated this by presenting people with one of the four sentences. Each was the same recording with the exception of the final word that has been spliced of and each contained a ,missing segment as indicated in am asterisk

a) *it was found that the *eel was on the <u>axel</u>*

b) *it was found that the *eel was on the <u>shoe</u>*

*c) it was found that the *eel was on the* ***orange***

*d) it was found that the *eel was on the* ***table***

Depending on the sentence participants reported hearing "*wheel, heel, peel, meal*"

Speech errors in production

besides perceiving speech from others we also produce speech for others to comprehend and process. Speech production can lead to generation of *speech errors – instances in which what the speaker intends to say is quite clear but the speaker makes some substitution or reorders the stimulus.* e.g.,

a) Mary keeps food in her *v*esk (substitution of v for d)

b) we'll sit around the *song* and sing *fires (exchange of words)*

Garret (1988) while studying such speech errors found that *word substitution* has two broad classes of errors

a) error that show meaning relations (finger / toe or walk / run)

b) errors that show form relations (guest / goat or mushroom / mustache)

Sentence comprehension

how do people understand or recover the meaning from sentences?

People pay attention to syntactic constituents however they do not process sentences clause by clause. It seems that people when finish the processing of a sentence, "discard" the exact wording and store only the representations of its gist.

Comprehending a sentence often involves resolving its possible ambiguities. The interesting thing is that we normally don’t notice ambiguities and only rarely with certain kind of sentences these ambiguities become evident.

a) The horse raced past the barn fell

b) The cotton shirts are made from comes from Arizona

These sentences are called *garden path sentences*

Results from several studies suggest that when we process ambiguous sentences, all the meaning of an ambiguous word are temporarily available, through a an automatic bottom up process. Context effects do not immediately restrict the listener to the most appropriate “reading” of the word. Instead for a short period all meanings are accessible. Three syllables after the presentation of the ambiguous word only one meaning remains active, suggesting the people resolve sentence ambiguity fairly quickly.

<u>Comprehending Text Passages</u>

For understanding how people process text passages we first need to know how people read. Just & Carpenter (1987) used the eye tracker to monitor the eye fixations for written text. Results indicate that reading consists of a series of fixations and jump across text, with average fixation & jump lasting 250 and10-20x10^{-3} sec

Just & Carpenter’s model assume that as soon as readers encounter a new word, they try to interpret it and assign it a role. this the *immediacy assumption.* The authors also formulated the *eye-mind hypothesis,* which holds that the interpretation of each word occurs during the time it is fixated.

Just & Carpenter argued that a number of variables influence fixation duration leading to ease of interpretation. These can be categorized as word length, word frequency and syntactically & semantically anomalous word.

Kintsch & Keenan (1973) found that semantic factors influenced the reading task. They showed that two sentences of equal length might be differentially difficult to process. The source of the difficulty they suggested lies in the *propositional complexity* of the sentence (the number of basic ideas conveyed)

Took (Romulus, women, by force)

SABINE (women)

Found (Rome, Romulus)

LEGENDARY (Romulus)

Romulus, the legendary founder of Rome, took the women of the Sabine by force

Because (ß, ∂)

Fell down (Cleopatra) = ß

Trust (Cleopatra, figures) = ∂

Foolish (trust)

Fickle (figures)

Part of (world, figure)

Political (figures)

Roman (world)

Cleopatra's downfall lay in her foolish trust in the fickle political figures of the Roman world

Another factor influencing the processing of text has to do with the relationships among sentences. Haviland & Clark (1974) described the *given-new* strategy, whereby listeners and readers divide sentences into two parts: the given and the new. The given part of a sentence contains information that is (or should be) familiar from the context, the preceding information or background knowledge. The new part contains unfamiliar information. Listeners first search memory for information corresponding to the given information and then update memory by incorporating the new information, often as an elaboration of the given.

Van den Broek & Gustafson (1999) offers three conclusions from research on reading texts.

a) the mental representation is a construction by the reader that differs from, and goes beyond, the information in the text itself.

b) good representation is coherent

c) readers attentional resources are limited

Story Grammars

story grammars describe the way people comprehend large integrated pieces of text (using script, schema & grammar of language)

Story grammars are similar to scripts in that both have variables or slots that are filled in differently for different stories (protagonist, setting, plots, conflicts & resolutions). Story grammar are similar to syntactic grammar in that they help us identify the units and the role each unit plays in the story.

story grammar provides the framework with which to expect certain elements and sequences and to fill in with “default values” things are not explicitly stated.

Title:	The 3 Little Pigs
Character:	3 Little Pigs, Wolf
Problem:	The Wolf wants to eat the 3 Little Pigs.
Events:	
1.	Wolf blows down the straw house.
2.	Wolf blows down the stick house.
3.	Wolf can't blow down the brick house.
4.	Wolf climbs down the chimney.
Resolution:	Wolf falls into a pot of boiling water, runs out the door, and is never seen again.

TABLE 1

SUMMARY OF REWRITE RULES FOR A SIMPLE STORY GRAMMAR[a]

FABLE → STORY AND MORAL

STORY → SETTING AND EVENT STRUCTURE

SETTING → { STATE* (AND EVENT*) / EVENT* }

STATE* → STATE ((AND STATE)^n)

EVENT* → EVENT (({ AND / THEN / CAUSE } EVENT)^n) ((AND STATE)^n)

EVENT STRUCTURE → EPISODE ((THEN EPISODE)^n)

EPISODE → BEGINNING CAUSE DEVELOPMENT CAUSE ENDING

BEGINNING → { EVENT* / EPISODE }

DEVELOPMENT → { SIMPLE REACTION CAUSE ACTION / COMPLEX REACTION CAUSE GOAL PATH }

SIMPLE REACTION → INTERNAL EVENT ((CAUSE INTERNAL EVENT)^n)

ACTION → EVENT

COMPLEX REACTION → SIMPLE REACTION CAUSE GOAL

GOAL → INTERNAL STATE

GOAL PATH → { ATTEMPT CAUSE OUTCOME / GOAL PATH (CAUSE GOAL PATH)^n }

ATTEMPT → EVENT*

OUTCOME → { EVENT* / EPISODE }

ENDING → { EVENT* (AND EMPHASIS) / EMPHASIS / EPISODE }

EMPHASIS → STATE

[a] See text for definitions of STATE and EVENT and for the connections AND THEN and CAUSE

Gricean Maxims of Conversation

Grice (1975) believed that for people to converse, each must do more than produce utterances that are phonologically, syntactically and semantically appropriate.

A: ……I just heard that Joe got promoted today. Isn't that great?

B: Salt lake city is located in Utah

C: No, Charles Darwin is the father of modern evolutionary theory

A: What's the square root of 34? / B: Chocolate ice-cream is sweet

Grice described speakers in a conversation as all following a "general cooperative principle" by following four conversational *maxims*

a) Maxims of quantity

b) Maxims of quality

c) Maxim of relation

d) Maxim of manner

Violation: Rule A & B -------- uncooperative, obnoxious etc
Rule C ------------- Bizzare

What influence does language have other cognitive processes?

1) Language and other cognitive processes operate independently

2) Language and other cognitive processed are dependent on each other

The Modularity Hypothesis

Philosopher Jerry Fodor (1982, 1985) argued that some cognitive process in particular perception and language are *modular.* Modularity of a process implies

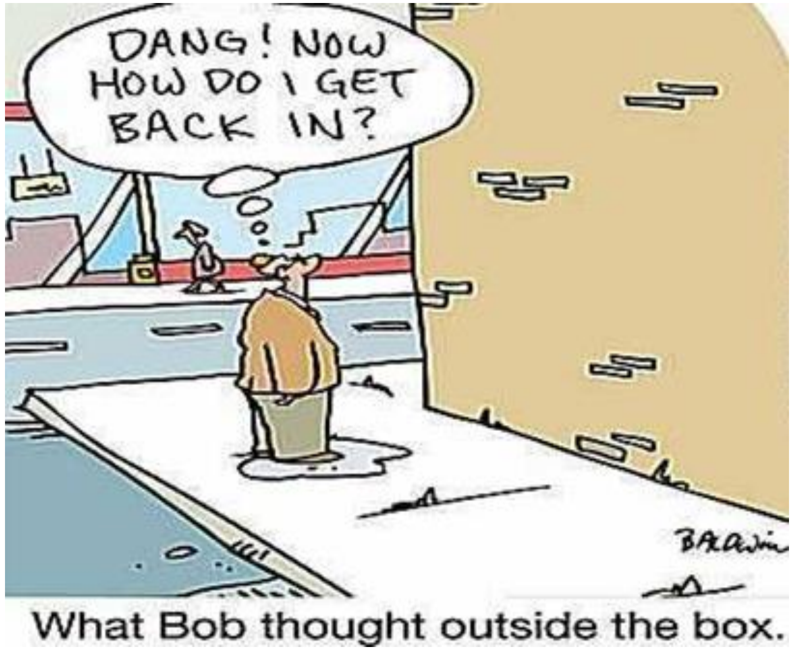
a) domain specificity: operates specifically with certain kinds of I/O

b) Informationally encapsulated: operates independent of the believes and   other information available to the processor

The Whorfian Hypothesis

Benjamin Whorf proposed that language and other cognitive processes are strongly related. He believes that language/s one grows up learning and speaking organize and directs the way one perceives the world, organizes information about the world and thinks.

Problem Solving



What is problem?

A problem consists of several basic components

1) ***An initial state*** *(the situation at the beginning of the problem)*

2) ***A goal state*** *(the solution to the problem)*

3) ***A set of rules*** *(constraints that must be followed)*

4) ***A set of obstacles*** *(hindrances that must be overcome)*

Types of Problems

Well and Ill defined problems

1) *Well defined problems* are ***clear and structured*** i.e., the initial state, goal state and constraints are all understood, and once you reach a solution, it's easily assessed. (e.g., solving and anagram)

2) *Ill defined problems* are ***fuzzy and abstract*** i.e., the initial state, goal and constraints have gaps in understanding leading to difficulty in accessing the solution (e.g., writing a research paper)

Routine and Non-Routine problem: (familiarity with procedures)

A routine problem is one that can be solved by applying well-practiced procedures (e.g., writing exams)

A non-routine problem is one that cannot be solved by applying well –practiced procedures (e.g., writing research paper)

Challenges with problem solving research

Problem solving is the last hurdle to most cognitive processes and thus takes much longer time to accomplish. Assessing problem solving in terms of accuracy rate provides a rather gross estimate of problem solving proficiency. Measuring solution times provides some useful information but doesn't shed much light on the nature of the processing that occurs during problem solving.

One Saturday night at a local county dance, 40 people, 20 men and 20 women showed up to dance. The dance was a contra dance, in which men and women face each other in lines. From 8-10 pm there were 20 heterosexual couples dancing on the floor. At 10 pm 2 women left leaving 38 people to dance. Could the dance called make arrangement so that the remaining people could all dance together at the same time in 19 heterosexual couples? The dance caller must remain a caller and cannot take a partner. Answer yes/no giving reasoning behind answer

--- Gick & McGarry (1992) Learning from mistakes Journal of Expt Psychol, 18, 623-639

Verbal protocol: In order to understand the processes of problem solving, researchers have made extensive use of verbal protocols – which are reports generated by problem solvers as they "think aloud" during the solution process. The limitation with such reports are:

1) not everyone has the verbal ability required to reflect accurately on what they are thinking

2) there is no way to assess the accuracy of the verbal report

3) the act of thinking out loud may interfere with or change the very nature of the thought process being described.

The varied nature of problems: The complexity of problem solving presents another challenge for researchers. The term *problem* can apply to a diverse set of circumstances from solving math problems to writing a term paper to figuring out an alternative route home during rush hour traffic.

Marr (1992) distinguishes between five types of problems

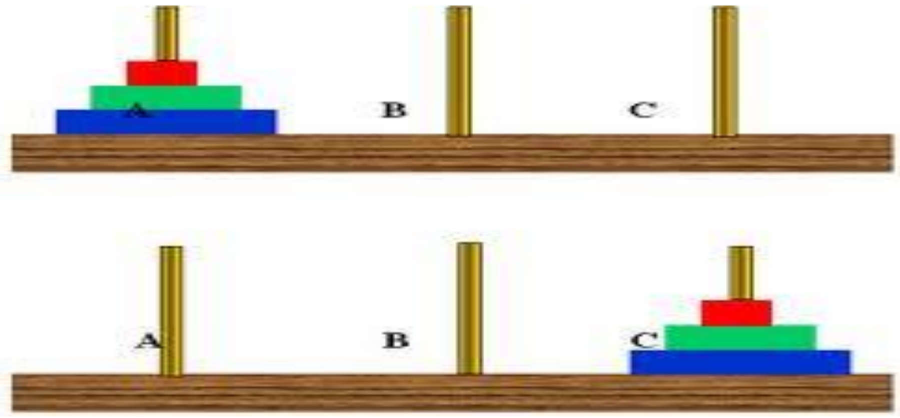
a) *Transformational*: presents the solver with a goal state, the solver must find the proper strategies that will eventually transform the initial state to the goal state

2) *Arrangement problems* – involve presentation of all the necessary elements to solve the problem; the solver must figure out how the elements are to be arranged

3) *Induction problems* – involves giving the solver a series of exemplars or instances using which they must figure out the pattern or rule that relates the instances

4) *Deduction problems* – presents the solver with premises or conditions and require them to determine whether a conclusion fits the premise

5) *Divergent problems* – require the solver to generate as many solutions as possible to a given problem



“KIGVIN” – rearrange letters to form another word

Arrangement

Think of as many uses of bricks as you can

Transformational

Divergent

Take a look at the number sequence

8, 5, 4, 1, 7, 6, 10, 0

What is the next number in the sequence?

Induction

“All professor are caring people” & “All caring people are good”.

Would you accept the statement all professors are good?

Deduction

Approaches to the study of problem solving

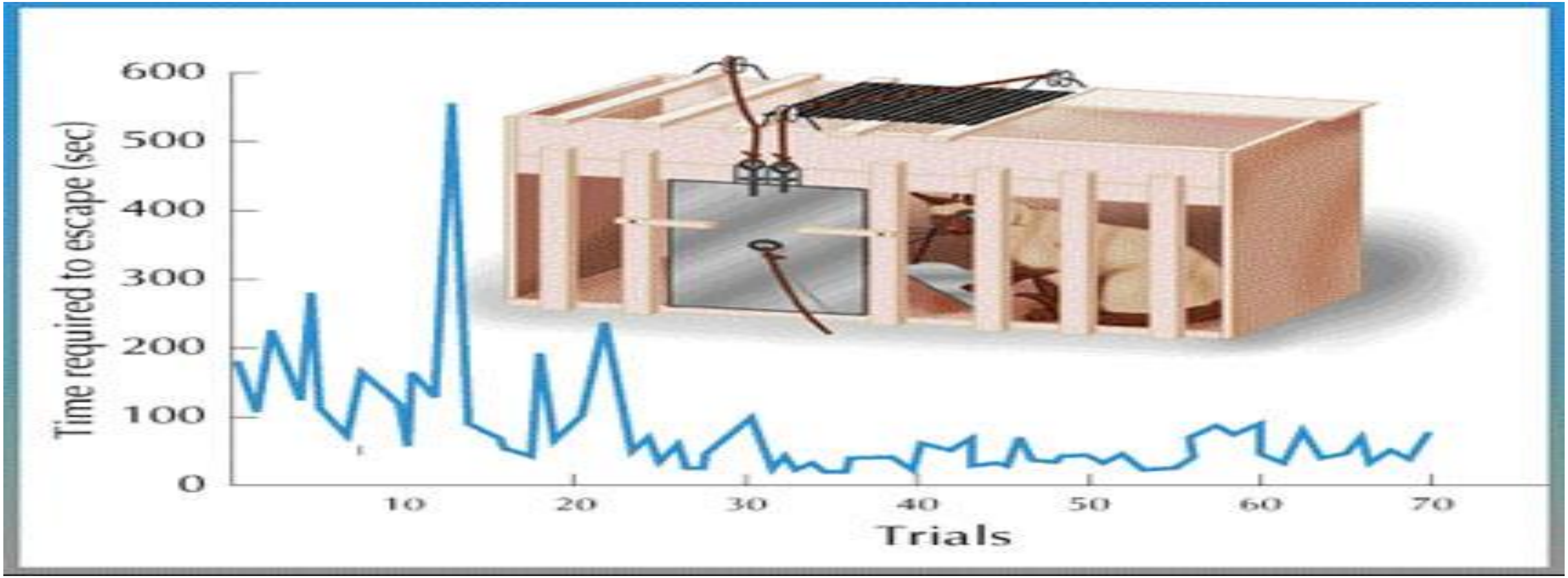
Behaviorism: Problem solving as associative learning

E.L. Thorndike (1800) conducted the first systematic study of problem solving using cats.

Thorndike was interested in knowing whether the ability to solve this confinement problem would appear suddenly as an insight, or gradually through a process of trial and learning.

He found that the cat learned to solve ***using trial and error***

Thorndike described this learning process with what he termed as ***law of effect - which states if a response leads to a satisfying outcome, the connection between the response and the situation will be strengthened.***



Gestalt Psychology: Problem solving as insight

Gestalt psychology believed that the mind has an inherent tendency to organize incoming information and these organizational processes are the defining features of cognition. Thus rather than defining problem solving as mindless playing out of associations that gradually build up over time, they believe it involves restructuring or reorganizing of problem elements that result in a sudden realization of the solution.

A pioneer study was done by Wolfgang Kohler (1925) with apes to support gestalt approach to problem solving.

For gestalt psychologists problem solving involves a process of restructuring whereby problem elements are suddenly reorganized and seen in a new way. The sudden and successful restructuring of problem elements is termed, *insight* and this is a major focus of the gestalt approach

Cognitive Psychology: Problem solving as information processing

Just as a computer solves problems by executing programs that use information stored in some types of database, humans solve problems by applying mental processes to representations in memory.

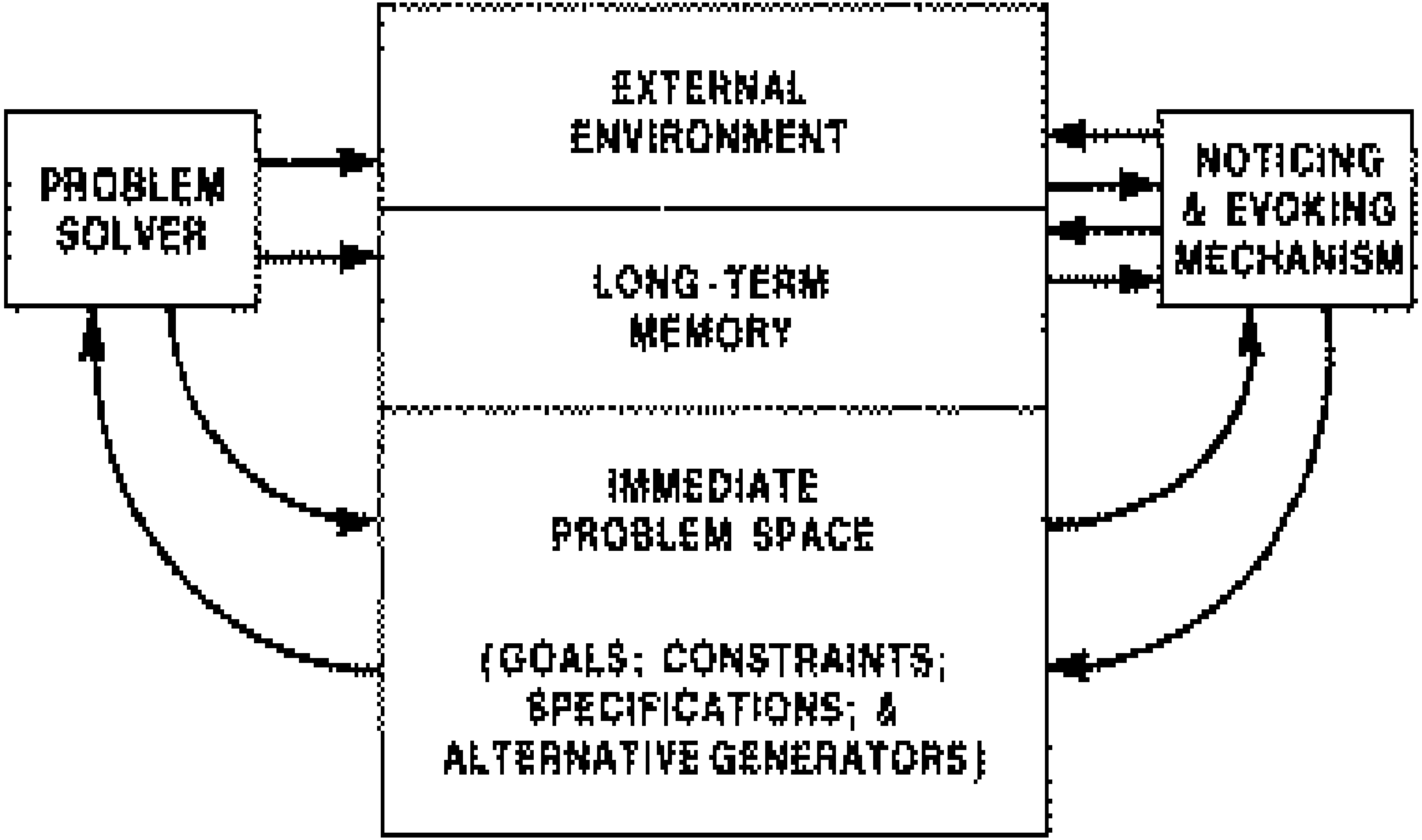
The General Problem Solver:

Newman & Simon (1972) originated the conceptualization of problem solving as a step-by-step progression from an initial state to a goal state. They did so within the framework of a computer program termed as *general problem solver (GPS).*

The GPS is a general model of human problem solving – one that can be applied to any problem. This approach minimizes the “distance” between an initial state and a goal state by breaking the problem down into a series *sub-goals*

The sub-goal analysis is accomplished through the application of *operators*, which is basically a fancy word for problem-solving techniques. These techniques are applied (at a micro level) to reduce the difference between the current state and the current sub-goal state and (at a macro level) to reduce the difference between the initial state and the final goal state.

GPS is a notion of *problem space* – which basically refers to the problem solvers mental representation of the initial state, the goal state and all possible intermediate (sub-goal) states, and the operators that can be applied to reach these sub-goals


PROBLEM SOLVER
EXTERNAL ENVIRONMENT
LONG-TERM MEMORY
IMMEDIATE PROBLEM SPACE
(GOALS; CONSTRAINTS; SPECIFICATIONS; & ALTERNATIVE GENERATORS)
NOTICING & EVOKING MECHANISM

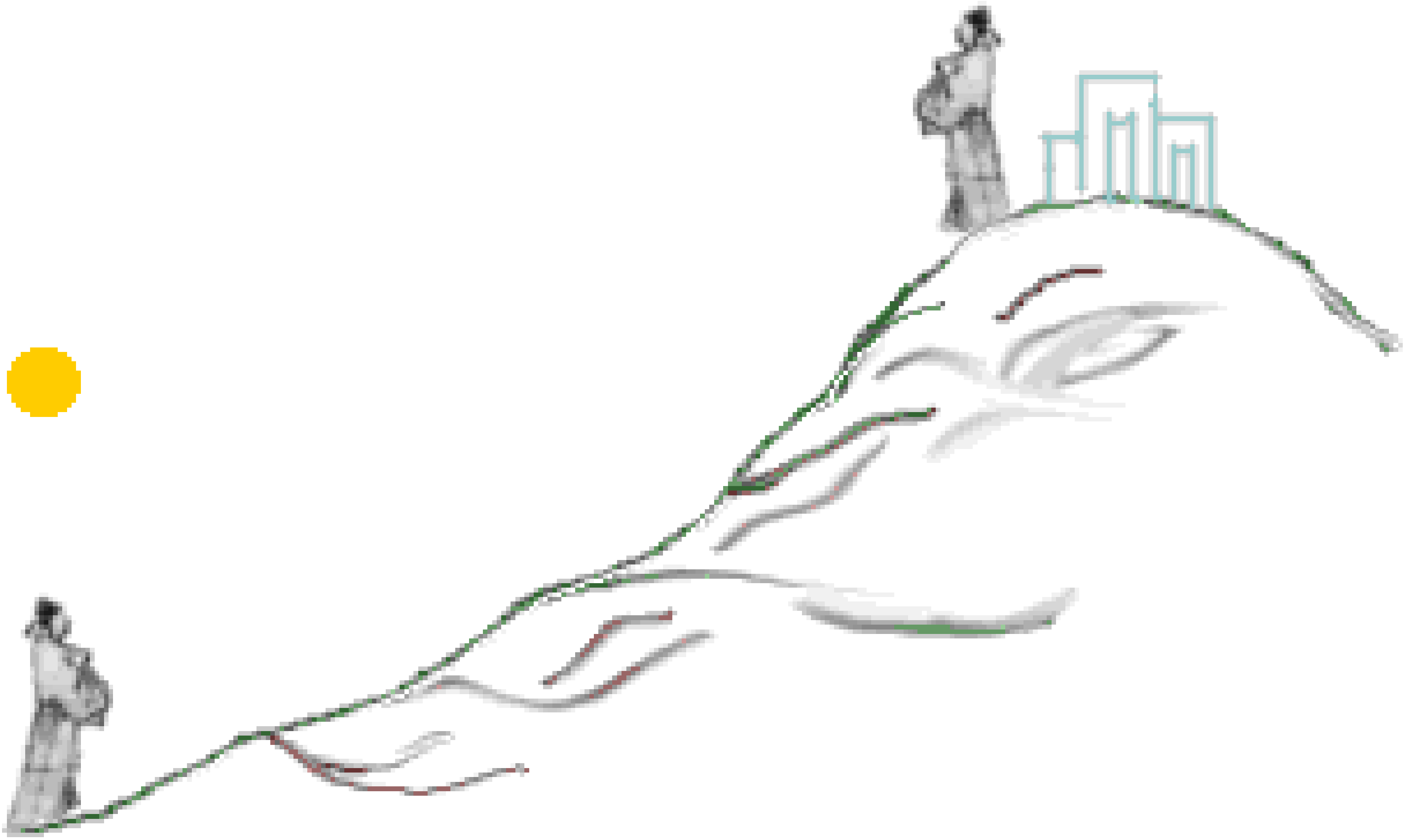
Problem Representation

Problem solving involves the process of converting presented information into some type of internal mental representation. Within the framework of GPS *problem representation,* involves correctly specifying the problem space – i.e. correctly identifying the initial state as well as the operators that may be applied within the constraints of the problem.

Try to solve this problem

Exactly at sunrise one morning, a Buddhist monk set out to climb a tall mountain. The narrow path was not more than a foot or two wide, and it wound around the mountain to a beautiful, glittering temple at the mountain peak. The monk climbed the path at varying rates of speed. He stopped many times along the way to rest and to eat the fruit he carried with him. He reached the temple just before sunset. At the temple, he fasted and meditated for several days. Then he began his journey back along the same path, starting at sunrise and walking, as before, at variable speeds with many stops along the way. However, his average speed going down the hill was greater than his average climbing speed.

Prove that there must be a spot along the path that the monk will pass on both trips at exactly the same time of day (Duncker, 1945)



Try to solve this problem

A man bought a white horse for $60 and then sold it for $70. The he bought it back for $80 and sold it for $90. What was his net gain (or net loss) in the horse business? (Maier and Burke, 1967)

Rigidity in Representation

The initial representation of a problem is critical to its eventual solution. Failure in representation might result from a number of factors

a) the problem elements may not have received sufficient attention

b) the problem elements may not have been understood

c) previous experience with similar problems may have led to encoding the problem elements in a rigid manner

Some of the major hindrances to problem solving arise from

a) Mental set: this tendency to rely on habits and procedures used in the past is termed *mental set*. Mental set can interfere with you ability to solve everyday problems (e.g.,)

<u>Solve the problem</u>: there are six eggs in a basket, six people take one of the eggs each. How is it that one egg can still be left in the basket?

Mental set tends to affect the representation phase of problem solving, as past experiences leads to an inappropriate representation of the problem.

b) *Functional fixedness*: refers to people's tendency to view objects in a narrow, fixed sense – i.e. in terms of the typical functions of the object. One development perspective on functional fixedness holds that older children are more likely than younger ones to demonstrate functional fixedness (e.g., writing in space with pen)

Try to solve the problem

two-string problem*: Knut is left in a room with a chair and a pair of pliers given the task to bind two strings together that are hanging from the ceiling. The problem he faces is that he can never reach both strings at a time because they are just too far away from each other. What can Knut do?*

Knut has to recognize he can use the pliers in a novel function – as weight for a pendulum. He can bind them to one of the :strings, push it away, hold the other string and just wait for the first one moving towards him. If necessary, Knut can even climb :on the chair, but he is not that small, we suppose…..

Stereotypes as a threat to problem representation

stereotype threat occurs when a member of a negatively stereotyped group feels that the stereotype might be used to judge their behavior thus resulting in a negative judgment that will propagate the problem. Quinin & Spencer (2001) has men and women solve either math word problem or numeric/algebraic equivalents of the word problem

Solve the problem

A sporting goods store sold 64 Frisbees in one week, some for $3 and rest for $4 each. If recipients from Frisbee sales for the week totaled $204, what is the fewest number of $4 Frisbees that could have been sold?

Or

Solve: $3(64-x) + 4(x) = 204$

Results form Quinin and Spencer

Correct Sol %	*word problem*	*Numeric*
Gender		
male	*20*	*40*
female	*8*	*38*

Problem Solution

once the problem has been successfully transformed from externally presented information into an internal representation, the next phase of the problem-solving process involves searching for; testing and evaluating solutions. Within the context of Newell & Simon’s (1972) IP approach, problem solution amounts to travelling through the problem space.

Algorithms – are basically a set of rules that can be applied systematically to solve certain types of problems. A mathematical formula is a good example of algorithm.

e.g., two short sides of a right angled triangle are 3cm and 4 cm. find the length of the hypotenuse

Algorithms are very powerful problem solving techniques; applied correctly, an algorithm will always lead to the correct solution, if one exists.

e.g., solve the anagram “kigvin” using algorithm

there are several shortcomings of using algorithm

a) the exhaustive nature make them overly tedious and quite impractical

b) there simply aren’t any for most of the problems in our daily life

Heuristics – are general strategies or rules of thumb, than can be applied to various problems. Heuristics serve as “shortcuts” through problem space. Given the strengths and limitations of human problem solver, along with the fact that most problems are ill-defined and have relatively large problem spaces, heuristic problem solving is much more effective.

Solving the anagram “kigvin”

Heuristics say no word in english start with gk, vg or ikn so these are eliminated and so on…..

Solve
You are purchasing three items at the store, at these prices:

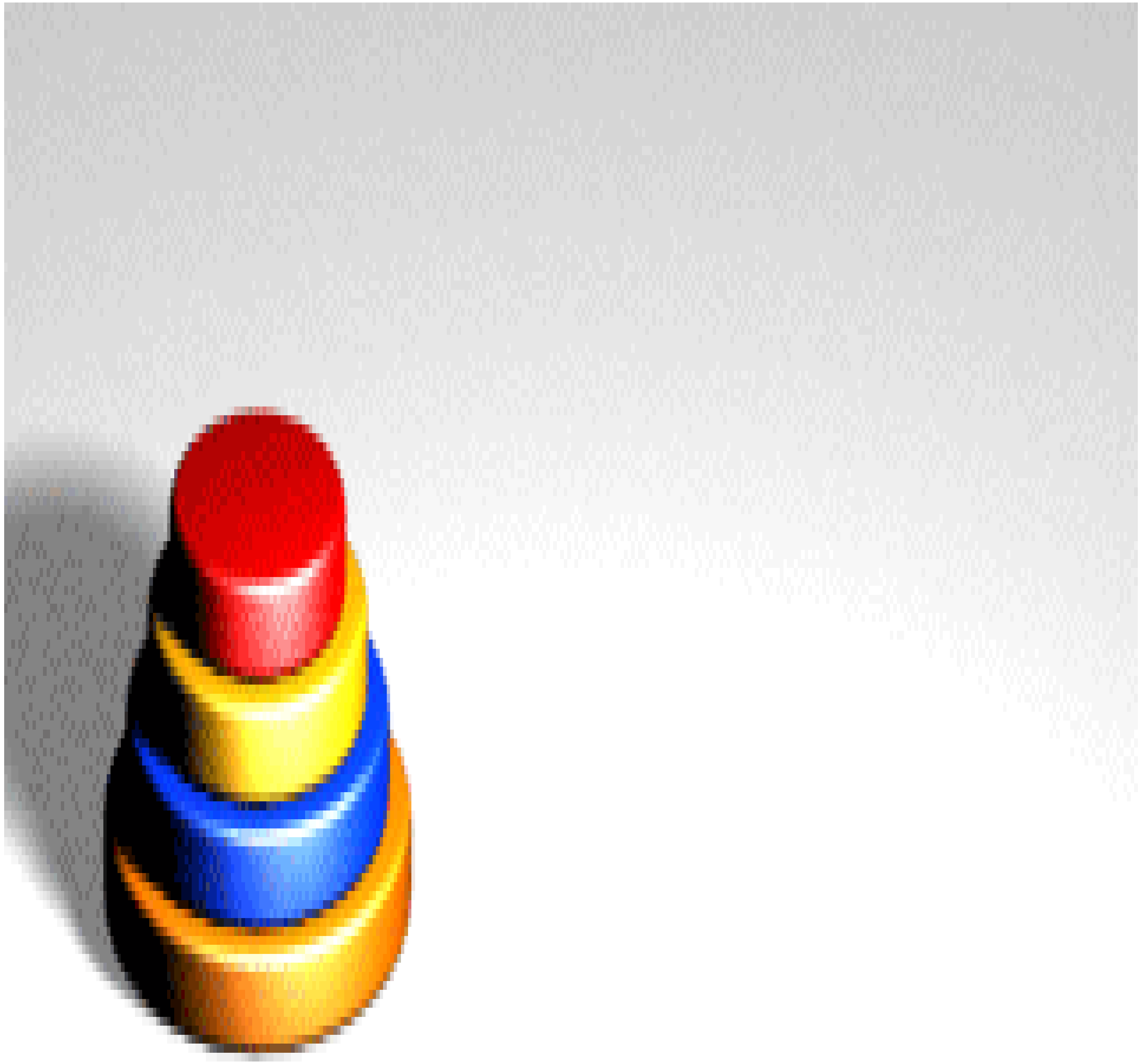
$19.95,
$39.98,
$29.97

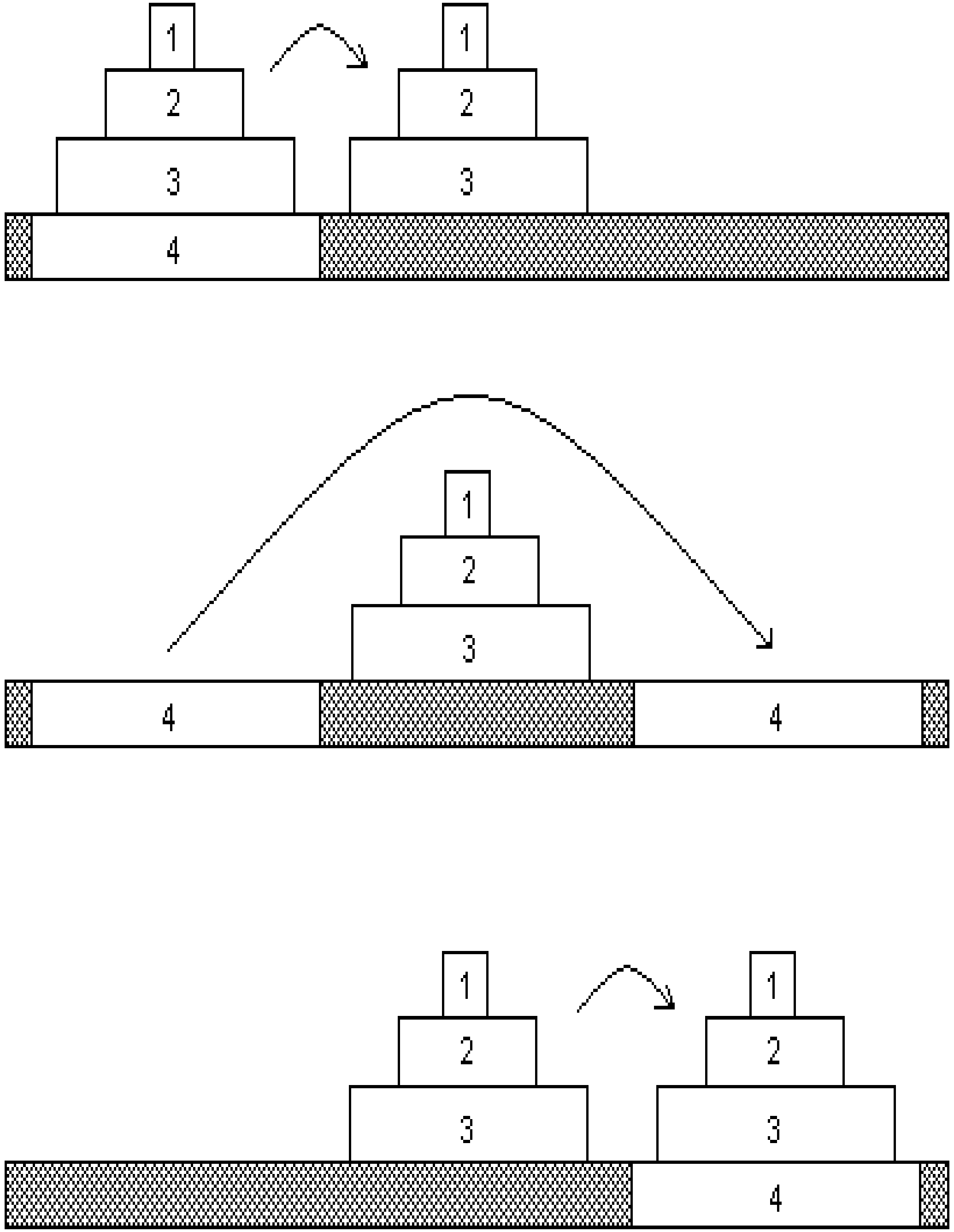
About how much money are you spending?

Solution: The fastest way to solve this problem is to round off and approximate. The first item costs about $20, the second about $40, and the third about $30; therefore, you are spending about $90 on your shopping spree.

Means-End-Analysis

The general problem solver developed by Newman & Simon utilizes the heuristic known as *mean-end-analysis.* MEA involves breaking a problem into smaller sub-goals in which accomplishing each sub-goal moves the solver closer to the final goal – the problem solution. As the term implies in MEA the solver systematically attempts to devise means to get to the each sub-goal's ends. MEA can be an effective way to solve transformational problems

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Surface vs. Structural Features

One of the primary steps in solving problems by analogies involve the use mapping between original and new problem. Gick & Holyoak term this mapping process as *schema induction*. Our ability to notice, map and develop schemata depends on the particular *type of similarity*. These can of two types (Gentner, 1989).

a) *surface features* – are the specific elements of the problem. If two problems share surface similarities, this means that the parts of the problem look pretty similar. (e.g.,)

the way paper jams trays on printers

b) *structural feature* – are the underlying relationships among the surface features of the two problems. If two problems are structurally similar, they may look quite different on the surface but have underlying similarities in terms of their relationships. (e.g.,)

the dog chased the cat

the cat was chased by the dog

How do experts solve problems?

Experts have something called *expertise – exceptional knowledge and/or performance in some specific problem domain.* Since 1950 expertise is no more viewed as the product of innate capacities but rather an outgrowth of learning and repetition over the course of years that produces an extensive body of knowledge and an extremely well learned set of skills. Experts are thus *skilled memorizers*

According to Ericsson & Polson’s 1988 *skilled memory theory* – there are several differences between experts and novices, all to the advantage of experts.

a) the semantic network are richly elaborated in experts

b) experts have quicker and more direct access to long term memory

c) information is more easily encoded onto long term memory by experts and the speed of this encoding improves with practice

Advantages for expert problem solvers

The core of problem solving is memory – the long term memory that allows for the storage of domain relates general knowledge and specific episodes and the working memory that allows for quick and efficient online processing of problem information.

a) Studies by Chase & Simon (1973), de Groot (1978) point that experts can instantly recognize problem configurations based on extensive knowledge & experience base

b) Ericsson & Kintsch (1995) propose the idea of long term working memory to explain expert advantage in online processing of problems. This theory states that experts can bypass the limits of working memory by using the information of working memory to directly access LTM.

c) Experts problem solvers use general strategies that differ from those of novice. They tend to search the problem space in a forward fashion, reasoning from givens towards goals.

d) Experts are much better at picking up on structural features of problems, and recognize analogous problems when faced with novel problem

e) Lemaire & Siegler (1995) propose the *adaptive strategy model* which distinguish experts from novice on four layers

1) *strategy existence – experts have more strategies at disposal*

2) strategy base rate – experts in a given domain know which strategies tend to work and select those strategies

3) strategy choice – refers to experts advantage in discerning which strategies should be chosen for a specific circumstance

4) strategy execution – refers to the expert advantage in actually carrying out the strategy in terms of speed accuracy

Expert disadvantages

a) Novices are actually better at understanding randomly arranged problems than experts.

b) Novice remember more information about specific problems than experts and this is termed as *intermediate effect*

c) Experts may actually solve problems using mental set as compared to novice users

Insight and Creativity

What is creativity? What process lead to creative products?

Wallas (1926) proposed that the process leading up to a creative breakthrough can be described in terms of four stages

1) Preparation – in which the solver gathers information and makes initial attempts at problem solution

2) Incubation – which might described as a period of productivity inactivity

3) Illumination – a stage where the solver arrives at critical insight

4) Verification – in which the solver verifies if the solution will actually work

Wallas theory has not be accepted in entirety however it has pointed out two major question in problem solving

1) what is the nature of insight?

2) if sudden breakthrough in problem solving is a reality, can these be encouraged by a period of incubation

Insight

Insight involves the sudden realization of a problem solution (or of any key idea necessary to the solution). The problem with insight is that theorist believe problem solving to be an incremental process and not sudden realization, another problem lies with the clear definition and non experimental proof of the existence of insight by the Gestalt psychologists

Gilhooly & Murphy, 2005 made an observation that even if insight was a reality if could not be applied to all types of problems. They distinguished between problems as

1) Non-insightful problems – are those that are likely solved through incremental process. They require analytical step-by-step processing.

2) Insightful problems – are those in which solutions appear suddenly

Two key assumptions about insightful problems solving are

1) it involves a mistaken assumption that once removed will clear the way to successful solution of the problem

2) that the solver is hit with the solution suddenly and has what might be termed as an "Aha!" experience

Insightful problems

Water lilies double in area every 24 hours. At the beginning of summer there is one water lily on the lake. It takes 60 days for the lake to become completely covered with water lilies. On which day is the lake half covered?

A prisoner was attempting to escape from a tower. He found in his cell a rope which was half long enough to permit him to reach the ground safely. He divided he rope in half, and tied the two parts together and escaped? How could he have done this?

Non Insightful problems

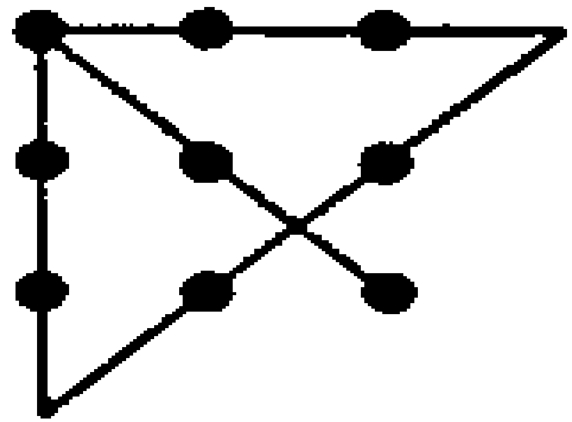
three people play a game in which one person loses and two people win each round. The one who loses must double the amount of money that each player has at that time. The three player agree to play three games. At the end of the three games, each player has lost one game, and each person has $8. what was the original stake of each player?

Next week I am going to lunch with my friend, visit the new gallery, go to the social security office and have my teeth checked at the dentist. My friend cannot meet me on Wednesday, the social security office is closed on weekends, the dentist has office hours on tue, fri and sat and the gallery is closed on tue, thurs and weekends. What day can I do everything I planned?

Removal of a mistaken assumption?

The difficulty of insightful problems is that they involve one key –but errant- perception or assumption that if removed, would lead to an easy solution. One of the most studied problem in this regard is the nine-dot problem.

Nine dot problem - connect all the dots with one continuous line.



Due to the mental set of staying within the boundary the problem appears unsolvable

According to Kershaw and Ohlsson (2004) three sources of difficulty are evident in the nine-dot problem

1) perceptual factors – relate to the Gestalt organizational principles

2) process factors – relate to the information processing demand of the problem

3) knowledge factors – involves prior knowledge that a solver brings to bear on the problem

Any/all of these factors might come into play and prevent people from solving problems

The “Aha!” Experience

another defining feature of the insight experience is a sudden and tangible feeling of discovery, usually described as an “Aah!” experience. The issue of what someone is thinking as they think related to metacognition. Metacognition refers to a person’s knowledge of their own thought process. Using metacognition and warmth ratings while solving insightful and non-insightful problems, Metcalfe & Weibe (1987) reported that, accuracy was higher for the later than for the former.

Intuition as Insight

The issue of whether insight problem solving involves special, unconscious processes-like sudden restructuring of problem elements or removal of some mistaken information-still stirs controversy in the field

Does incubation lead to insight?

One of the most controversial notions within the study of problem solving is incubation, or the idea that taking a break in problem solving leads to a quicker solution than does continuing effort. The idea is that break allows for the elements of the problems to be reorganized or for unconscious processes to continue to work on the problem and that this unconscious is limited by conscious work on the problem.

Can you come up with a saying represented by each?

YOU JUST ME

r|e|a|d|i|n|g|

0

M.Sc PhD M.D

Fly night

Smith (1995) suggests that incubation effects do occur, but only under specific circumstances – namely, when a problem is doable and when the solver is blocked in some way from the solution. Smith offers a contextual view of incubation, which is basically the encoding specificity principle in reverse

the *contextual view* of incubation states that when problem solving is stymied, a solution will come more easily if there is a contextual change from the previous situation

Creativity

creative individuals are able to think “outside the box” – to come up with new ideas, view old problems from a fresh perspective, and connect seemingly disparate problem situations.

What is creativity?

experts on creativity generally agree that creative solutions have two components – novelty and appropriateness (Lubart, 1994 & Sternberg, 2004). Creative solutions are novel, different from previous solutions and usually unexpected. The solution of creative problems must also satisfy the constraints of the problem at hand; it must fulfill a need and be sensible and useful.

one of the most – cited framework for describing and investigating creativity was originally proposed by Rhodes, who suggested that creativity can be informed by a focus on several dimensions, which he labeled *person, process, press and product*.

1) person – creativity to some extent is related to aspects of person / personality. Creative persons are thought to exhibit a number of personality like – broad interests, appreciation of complexity, tolerance of ambiguity, self-confidence, independence and sensible risk taking

Simonton believes that creativity is not always the product of a particular comfortable environment. If fact creative depends on diverse set of life experiences

2) Process – creativity also refers to specific set of processes. Two contradictory ideas about cognitive processing in creativity has been proffered –

one view asserts that creativity involves special processes and abilities like the ability to quickly restructure problem information and to connect seemingly remote possibilities.

another view contends that creative thinking is the product of the garden variety cognitive processing as attention and memory.

The creative cognitive approach (smith 2003) argues that the answer is probably that creative thinking can be the result of either type of processes or both.

Sternberg & Davidson (1995) cite three processes as important in reaching creative insights.

1) selective encoding – involves distinguishing between relevant and irrelevant information in the domain of expertise. Creative individuals are better at distinguishing useful information from red herrings

2) selective combination – involves going beyond discovering and encoding the information to the combination of the information in new and productive way

3) selective comparison – involves relating new information to old information in novel ways.

3) press – refers to the notion that creative behavior does not occur in a vacuum, that it’s subjects to various external pressures and contextual factors. Creative acts are also products of interpersonal, disciplinary and socio-cultural environments. (brainstorming)

4) products – which refers to the outcome yielded by the creative process be it a painting, poem, design or new technology. The analysis of creativity from this perspective is a challenge as its evaluation requires some type of objective standard

A taxonomy of creative processes and products

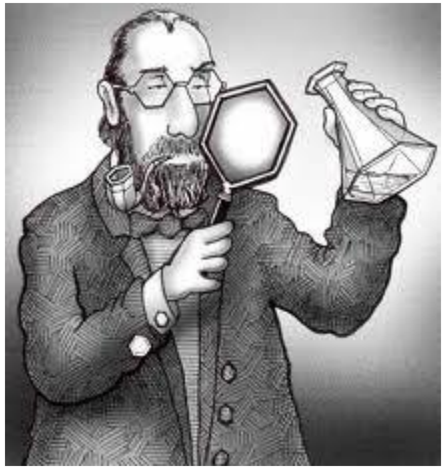
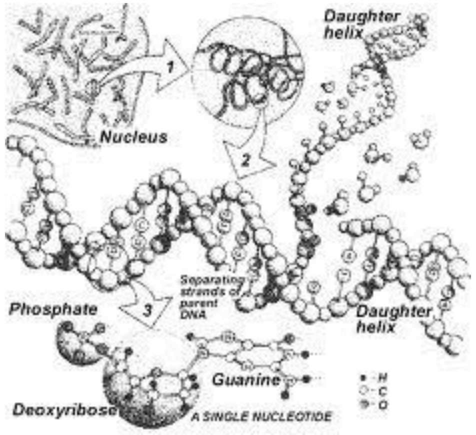
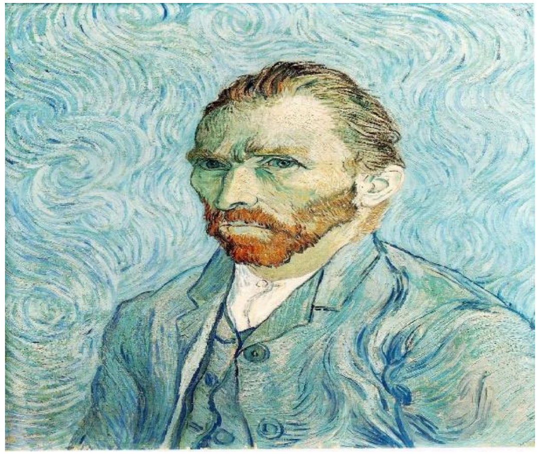
Dietrich (2004) proposes a useful scheme that imposes some order on the disparate research into creativity. Dietrich's characterizes creative insights as a product of two distinct dimensions: processing mode and knowledge domain

1) processing mode – refers to whether creative insight emerges as result of a deliberate and effortful search, or whether it emerges spontaneously as an unexpected flash of insight.

2) knowledge domain – refers to the nature of the creative insight, and whether it is characterized more by a cognitive or by a emotional breakthrough

Processing Mode

Knowledge Domain

	Spontaneous	Deliberate
Cognitive	Kekule’s Dream (Benzene ring) 	Mapping of human Gemone 
Emotional	Van Gough’s self portrait 	Insight during psychotherapy 

Try to solve the following problems

1) How could a baby fall out of a twenty-story building onto the ground and live?
2) A man and his son are in a car crash. The father is killed and the child is taken to hospital gravely injured. When he gets there, the surgeon says, 'I can't operate on this boy - for he is my son!!!' How can this possibly be?
3) Three cannibals and three anthropologists have to cross a river. The boat they have is only big enough for two people. The cannibals will do as requested, even if they are on the other side of the river, with one exception. If at any point in time there are more cannibals on one side of the river than anthropologists, the cannibals will eat them.What plan can the anthropologists use for crossing the river so they don't get eaten? *Note: One anthropologist can not control two cannibals on land, nor can one anthropologist on land control two cannibals on the boat if they are all on the same side of the river. This means an anthropologist will not survive being rowed across the river by a cannibal if there is one cannibal on the other side.*
4) *A police officer saw a truck driver clearly going the wrong way down a one-way street, but did not try to stop him. Why not?*

Reasoning and Judgment

The process of complex thinking involves the three processes of reasoning, judgment and decision making

Reasoning involves evaluation of a conclusion based solely on given information

In Judgment reasoning is applied on the given information to arrive at a conclusion

Decision making evaluation of the given information is done to arrive at a judgment and based on the judgment a choice among several possible alternatives is achieved.

The focus on Errors

The emphasis in research on reasoning, judgment and decision making has been on mistakes people make. Daniel Kahneman (1991) believes errors provide us with informativeness. The conditions under which our thinking fails us reveal important aspects of cognitive processing and inform us how the process of reasoning, judgment and decision making process works

How exactly do we know that a given chain of reasoning, judgment and decision making is in error?

one approach *normative approach* describes how we ought to think in a given situation, while a second approach *descriptive approach* describes how we actually think.

Bounded Rationality

Adherence to or deviance from rational thoughts and behavior depends on a variety of factors (an important one is how we define rational). Baron (1999) believes rationality in not necessarily the same as accuracy and that irrationality is not the same as error. Rationality involves choosing the methods that help us attain our goals. We can reason well but still have a decision work out badly; conversely we can reason badly yet still luck into a good outcome. The simple notion that there are limits to our powers of reason is termed *bounded rationality.*

Dual process views

According to this view the human thinker operates in one of the two modes depending on the particular nature of the situation. In *heuristic mode (system 1)*, the process used for thinking operate quickly and without much deliberation (automatic) while in *analytical mode (system 2)* the processes are relatively slow, deliberate and controlled. The analytical mode is more cognitively demanding than the heuristic mode in that it demands more working memory

Reasoning

***Deductive reasoning* –** involves determining if a specific conclusion is valid based on general principle or assertions (premises). Deductive reasoning problems involve a large degree of constraint and the conclusion is easily assessed using the algorithmic approach. Two primary types from Evans (2002) are discussed

Syllogistic Reasoning

All students are bright
All bright people complete assigned work on time
Therefore, all students complete assigned work on time

1) Syllogisms consists of two premises and a conclusion.

2) The premises & conclusions may begin with a *universal quantifier (all)* or a *particular quantifier (some).*

3) Also the terms within a syllogism may be stated positively ("All A are B") or negatively ("All A are not B").

Syllogism are either valid or not valid – that is the conclusions either does or does not hold, given the premises

Valid arguments imply that the conclusions does follow from the premises. However it says nothing about whether the premises themselves are true. The truth value of an argument depends on *both* the validity of the argument form and the truth of the premises. Consider

All professor are comedians
All comedians are funny
Therefore, all professors are funny

All A are B
All C are B
Therefore, All A are C

No oranges are apples
No lemons are oranges
Therefore, no apples are lemons

Are these conclusions valid based on their respective premises? The reasoning errors are caused by

a) Atmosphere effects – according to this explanation the quantifiers used in the premise combine to form an "atmosphere" within which the validity of the conclusion is assessed. For instance the premises in syllogism 1 create a “positive universal atmosphere”. This produces an erroneous tendency to claim that the universal and positive conclusion are valid.

b) Belief bias – our beliefs about truth interfere with our ability to assess argument validity.

All intelligent beings are Simpsons fans
All dolphins are intelligent beings
Therefore, all dolphins are Simpsons fans

The tendency to allow belief to interfere with the evaluations of conclusions in syllogistic arguments has been termed *belief bias*

All smart people are reasonable
All Democrats are smart people
Therefore, all Democrats are reasonable

Conditional Reasoning

the second form of deductive reasoning is called *conditional reasoning (or if –then reasoning*) and involves evaluating whether a particular conclusion is valid given that certain conditions (premises) hold. Consider

1. if someone likes Winnie-the-Pooh, they are a sensitive person.
2. Mary likes Winnie-the-Pooh.
3. Therefore, Mary is a sensitive person

Another version of the reasoning problem is

1. if someone likes Winnie-the-Pooh, they're a sensitive person
2. Mary is a sensitive person
3. Therefore, Mary likes Winnie-the-Pooh.

Conditional reasoning conclusions can be evaluated quite easily if one applies a set of logical rules.

Conditional statement

if a person likes Winnie-the-Pooh, then they're a sensitive person

(Antecedent) (Consequent)

Four conditional scenarios

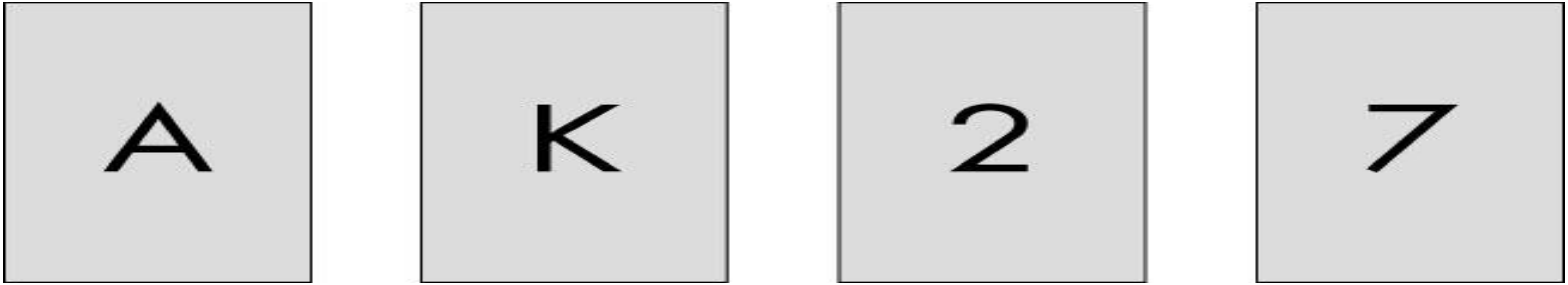
	Affirm	Deny
Antecedent	Mary like Winnie-the-Pooh Therefore, Mary is a sensitive person (*Modus Ponens*)	Mary does not like Winnie-the Pooh Therefore, Mary is not a sensitive person
Consequent	Mary is a sensitive person. Therefore, Mary likes Winnie-the-Pooh	Mary is not a sensitive person. Therefore, Mary does not like Winnie-the-Pooh (*Modus Tollens*)

People run into fair amounts of difficulty when judging the validity of conclusions derived from *if –then* statements. One tendency people have is to interpret the initial conditional statement as *bi-conditional*- thinking that *"if p, then q"* also means *"if q, then p"*

Wason's Selection task

the classic version of the task is requires the reasoner to decide which of the four cards needs to be turned over in order to determine whether the following *if-then-statement* holds:

if a card has a vowel on one side, then it must have an even number on the opposite side



The selection tendencies of WST reveal *confirmatory bias* – which refers to our tendency to seek out or notice evidence that is consistent with a particular hypothesis rather than evidence that would be inconsistent with the hypothesis.

Rules or Models of deductive reasoning

Explanations' of how we reason deductively generally fall into two main camps

1) *strict or rule based account* (Rips, 1994) – which contends that people possess the representational equivalent of logic rules. These rules are applied to the premises to determine if the conclusion is valid

2) *mental model view* (Johnson-Laird, 2002) – which believes that we first form a mental model based on the information in the premises and out own previous experiences. Next we search for a mental model in which the premises would be true but the stated conclusion would be false. If successful we deem the conclusion invalid; if we don’t we deem the conclusion valid.

Inductive Reasoning

In inductive reasoning we reason from specific pieces of data or information towards a general conclusion. Unlike deductive reasoning where conclusions are labeled as *valid/invalid* with absolute certainty, inductive reasoning leads to uncertain conclusions that vary in their strength

Professor X gets upset when asked if she'll issue paper extension
Professor Y won't accept late papers
Professor Z takes 20% off each day a paper is late

Bisanz, Bisanz & Korpan (1994) describe some characteristics that seem to typify inductive reasoning

1) The product of inductive reasoning is not necessarily correct. Inductive arguments are evaluated in terms of their strength rather than in terms of their validity.

2) Ripps (1990) points out that with inductive reasoning there is a need for constraint on the conclusion to be reached

Rules or Instances?

what mental structures & processes underlie inductive reasoning?

Researchers disagree on whether induction is based on formal, rule-driven processes or on more context-bound, experience based heuristic processing. The rule based view – termed as *strict/syntactic view* – states that inductive reasoning involves special processes and representations that operate in the abstract, outside of any real life context. The experience-based view – termed *loose view* – contends that inductive reasoning involves updating the strengths of one's belief based on the recall of specific instances

The Omnipresence of Inductive Reasoning

Inductive reasoning is in some part involved with most of the cognitive processes. Two examples are

a) Inductive reasoning in Categorization – inductive reasoning provides another view through which the phenomenon known as the *typicality effect* can be viewed.

1. Robins are susceptible to disease A
   Therefore, all birds are susceptible to disease A
2. Turkeys are susceptible to disease B
   Therefore, all birds are susceptible to disease A

subjects rated argument 1 as more likely to be true because robins are seen as more typical birds than turkeys

Another interesting phenomenon observed in inductive reasoning about categories might be termed as *diversity effect*. Which of the following arg. is strong

1. Robins are susceptible to disease Y
   Sparrows are susceptible to disease Y
   Therefore, all birds are susceptible to disease Y
2. Cardinals are susceptible to disease Z
   Turkeys are susceptible to disease Z
   Therefore, all birds are susceptible to disease Z

In this case people rated argument 2 as stronger because cardinals and turkeys represent a more diverse set of birds relative to robins and sparrows

(b) Inductive reasoning and problem solving

another set of cognitive processes that depends critically on inductive reasoning is problem solving – more specifically solving problems by analogy.

Judgment

Inductive reasoning involves arriving at general conclusions based on specific pieces of what might be called "data". *Judgment* is an extension of inductive reasoning. Hastie & Dawes (2001) define –

judgment is the human ability to infer, estimate & predict the character of unknown events.

Judgment is the process of making educated guesses, based on limited information along with our previous knowledge, expectations and beliefs (stereotypes)

Basing judgment on memory: The availability heuristic

the availability heuristic indicates that we base our estimates of likelihood, or probability, on the ease with which we can think of examples. The availability heuristic is dependent on two main sub processes

a) biased encoding – leads to overrepresentation of certain facts in memory. This in turn makes bias retrieval from memory as the information stored is memory is biased. (e.g., media overestimation)

b) biased retrieval – availability can lead us astray if the sampling process itself is biased. (e.g., Try the following and state whether there are more of number 1 or number 2)

1. six letter words that have the letter n as the fifth letter

2. words that fit the pattern _ _ _ *i n g.*

c) illusory correlations – when one notices primarily coincidences, two events will seem to be linked even when they're not. This perception is called illusory correlation (sports illustrated jinx)

A recognition Heuristic – reasoning is adaptive, we simply cannot consider all of the data, nor do we have access to it. The *lack of data* can be informative!. Recognition heuristic is often used when we're faced with two alternatives – one that's recognizable and one that's not.

The Representative Heuristic: Basing judgment on similarity

When trying to place a person in a particular category our judgment rely on representational heuristic – the degree to which the object represents our basic idea of that object

Ignoring base rates

people mostly commit the base rate fallacy – ignore thee rate of occurrence of a particular category in the population or sample (i.e., how often a certain event tends to occur) – there by getting biased by similarities. For example consider the classic demonstration by Kahneman & Tversky (1973).

Subjects were given the following instructions

a panel of psychologists have interviewed and administered personality tests to 30 engineers and 70 lawyers, all successful in their field. On the basis of this information, thumbnail descriptions for each of these individuals have been written. For each description, please indicate the probability that the person described is an engineer from 1 to 100.

Subjects were then given the following description

jack is a 45-year-old man. He is married and has 4 children. He is generally conservative, careful and ambitious. He shows no interest in political and social issues and spends most of his times on his many hobbies, which include home carpentry, sailing and mathematical puzzles.

Subjects were required to rate the probability that jack was an engineer.

when not given the profile the probability that a randomly drawn name is an engineer was 30/100 or 30%, however with profile it was 50/100 or 50%.

Use of representative heuristic and the concomitant tendency to ignore base rate may relate to the use of the controversial practice known as *racial profiling.*

The conjunction fallacy

the conjunction fallacy is another cause of bias which is caused by stereotyping. In a classic study Tversky & Kahneman (1983) demonstrated this fallacy at work. They presented the following problems to subjects

Linda is 31 years old; she's single, outspoken and very bright. She majored in philosophy. As a student, she was deeply consumed with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations.

The subjects were asked to decide whether it was more likely that she was (1) a bank teller (2) a bank teller who was active in the feminist movement.

if probability of 1 was 0.5 and that of 2 was 0.5 then since their combined probability (since 1 includes 2) is 0.5 x 0.5 = 0.25

Misperception of event clusters

when a given event has two different ways of working out, such as a coin flip, people tend to misconstrue what a random sequence should look like (i.e.,) they tend to underestimate the number of clusters of like event, that would occur in a truly random sequence.

H T H T T H T H H T H T H H H H H H T T T T T T

Examples of misperception of event clusters

a) The hot hand – the tendency to misperceive event clusters as indicating non-randomness may underlie what sports fans terms as hot hand.

b) The Gamblers fallacy – refers to the belief that after a run of bad luck (or a run of a certain type of outcome), a change is *“due”* to occur

The Anchoring-and-Adjustment Heuristic

In many cases of judgment people start with an idea or standard in mind. This initial estimate or first impression tends to make us overly biased towards it. The heuristic involved in these judgment is termed *anchoring and adjustment.* A good example of this heuristic at work is the *spotlight effect*.

spotlight effect – refers to our tendency to believe that others notice our actions and appearance more than they actually do – i.e., we believe that the "social spotlight" shines more brightly on us than it actually does.

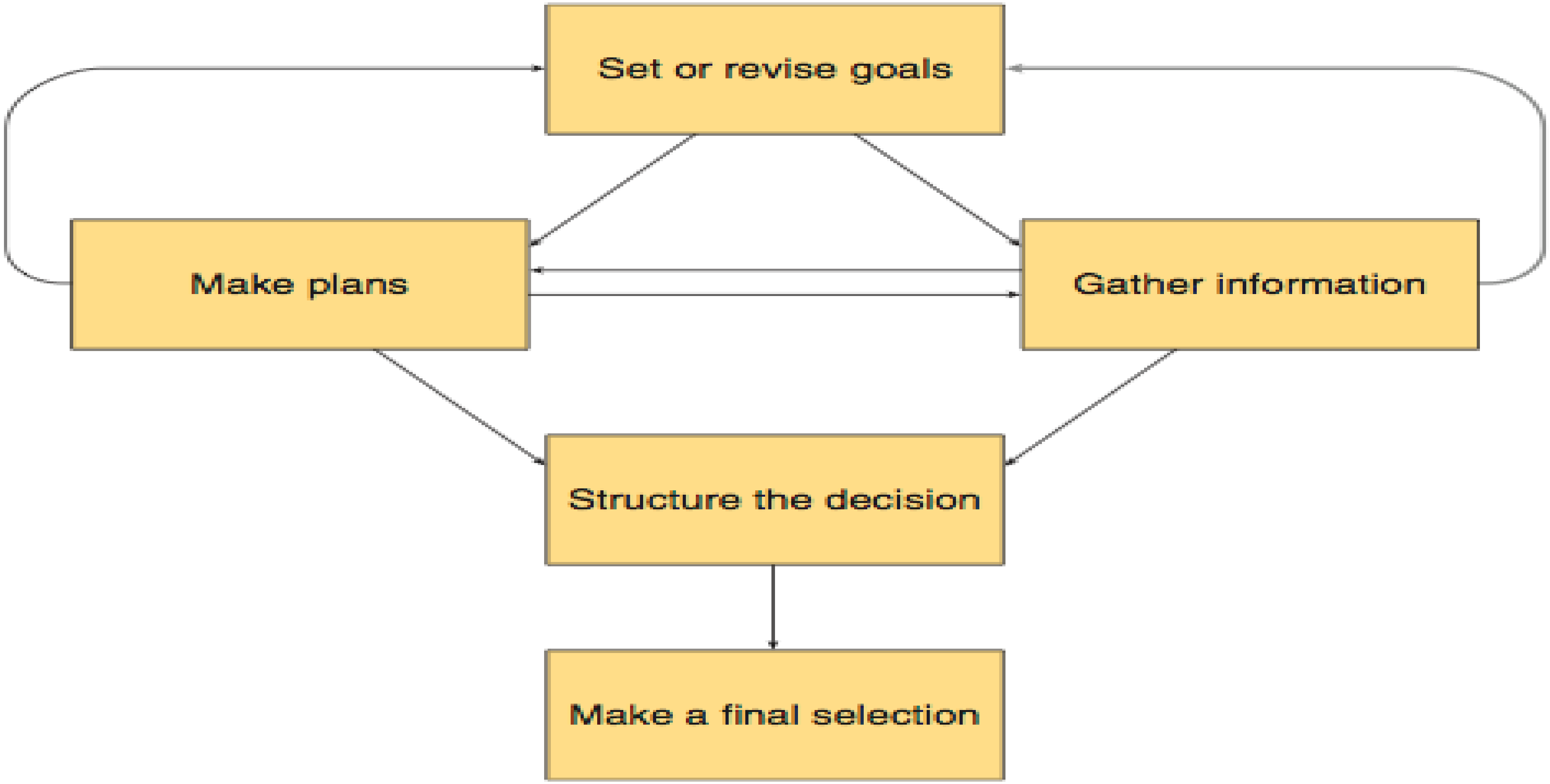
Biased Evaluation of Our Judgments

Biases in judgment can also arise from the fact the at times we're not good at estimating how much we know or when we knew it. A couple of biases of this sort are

a) *Hindsight Bias*: people often seem to be sure after something has occurred that they knew things would work out just that way. This tendency is termed as *hindsight bias (i-knew-it-all-along-effect). [e.g., civil suits]*

b) *Miscalibration of Confidence:* the fact that we overestimate the extent to which we knew something we going to happen demonstrates an insensitivity to what we knew and when we knew it.

Decision making



Decision Making

Despite the errors that occur when we make judgment, these judgment form an important part of the database for the process of decision making. Decision making includes a choice between alternatives. With the increase in the number of alternatives available the probability/chance of alternatives being wrong also increases – leading to the increase of risk/uncertainty in choice

According to the *threshold approach of choice* (Clemen,1991), if a decision depends on the likelihood of another event happening, then the attractiveness of the option should increase as the probability of the other event increases. Once that probability reaches a minimum level of certainty, the alternative would be chosen.

Decisions which involve over-confidence in judgment attain the minimum level of certainty too easily leading to choice of wrong/un-rewarding choices

Does the minimum level of certainty vary with culture?

Expected Utility: A Normative Approach

Economists are interested in the factors involved in choice and what type of model describes rational choice behavior. One of the well-established theories of decision making is *expected utility theory*

the theory states that when faced with some type of uncertain choice, we make our decisions based on two factors

1) the expected utility of the outcomes

2) their respective probability

Utility refers to whatever end a person would like to achieve, be it happiness, money or something else. Broome (1991) suggests – utility refers to the amount of good that comes out of a decision. Thus while making decisions we weigh the good that might come out of each alternative against the cost of that alternative. We also access the probability of each alternative occurring. Whatever alternative provides the best combination of "good" and "likelihood" will be the chosen one. Consider

flip a coin; if it turns up head, you get $40
Roll a dice, if it come up 4, you get $50.

Which option would you chose?

Violation of Expected Utility

One of the normative predictions made by expected utility theory is that our choices should show *invariance's*; that is, a decision maker's choice should not depend on the way a choice is presented. If I prefer choice A over choice B in situation 1, then I should prefer choice A over choice B in situation 14 (as long as A and B are identical in the two situations)

People often switch their preferences of one outcome over another, based on how these outcomes are presented, demonstrating *irrationality*. Consider the *preference reversal* shown (Lichtenstein & Slovic, 1971). Their general procedure involved having subjects look at two different gambles and decide – (1) which gamble they would like to play & (2) how much the gamble was worth.

1) 80% chance to win \$ 4.00 20% chance to lose \$ 0.50	4) 10% chance to win \$ 40.00 90% chance to lose \$ 1.00
2) 95% chance to win \$ 3.00 5% chance to lose \$ 2.00	5) 50% chance to win \$ 6.50 50% chance to lose \$ 1.00
3) 99% chance to win \$ 4.00 1% chance to lose \$ 1.00	6) 33% chance to win \$ 16.00 67% chance to lose \$ 2.00

Lichtenstein & Slovic expected that the choice of which gamble to play would be influenced by the probability of winning, whereas the choice of the selling price for the gamble would depend on the potential dollar amount to be won. Why is this preference reversal irrational?

The *preference reversal* phenomena demonstrates the inadequacy of expected utility as a descriptive model of decision making. The expected utility model fails to provide a good description of how we make choices in many circumstances because it assumes too much; humans rarely have all the information necessary to make a decision. Even if they did, they lack the ability to combine and weigh the information accurately

Multiattribute Utility Theory (MAUT)

- What if the choices differ on many dimensions?
- Example: Choosing a major
- Majors differ in many ways: your interest in them, the job market after graduation, the faculty, etc.
- How should one choose?

Steps in MAUT

1. Break the decision down into its important dimensions.
2. Determine the relative weight (importance) of each dimension.
3. List all of the alternatives.
4. Rank the alternatives along each dimension.
5. Multiply each ranking by the appropriate weight.
6. Choose the alternative with the highest value.

An example of MAUT in action

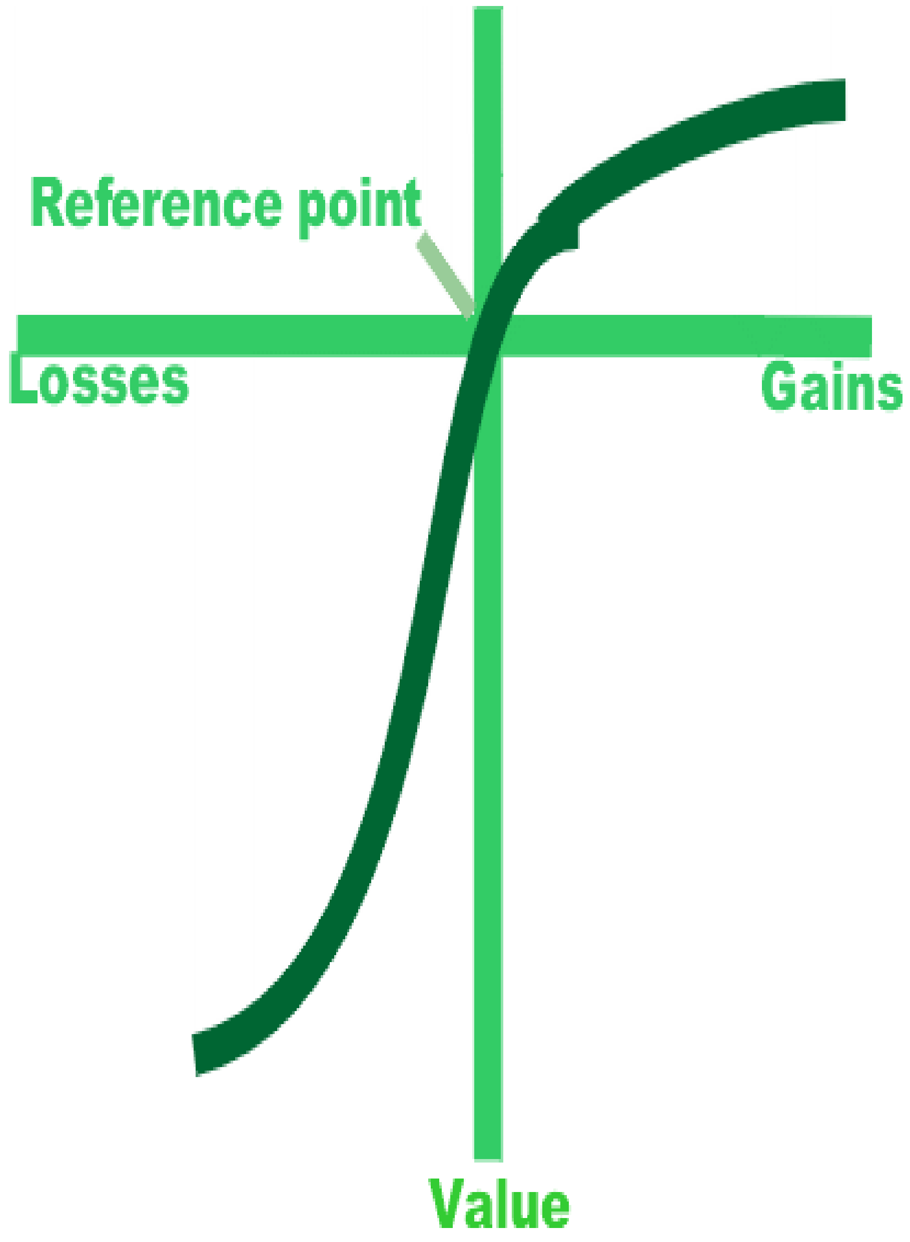
Criterion	Importance weight	Options: Major: Psychology	Major: Biology	Major: Mathematics	Major: Classics	Major: Sociology
Interest in topic	9	9	8	7	4	6
Job prospects	8	7	9	8	1	3
Faculty in department	5	3	4	3	9	5
Requirements	7	5	4	3	7	8
Model				**Summary Scores**		
Full Multiattribute Utility Theory		187	192	163	138	159
Equally Weighted Criteria		24	25	21	21	22
Top Criterion		9	8	7	4	6

Prospect Theory

One popular alternative to expected utility theory is Kahneman & Tverskys (1979) prospect theory. Prospect theory is a descriptive model of decision making that attempts to describe how we make decisions and why our decisions violate the expected utility model. The theory states

decisions are not valued based on the absolute value of the end result, as proposed by expected utility; instead we value decisions based on the amount of gain or loss from what we have right now. It also adds that gains and losses are on different scales of value.

The value we attach to gain increases more slowly as a function of the size of the gains than does the (negative) value we place on the loses as a function of the size of the loss. Basically we feel losses more acutely then we feel gains; the psychological pain associated with losing $50 is greater than the psychological pleasure of gaining $50. prospect theory predicts that people will be especially aversive to loss and will show difference in preference depending on how alternatives are presented or framed



Framing – is the term used to describe the effects on our decisions oh how a scenario is presented.

Prospect theory predicts our preferences will change whenever our reference point changes. Decisions can be influenced by how information is presented. If information is presented in terms of a positive “gain frame”, we will be more likely to avoid risk (risk averse) and pick a sure bet. However if the same information is presented in a negative “loss frame”, we will be more likely to take a risk (risk prone) to avoid loses.

Consider the results of a classic study by Tversky & Kahneman (1981). Subjects were presented with this scenario and two choices

Imagine that the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs for combating the disease have been proposed. Assume that the exact scientific estimate of the consequences of the program is as follows:

If program A is adopted, 200 people will be saved.

If program B is adopted, there is a 1/3 probability that 600 people will be saved and 2/3 probability that no one will be saved.

Other subjects were presented with exactly the same problem but with different choices

If program C is adopted, 400 people will die

If program D is adopted, there is 1/3 probability that nobody will die, & 2/3 probability that 600 people will die.

Psychological Accounting

this principle states that people will make different decisions depending on how the outcomes is felt or perceived. Consider

1) imagine you have decided to see a play for which admission is $10 a ticket. As you enter the theater, you discover that you have lost a $10 bill. Would you still pay $10 for a ticket to the play?

2) Imagine that you have decided to see a play for which admission is $10 a ticket. As you enter the theater, you discover that you have lost the ticket. The seat was not marked and the ticket cannot be recovered. Would you pay $10 for a ticket to the play?

In Kahneman & Tversky (1981) original study the subjects were less willing to purchase a ticket in scenario 2. Why could this be?

Sunk Cost

the sunk cost effect is another interesting variation of the notion of psychological accounting. This effect was demonstrated by Arkes and Blumer (1985) In one experiment

subjects were to imagine that they had purchased tickets for two different ski trips: one ticket (for trip to Wisconsin) cost $50, while the other ticket (for trip to Michigan) cost $100. the scenario made it clear that the trip to Wisconsin was preferable because it would be more enjoyable.

then a complication arose: the two trips were on the same weekend and the tickets were non refundable. Which trip would you choose to go on?

Affect and Decision Making

Positive and negative outcomes *feel* different to us, with predictable implications for the decisions we make. Affect thus is an important determinant of decision making, and can have sizable impact on psychological accounting process.

Hsee & Rottenstreich (2004) make this point by highlighting an important dimension of choice that interacts with affect, which they term *scope*; it basically refers to the sweep of a decision or action – how much impact will it have? Consider

suppose you gave $10 to help save one endangered tiger--- feels good. Now much would you give to save 4 endangered tigers?

The answer depends on whether the subjective value you derive from saving tigers is somehow multiplicative?

The authors propose a dual-process view of the relative impact of scope and subjective value on decision making. Their dual processes are – *a deliberate mode (which would map into the conscious reasoning) and an affective mode (which would map onto the unconscious reasoning).*

when we're in a deliberate decision making mode, we value things by calculation (4 > 2); while in an affective decision making mode we value things by feeling (help tigers). In deliberate decision making mode as scope increases subjective value increases correspondingly, while in affective decision making mode scope doesn't matter nearly as much and we are affected by the presence/absence of a stimulus