Indian Institute of Technology Kanpur

References

- Braisby & Gellatly (2005). Cognitive Psychology. *Oxford University Press.*

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National Program on Technology
Enhanced Learning (NPTEL)

Presents

Course Title:

Basic Cognitive Processes

By: Dr. Ark Verma,
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Lecture 19: Approaches to Visual Perception - 2

Marr's Theory of Perception: The 2.5D Sketch

- *"the detection of physical invariants, like image surfaces, is exactly and precisely an information processing problem, in modern terminology. And second, he (Gibson) vastly underrated the sheer difficulty of such detection. … Detecting physical invariants is just as difficult as Gibson feared, but nevertheless we can do it. And the only way to understand how is to treat it as an information processing problem." - (Marr, 1982)*

- While Gibson identified the need for invariants for solving problem of visual perception, he did not specify the possible mechanisms about how the information was "picked up" about these invariants.
- To address, the gap, a theory was needed that attempted to explain exactly how the brain was able to take the information sensed by the eyes and turn it into an accurate, internal representation of the surrounding world. Such a theory was put forward by David Marr (1982).

- Common points between Gibson’s & Marr’s theories.
  - Like Gibson, Marr suggested that the information from the senses is sufficient to allow perception to occur.
  - Marr adopted an information processing approach in which the processes responsible for analyzing the retinal image were central.
  - Marr’s theory is also therefore strongly bottom - up, in that it sees the retinal image as the starting point of perception and explored how this image might be analyzed in order to produce a description of the environment.
    - note that Marr was interested in perception of the kind involved in object recognition & not the one used for action.

- Marr saw the analysis of the retinal image in four distinct states, with each stage taking the output of the previous one and performing a new analyses on it:
  - *Grey level description*: the intensity of light is measured at each point in the retinal image.
  - *Primal sketch*: first, in the raw primal sketch, areas that could potentially correspond to the edges and texture of objects are identified. Then, in the full primal sketch, these areas are used to generate a description of the outline of any objects in view.

- *2.5D sketch*: at this stage a description is formed of how the surfaces in view relate to one another and to the observer.

- *3D object centered description*: at this stage object descriptions are produced that allow the object to be recognized from any angle (i.e. independent of the viewpoint of the observer).

- Marr concerned himself mostly at the computational level and algorithmic levels of analysis and did not say much about the neural hardware that might be involved.

- **The Grey Level Description**:
  - Marr thought that colour information was processed by a distinct module and need not be involved in obtaining descriptions of the shape of objects and the layout of the environment.
    - “ Computer scientists call the separate pieces of a process its modules, and the idea that a large computation can be split up and implemented as a collection of parts that are nearly as independent of one another as the overall task allows, is so important that I was moved to elevate it to a principle; the principle of modular design.” (Marr - 1982).

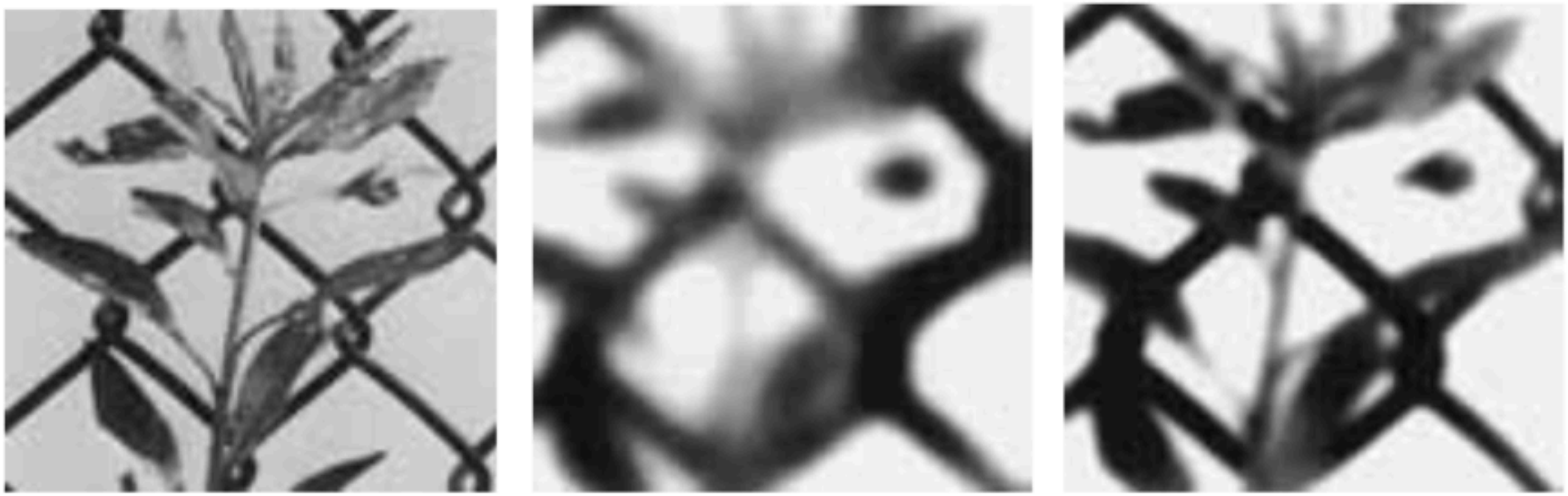
- This first stage in Marr’s theory acts to produce a description containing the intensity (i.e. the brightness) of light at all points of the retina.
  - A description composed solely of intensity information is referred to as the ‘greyscale’.
  - Algorithmically speaking, it is possible to derive the intensity of the light striking each part of the retina, because as light strikes a cell in the retina, the voltage across the cell membrane changes and the size of this change (or depolarization) corresponds to the intensity of light.
  - therefore, a greyscale description is produced by the pattern of depolarization on the retina.

- **The primal sketch**: The generation of the primal sketch, occurs in two phases.
    - The first phase consists of forming a raw primal sketch from the grey level description by identifying patterns of changing intensity.
    - Changes in intensity of the reflected light can be grouped into three categories:
        - Relatively large changes in intensity produced by the edge of an object.
        - Smaller changes in intensity caused by the parts & texture of an object.
        - Still smaller changes in intensity due to random fluctuations in the light reflected.

- Marr & Hildreth (1980) proposed an algorithm that could be used to determine which intensity changes corresponded to the edges of objects, meaning that changes in intensity due to random fluctuations could be discarded. The algorithm made use of a technique called **Gaussian Blurring**, which involves averaging the intensity values in circular regions of the greyscale description.

- The values at the center of the circle are weighted more than those at the edges in a way identical to a normal distribution.

- By changing the size of the circle in which intensity values are averaged, it is possible to produce a range of images blurred to different degrees.



(a) (b) (c)

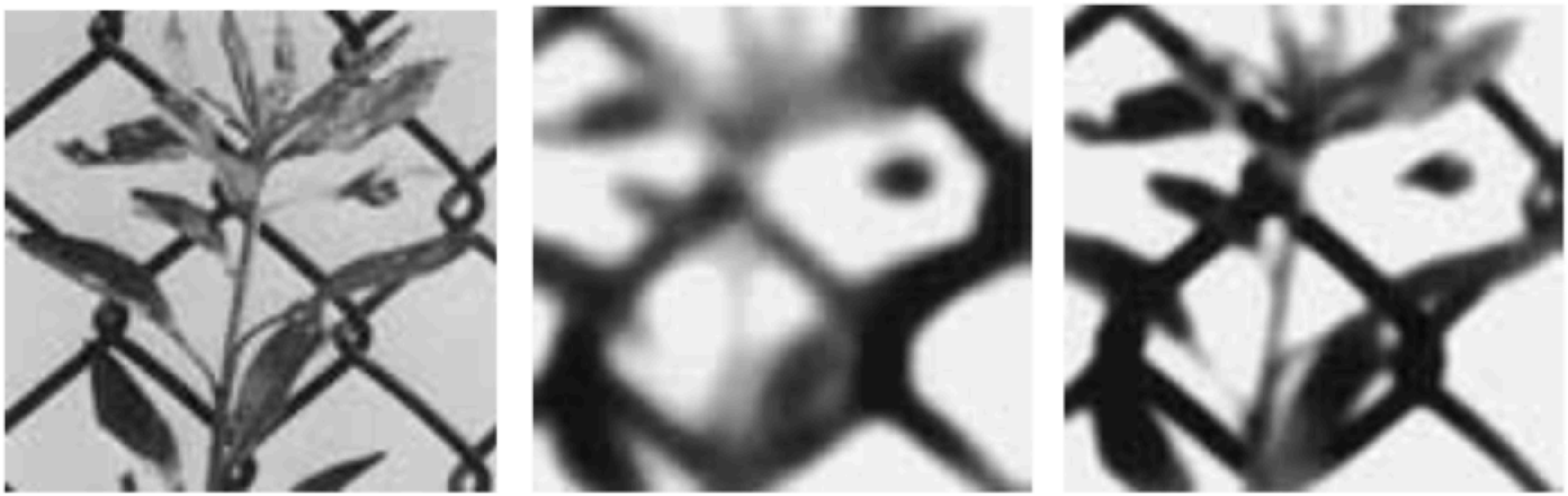
Figure 3.17 Examples of Gaussian blurred images

Image: Braisby & Gellatly (2005). Cognitive Psychology. *Oxford University Press. (*Fig. 3.17, p.93)

- Marr & Hildreth's algorithm works by comparing images that have been blurred to different degrees. if an intensity change is visible at two or more adjacent levels of blurring, then it is assumed that it cannot correspond to a random fluctuation and must relate to the edge of an object.

- Although this algorithm was implemented on a computer, there is evidence that retinal processing delivers descriptions that have been blurred to different degrees.

- By analyzing the changes in intensity values in the blurred images, it is possible to form a symbolic representation consisting of four **primitives** corresponding to four types of intensity change:
    - edge - segments: represent a sudden change in intensity
    - bar: a bar represented two parallel edge - segments
    - a termination: represented sudden discontinuity
    - a blob: corresponded to a small enclosed area bounded by changes i intensity



(a) (b) (c)

Figure 3.17 Examples of Gaussian blurred images

Image: Braisby & Gellatly (2005). Cognitive Psychology. *Oxford University Press. (*Fig. 3.17, p.93)

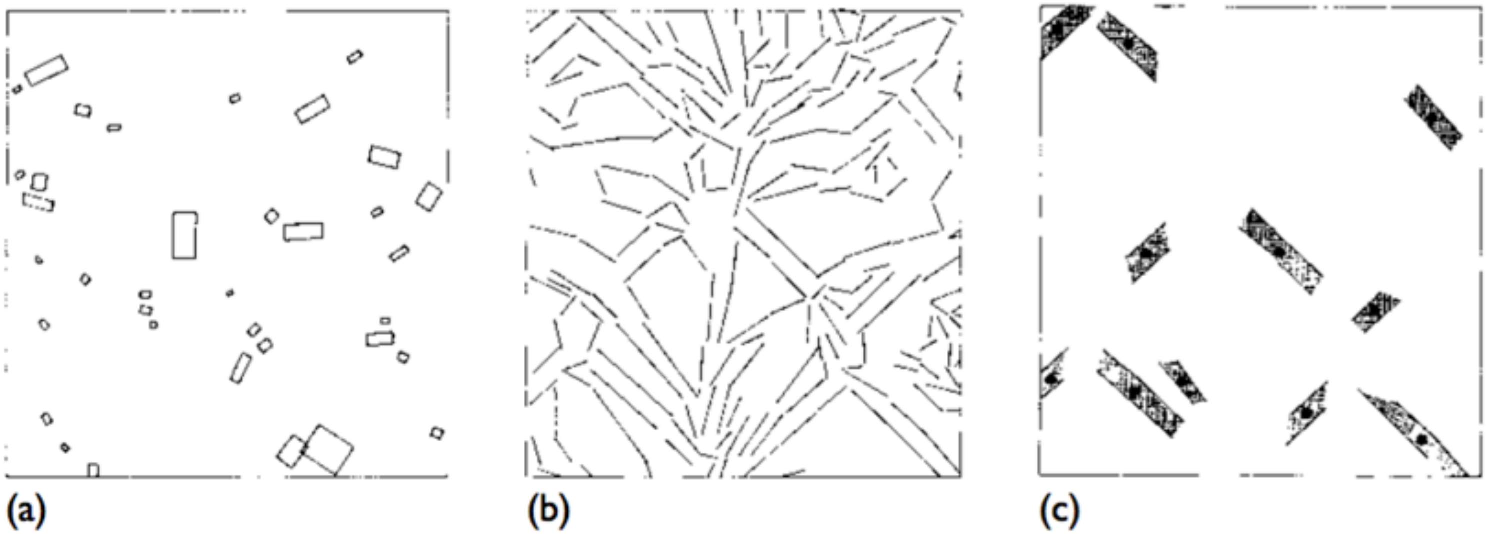


Figure 3.18 Primitives used in the raw primal sketch: (a) blobs, (b) edge-segments and (c) bars

Image: Braisby & Gellatly (2005). Cognitive Psychology. *Oxford University Press. (*Fig. 3.18, p.93)

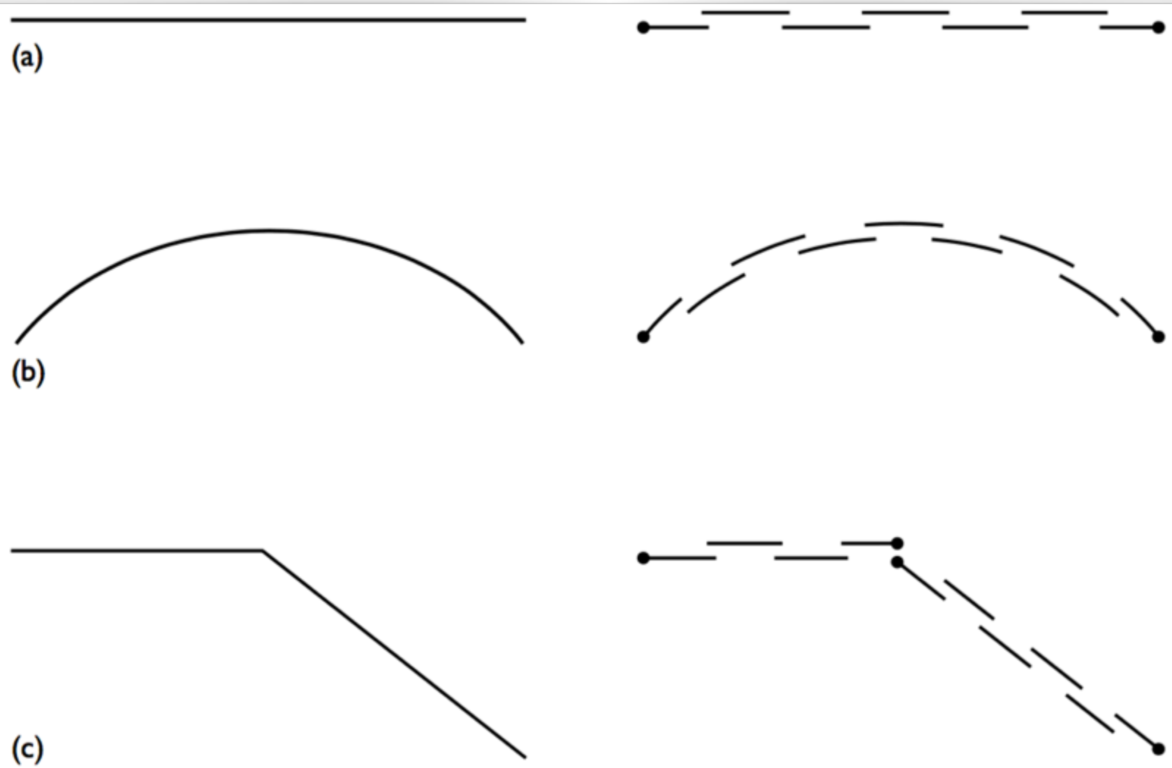


Figure 3.19 Representation of three simple lines in the raw primal sketch: 'The raw primal sketch represents a straight line as a termination, several oriented segments, and a second termination (a). If the line is replaced by a smooth curve, the orientations of the inner segments will gradually change (b). If the line changes its orientation suddenly in the middle (c), its representation will include an explicit pointer to this discontinuity. Thus in this representation, smoothness and continuity are assumed to hold unless explicitly negated by an assertion' (Marr, 1982, p.74)

Image: Braisby & Gellatly (2005). Cognitive Psychology. *Oxford University Press. (*Fig. 3.19, p.94)

- The next step is to transform the raw primal sketch into a description, known as the **full primal sketch**; which contains information about how the image is organized, particularly about the location, shape, texture and internal parts of any objects that are in view.

- Basically, the idea is that **place tokens** are assigned to areas of the raw primal sketch based on the grouping of the edge segments, bars, terminations & blobs.

- If these place - tokens then form a group among themselves, they can be aggregated together to form a new, higher - order place token.

- An example: consider looking at a tiger.
  - the raw primal sketch would contain information about the edges of the tiger’s body; but also about the edges & patterns of its stripes and the texture of it’s hair.
  - in the full primal sketch, place tokens will be produced by the grouping of individual hairs into each of the stripes. the place tokens for each stripe would then also be grouped into a higher - order place token; meaning that there will be at least two levels of place tokens making up the tiger.

- various mechanisms exist for grouping the raw primal sketch components into place tokens & then for grouping the place tokens together. these include **clustering,** in which tokens that are close to one another are grouped in a way very similar to the Gestalt principle of proximity & **curvilinear aggregation**, in which tokens with related alignments are grouped in a similar fashion to the Gestalt principle of good continuation.

- **The 2.5D sketch:** Marr's modular approach to perception means that while the full primal sketch is being produced, other visual information is being analyzed simultaneously.
    - for e.g. depth relations, distance between a surface & the observer, motion etc.
- Marr proposed that the information from all such modules was combined together to produce the 2.5D sketch. It is called the 2.5D sketch, because the specification of the position & depth of surfaces and objects is done in relation to the observer. thus, the description of the object will be **viewer - centred** and will not contain any information about the object that is not present in the retinal image.
- the viewer centred image is turned into a fully 3D **object - centred** description using some steps (to be discussed later)

- Marr saw the 2.5D sketch as consisting of a series of primitives that contained vectors showing the orientations of each surface.

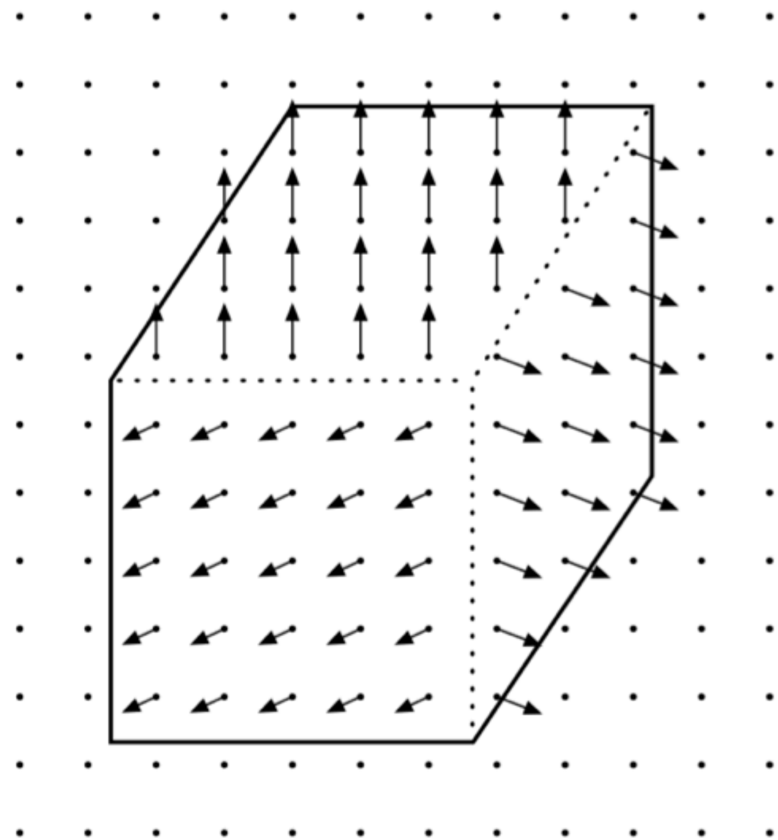


Figure 3.20 A 2½D sketch of a cube

Image: Braisby & Gellatly (2005). Cognitive Psychology. *Oxford University Press. (*Fig. 3.20, p.96)

- **Evaluating Marr's approach**: A lot of research has followed Marr's theory; some of it indeed confirming his proposed mechanisms while some finding out it's shortcomings.

- Marr & Hildreth (1980) proposal of primal sketch being formed by looking for changes in intensity worked well with computer simulations but it could not be guaranteed that the same is followed by human visual system.

- Ens & Resnick (1990) showed that the participants of their study could also use 3D information instead of only 2D information to form a full primal sketch.

- However, Marr’s proposal of the integration of depth cues in the 2.5D sketch was supported by experiments done by Young et al., (1993); who reported that the perceptual system does process these cues separately, and will also make selective use of them deepening on how noisy they are.

To Sum Up

- We talked about David Marr's 2.5 D Approach to Perception.
- We saw again that information from the sensory experience can be systematically analysed to construct a good perceptual representation of the world.
- There are however shortcoming & gaps in linking this computational approach to match human performance.

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Lecture 20: Approaches to Visual Perception - 3

Helmholtz's Theory of Unconscious Inference

- Helmholtz proposed a principle called the ***theory of unconscious inference,*** which states that some of our perceptions are the result of unconscious assumptions that we make about the environment.

- This theory was proposed to account for our ability to create perceptions from stimulus information that can be seen in more than one way.

- For example:

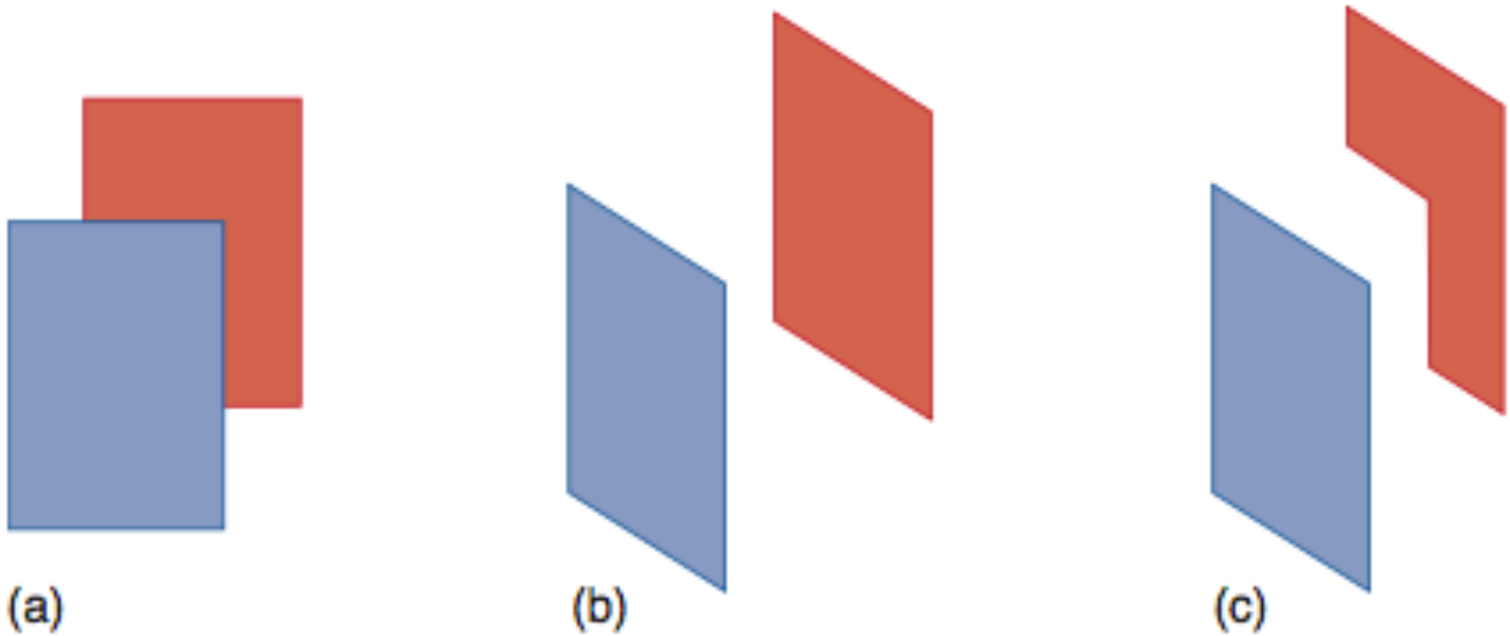


FIGURE 3.14 The display in (a) is usually interpreted as being (b) a blue rectangle in front of a red rectangle. It could, however, be (c) a blue rectangle and an appropriately positioned six-sided red figure.

Image: Goldstein E.B. (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 3rd Ed. (Fig. 3.14, p.58)

- The theory of unconscious inference includes the ***likelihood principle,*** which states that we perceive the object that is *most likely* to have caused the pattern of stimuli we have received.

- Thus, we infer that it is likely that the fig 3.14 is a rectangle covering another rectangle because of experiences we have had with similar situations in the past.

- Helmholtz therefore described the process of perception as being similar to the process involved in solving a problem.

- The problem is solved by a process in which the observer applies his or her knowledge of the environment in order to infer what the object might be.

- In cases such as the one we discussed, this process is unconscious, hence the term ***unconscious inference.***

Gestalt Approach to Perception

The Whole is More than the Sum of It's Parts

- The Gestalt Psychologists were the first group of psychologists to systematically study **perceptual organisation** in the 1920's in Germany.
- Some of the notable names were, Johann Wolfgang von Goethe, Ernst Mach, Kurt Koffka, Max Wertheimer, Wolfgang Kohler etc.
- The basic idea of perceptual organisation is the fact that, "any image tends to be perceived according to the organisation of the elements with in rather than merely according to the nature of the individual elements themselves"

Law of Closure

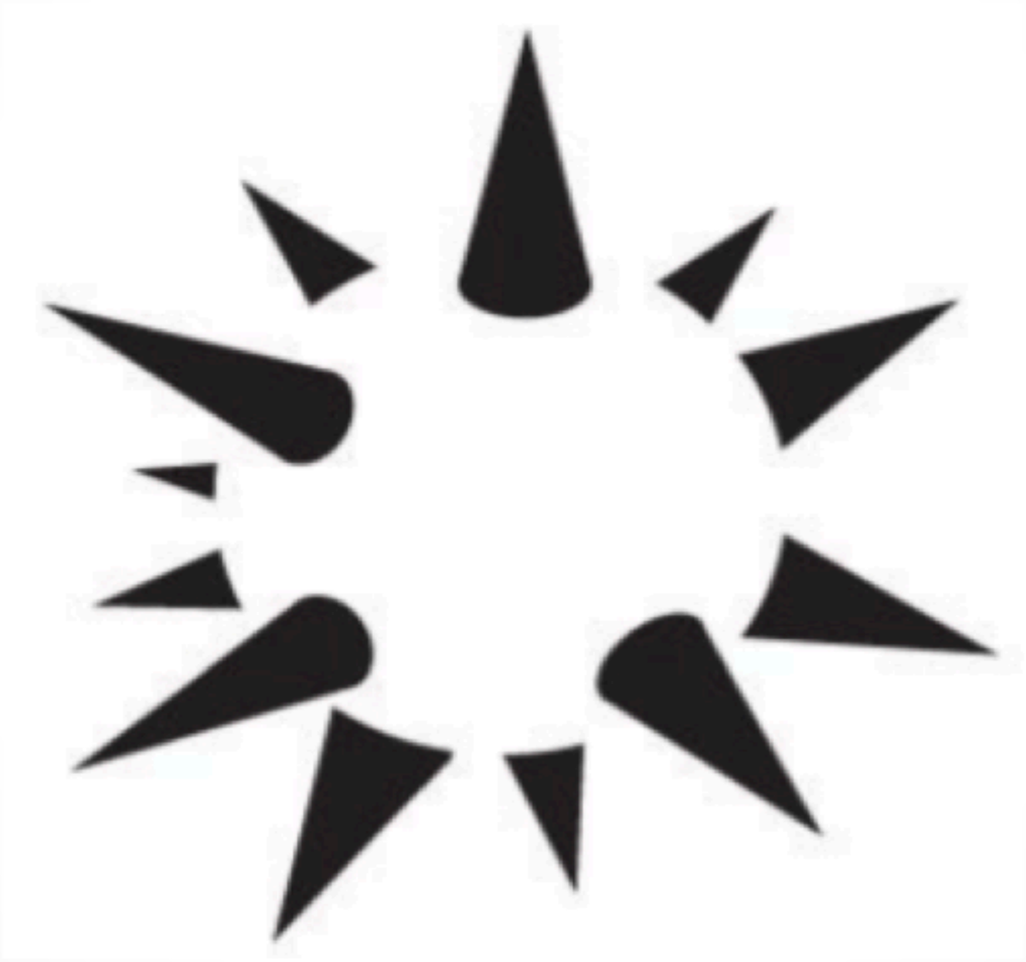
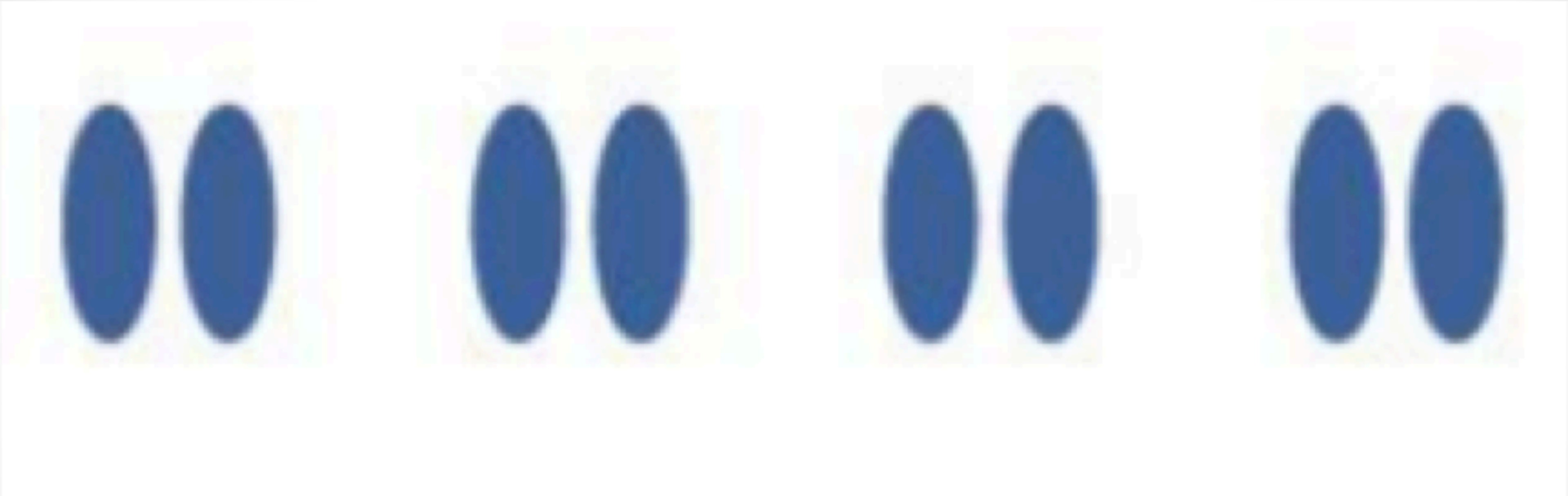


Image: Stangor (2010). Introduction to Psychology. *Flat World Knowledge*. (p.192).

Law of Proximity



- Image: Stangor (2010). Introduction to Psychology. *Flat World Knowledge*. (p.191).

Law of Similarity

Image: Stangor (2010). Introduction to Psychology. *Flat World Knowledge*. (p.190).

Law of Good Continuation

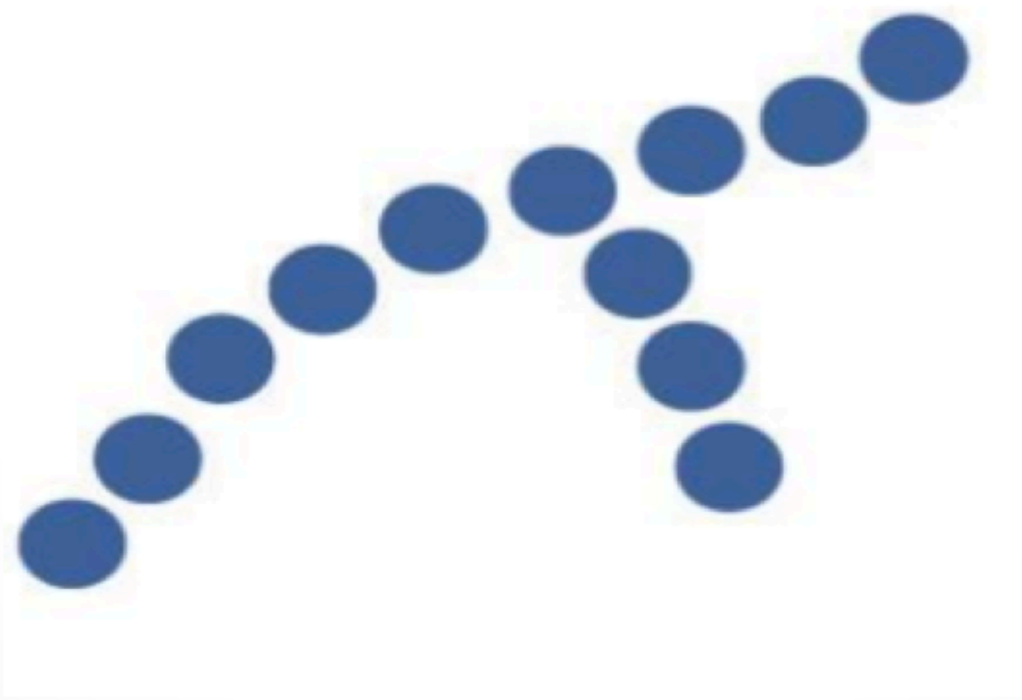


Image: Stangor (2010). Introduction to Psychology. *Flat World Knowledge*. (p.191).

- The Gestalt researchers formulated many other organisational laws, but most of them were deemed to be the manifestations of the **Law of Pragnanz**, described by Koffka as:

"***Of several geometrically possible organisations that one will actually occur which possesses the best, simplest and most stable shape***" (Koffka, 1935).

Image: [https://s-media-cache-ak0.pinimg.com/736x/2f/b2/34/2fb23424dd80ae04fe78d188fd4644e0--gestalt-laws-tech-art.jpg]

Image: [http://graphicdesign.spokanefalls.edu/tutorials/process/gestaltprinciples/proximity/images/proximity01.gif]

Hope for African Children Initiative

Image: [https://www.google.co.in/search?biw=1280&bih=627&tbm=isch&sa=1&q=african+continent+gestalt&oq=african+continent+gestalt&gs_l=psy-ab.3...101077.106189.0.106636.19.18.0.0.0.0.200.1930.0j13j1.14.0....0...1.1.64.psy-ab..6.2.251...0i8i13i30k1j0i8i30k1.eHuNCUjYVVo#imgrc=dJlFKiZbZ9xxNM:]

Moving Further...

Sternberg & Sternberg (2011). Cognitive Psychology. *Wadsworth Publishing*. 6th Ed. (Fig 3.3, p. 90).

Dallenbach's Cow.

Sternberg & Sternberg (2011). Cognitive Psychology. *Wadsworth Publishing*. 6th Ed. (Fig 3.3, p. 90).

Constructivist Approaches to Perception

- The notion that perceiving something involves using stored knowledge as well as information coming in from the senses is embodied in form of an approach referred to as the **constructivist approach to perception.**

- this is based on the idea that the sensory information that forms the basis of perception is incomplete. & it is necessary to build our perception of the world from *incomplete* information.

- to accomplish that, we use what we already **know** about the world to interpret the incomplete sensory information coming in, and to 'make sense' of it. The stored knowledge is used to aid in the recognition of objects.

- Two of the foremost proponents of the constructivist approach were Irvin Rock (1977.1983,1997) & Richard Gregory (1980).

- Gregory suggested that individuals attempted to recognize objects by generating a series of **perceptual hypotheses** about what the object might be.

- Gregory conceptualized this process as being akin to how a scientist might investigate a problem by generating a series of hypotheses and accepting the one that is best supported by the data.

- Stored knowledge is assumed to be central to the generation of perceptual hypotheses as it allows us to fill in the gaps in our sensory input.

- the influence of stored knowledge is guiding perceptual hypotheses can be demonstrated by impoverished figures.

Figure 3.22 An example of an impoverished figure

Image: Braisby & Gellatly (2005). Cognitive Psychology. *Oxford University Press*. (Fig. 3.22, p. 100).

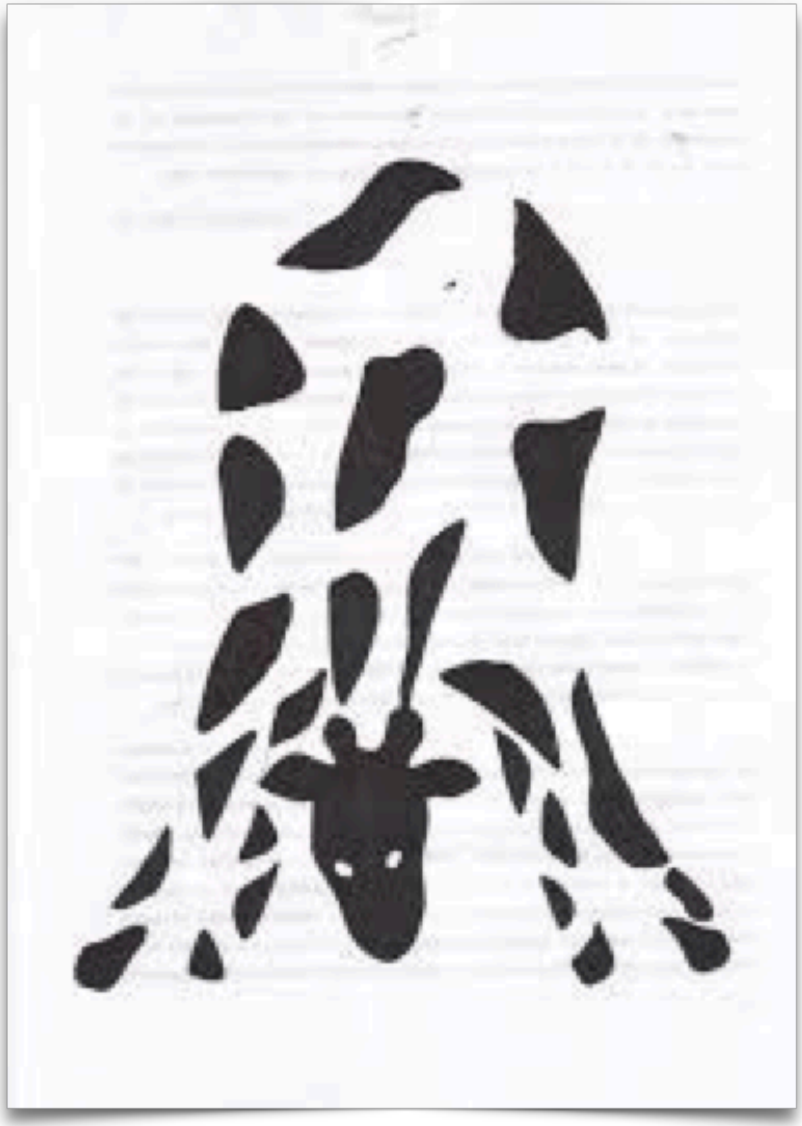


Image: [https://s-media-cache-ak0.pinimg.com/736x/2f/b2/34/2fb23424dd80ae04fe78d188fd4644e0--gestalt-laws-tech-art.jpg]

- The use of knowledge to guide our perceptual hypotheses may not always lead to ‘correct perception’; sometimes the same may lead towards accepting incorrect hypotheses and in ‘false perception’.

Figure 3.23 The mask of Hor

Image: Braisby & Gellatly (2005). Cognitive Psychology. *Oxford University Press*. (Fig. 3.23, p. 100).

- Although the constructivist approach in general & Gregory's theories in particular, provide an attractive explanatory framework for perception, there are areas of the theory that are left 'vague'.

- for e.g. how do we actually generate hypotheses & how do we know when to stop & decide which is the right one!

- however, there appears to be evidence that perceptions of the outside world can be ‘constructed’ using information flowing ‘up’ from the senses & combined with knowledge flowing ‘down’.

- note that this is entirely in contrast to Gibson & Marr.

To Sum Up

- We examined alternative or top – down approaches to perception.
- We saw that in addition to information from the sensory experience, information already stored in the brain/mind shall be useful in making sense of the external environment, especially in case of impoverished information from the senses is delivered.
- We may conclude that both top –down & bottom up processes may be involved in constructing perceptual representations of the external world.

References

- Braisby & Gellatly (2005). Cognitive Psychology. *Oxford University Press.*

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Lecture 21: Theories of Object Recognition

Theories of Visual Object Recognition

- A variety of theories have been proposed in order to explain how visual object recognition is achieved.
- These theories may differ depending upon the theoretical stance they subscribe to as far as bottom - up or top - down processing is concerned.
- All in all they attempt to account for the excellent performance of object recognition in both viewer - centred & object - centred representations.

- Template Matching Theory:
- Acc. to the template matching theory, one compares a stimulus with a set of templates, or specific patterns that we have already stored in memory.
- After comparing the stimulus to a number of templates, we note the template that matches the stimulus.
- In the template matching account, we are looking for the exact match between the stored template & the input representation.

An example of variability in the shape of letters. Notice specifically the difference in the shape of the letter *P* in *Pattern*.

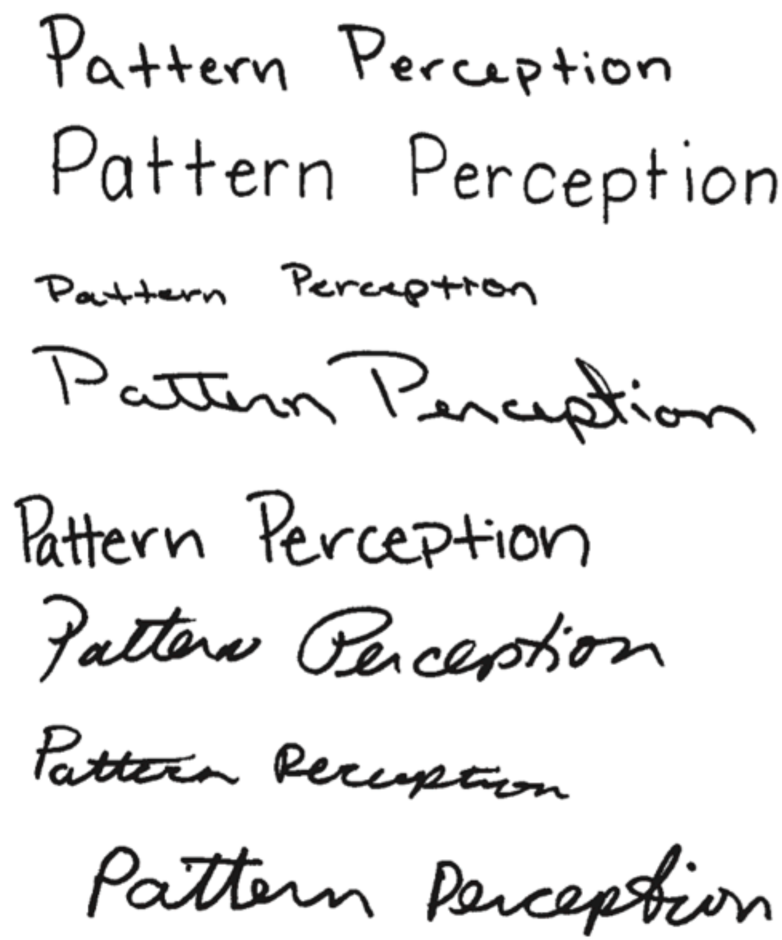


Image: Matlin M. W. (2008). Cognition. *Wiley*.7th Ed. (Fig. 2.4; p. 39).

- Several machine recognition systems are based on templates. for e.g. bank cheque books.

- One problem with the template matching theory is that it is extremely inflexible. If a letter differs from the appropriate template even slightly, the pattern cannot be recognised.

- Furthermore, template models work only for isolated letters, numbers, & other simple two - dimensional objects presented in their complete form (Palmer, 2003).

- Feature Analysis Theory:

- Several feature analysis theories propose a more flexible approach, in which a visual stimulus is composed of a small number of characteristics or components (Gordon, 2004).

- Each characteristic is called a distinctive feature.

  - Consider for example, the letter R. it has three distinct features, i.e. a curved component, a vertical line & a diagonal line.
  - When we look at a new letter, the visual system notes the resence or absence of various features and compares the list with the features stored in memory for each letter of the alphabet.

- Even though people's handwritings may differ, the letter R will always have these three features.

Demonstration 2.2

A Feature-Analysis Approach

Eleanor Gibson proposed that letters differ from each other with respect to their distinctive features. The demonstration below includes an abbreviated version of a table she proposed. Notice that the table shows whether a letter of the alphabet contains any of the following features: four kinds of straight lines, a closed curve, an intersection of two lines, and symmetry. As you can see, the P and R share many features. However, W and O share only one feature. Compare the following pairs of letters to determine which distinctive features they share: A and B; E and F; X and Y; I and L.

Features	A	E	F	H	I	L	V	W	X	Y	Z	B	C	D	G	J	O	P	R	Q
Straight																				
horizontal	+	+	+	+		+					+				+					
vertical		+	+	+	+	+				+		+		+				+	+	
diagonal/	+						+	+	+	+	+									
diagonal\	+						+	+	+	+									+	+
Closed Curve												+		+			+	+	+	+
Intersection	+	+	+	+					+			+						+	+	+
Symmetry	+	+		+	+		+	+	+	+		+	+	+			+			

Source: Based on Gibson, 1969.

Image: Matlin M. W. (2008). Cognition. *Wiley*.7th Ed. (Demo. 2.2; p. 40).

- the feature analysis theories propose that the distinctive features for each alphabet letters remains constant, whether the letter is handwritten, printed or typed.

- these models can also explain how we perceive a wide variety of two - dimensional patterns such as figures in a patinting, design or fabric etc.

- Feature - analysis theories are consistent with both psychological & neuroscience research. for e.g. Gibson (1969) demonstrated that people require a relatively long time to decide which of the two letters is different, if they share a number of critical features.

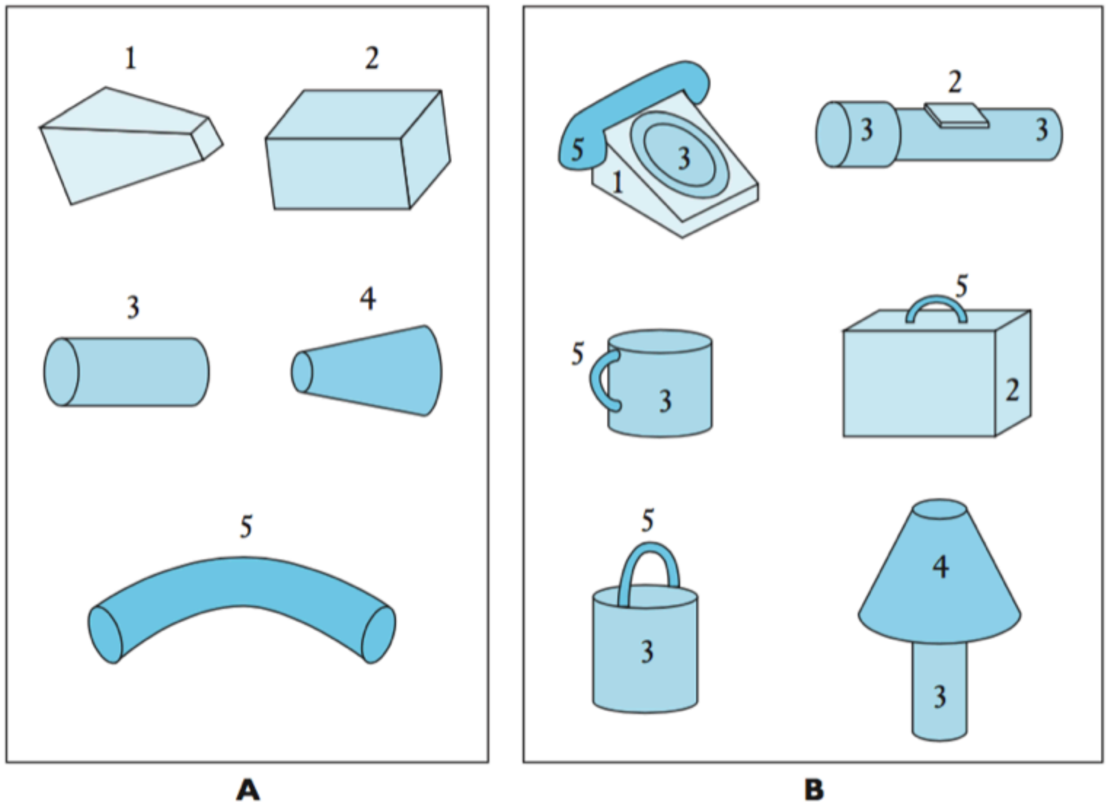
- Similarly, Larsen & Bundesen (1996) designed a model based on feature analysis that correctly recognized an impressive 95% of the numbers written in street addresses and zip codes.

- Even, neuroscience research seems to support features analysis (Remember Hubel & Wiesel, 1969, 1975, 2005).

- However, feature analysis also has several problems.
  - First, a theory of object recognition should not simply list the features contained in a stimulus; it must also describe the physical relationship between those features (Groome, 1999). e.g. in the letter T, the vertical line **supports** the horizontal line; whereas in letter L the vertical line is resting at the side of the horizontal line.
  - Also, the feature analysis theories were constructed to explain the relatively simple recognition of letters. In contrast, the shapes that occur in nature are much more complex (Kersten et al., 2004). e.g. a horse or a lion?
  - the theories also need to take into account distortion in features due to movements etc.

- **The recognition by components theory:**
  - Irving Biederman & colleagues developed a theory to recognise three dimensional shapes (Biederman, 1990; 1995).
  - the basic assumption of their recognition by components theory is that a specific view of ab object can be represented as an arrangement of simple 3 - D shapes called **geons**.
  - these geons can be combined to form a variety of meaningful objects.

Five of the Basic Geons (A) and Representative Objects that can be Constructed from the Geons (B).



Source: Biederman, 1990.

Image: Matlin M. W. (2008). Cognition. *Wiley*.7th Ed. (Fig. 2.5; p. 42).

- In general, an arrangement of three geons gives people enough information to classify an object.
    - In that sense, Biederman's recognition by components theory is essentially a feature analysis theory for 3D objects.
- Biederman & colleagues have conducted fMRI research with humans and single - cell recording with monkeys; & their findings show that areas of the cortex beyond the primary visual cortex respond to geons as presented earlier.

- However, the recognition - by - components theory requires an important modification because people recognize objects more quickly when those objects are seen from a standard viewpoint, rather than a much different viewpoint (Friedman et al., 2005)

- A modification of the present approach, by the name of **viewer - centered approach** proposes that we store a small number of views of 3D objects, rather than just one view (Mather, 2006) and when we come across an object we must sometimes mentally rotate the image of that object until it matches one of the views that is stored in the memory (Dickinson, 1999).

- Top - Down Influences on Object Recognition:
    - emphasizes how a person's concepts and higher - level mental processes influence object recognition. More specifically how a person's expectations & memory help in identifying objects.
    - we expect certain shapes to be found in certain locations & we expect to encounter these shapes because of past experiences. these expectations can help us recognize objects very rapidly.
-
    - the same also helps us fill the gaps in the sensory input.

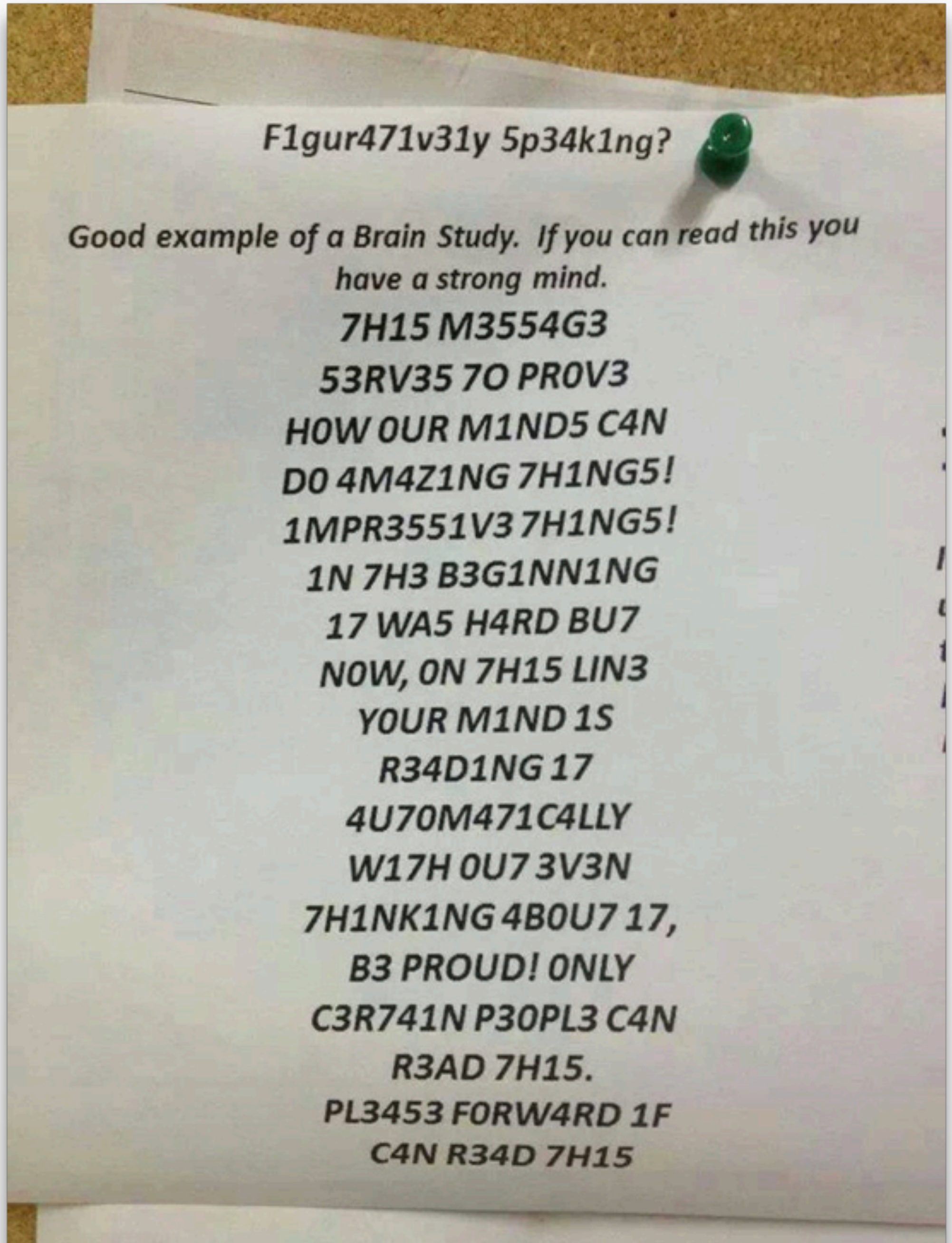
Demonstration 2.3

Context and Pattern Recognition

Can you read the following sentence?

THE MAN RAN.

Image: Matlin M. W. (2008). Cognition. *Wiley*.7th Ed. (Demo. 2.3; p. 45).



F1gur471v31y 5p34k1ng?

Good example of a Brain Study. If you can read this you have a strong mind.

7H15 M3554G3
53RV35 7O PR0V3
H0W 0UR M1ND5 C4N
D0 4M4Z1NG 7H1NG5!
1MPR3551V3 7H1NG5!
1N 7H3 B3G1NN1NG
17 WA5 H4RD BU7
N0W, 0N 7H15 LIN3
Y0UR M1ND 1S
R34D1NG 17
4U70M471C4LLY
W17H 0U7 3V3N
7H1NK1NG 4B0U7 17,
B3 PROUD! 0NLY
C3R741N P30PL3 C4N
R3AD 7H15.
PL3453 F0RW4RD 1F
C4N R34D 7H15

- *Face Perception*: As a special case of Object Recognition
  - Acc. to psychologists, most people perceive faces in a different fashion from other stimuli; face perception is somehow special (Farah, 2004).
    - e.g. young infants track the movements of a photographed human face more than other similar stimuli (Bruce et al., 2003).
  - Similarly, Tanaka & Farah (1993) found that people were significantly more accurate in recognising facial features when they appeared within the context of a whole face, rather than in isolation; i.e. they could recognise a whole face much faster than an isolated nose.

- in contrast, when they judged houses, they were just as accurate in recognizing isolated houses or an isolated house feature (e.g. window).

- this shows that we recognize faces on a **holistic basis,** i.e. in terms of the gestalt or overall quality that transcends its individual elements.

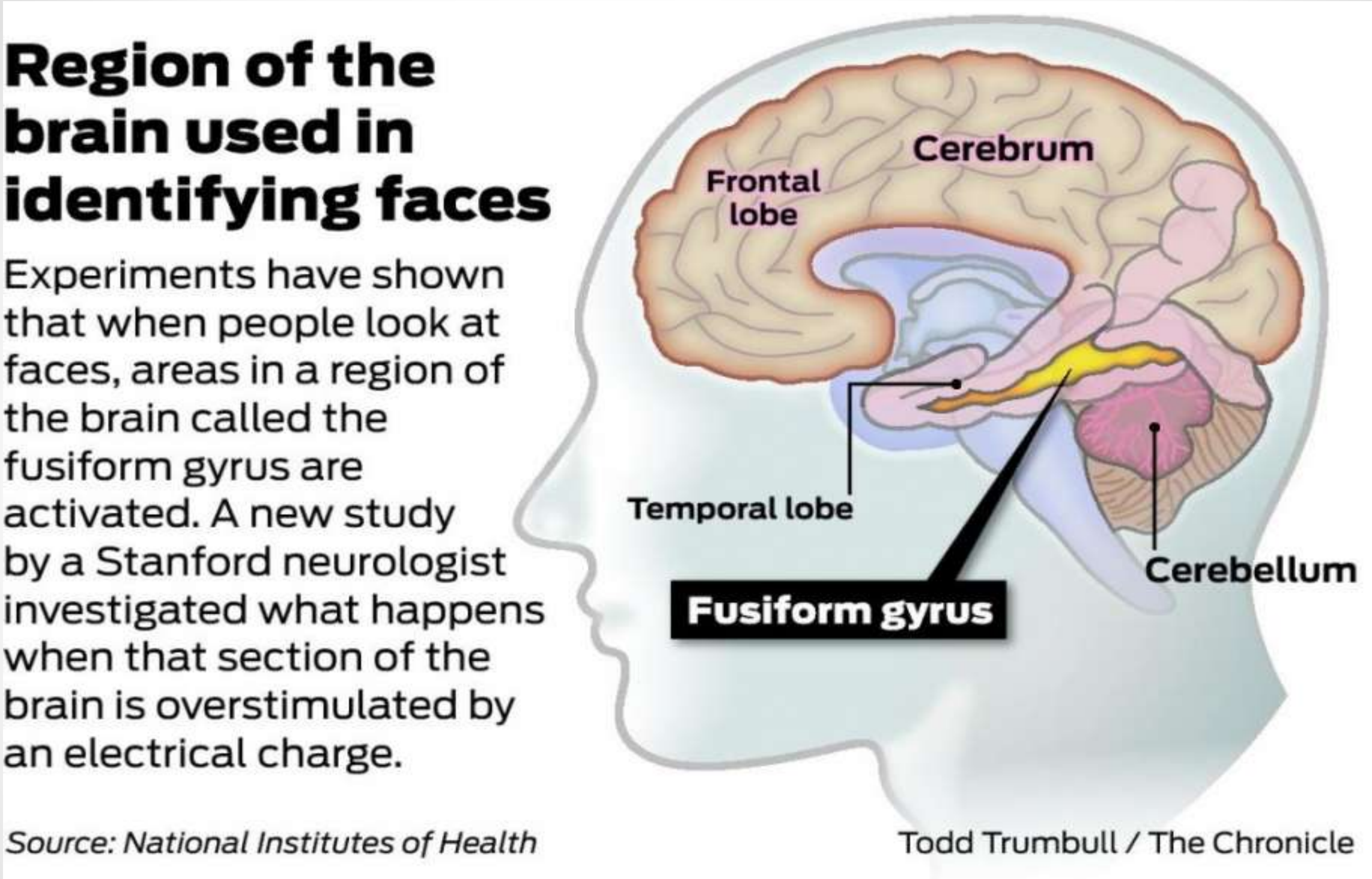
- it thus makes sense that face perception has a special status, given the importance of our social interactions (Farah, 2004; Fox, 2005).

- Neuroscience research on Face Recognition
  - McNeil & Warrington (1993) studied a professional who had lost his ability to recognize human faces after he had experienced several strokes.
  - This patient changed his career, & started to raise sheep. Surprisingly, he could recognize many of his sheep's faces, even though he could not recognize human faces.
  - This man was diagnosed as having **prosopagnosia**, i.e. a condition in which people cannot recognize human faces visually, though they perceive other objects relatively normally.

- The location most responsible for face recognition is the temporal cortex, at the side of the brain (Bentin et al., 2002). Specifically, the inferotemporal cortex, in the lower portion of the temporal cortex.

- It has been shown that certain cells in the inferotemporal cortex respond especially vigorously when encountered with faces (Farah, 2004).

- Also, it has been reported in fMRI studies that the brain responds much more quickly to faces presented in the upright condition in comparison to faces presented in the inverted position.



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To Sum Up

- We studied various approaches to object recognition.
- We saw that object recognition can be achieved by a co - operation bottom up & top – down mechanism
- We also saw that perception of faces is a special case of object recognition because faces carry much more information & value than some of the other objects.

References

- Matlin, M. W. (2008). Cognition. *Wiley*. 7th Ed.

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Course Title:

Basic Cognitive Processes

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Lecture 22: Perception & Action

Linking Perception to Action

- In the course of the last few lectures we have often wondered the utility of perception.

- Certainly, humans are not perceiving the environment only passively.

- We interact with the environment & the link between perception and action is established thereof.

Theoretical Background

- J. J. Gibson's Ecological Approach to Perception
    - the idea that perception should be studied as people move through the environment and interact with it.
    - the ecological approach to perception then focused itself on studying moving observers and determining how this movement creates a perceptual input leading to better navigation in the environment.

- As, we have already studied in detail, the concept of ***optic flow*** is informative about our movements in the environment for e.g. direction, speed, relative distance etc.

  - Optic is flow is rather fast near the observer & slower farther away from the observer, this is referred to as ***gradient of flow***.

  - There is now flow at the point which the observer is approaching, which is called the ***focus of expansion*** **(FOE).**

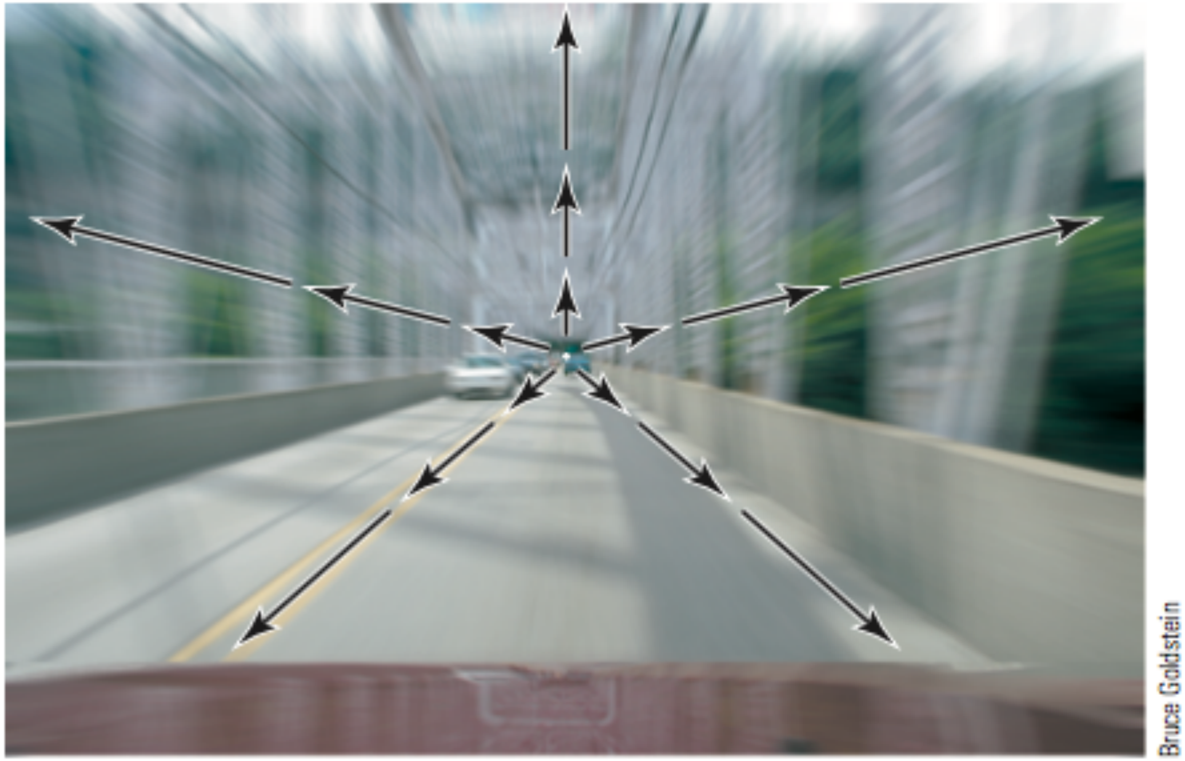


Figure 7.1 The side and top of the bridge and the road below appear to move toward a car that is moving forward. This movement is called optic flow.

Goldstein (2013). Sensation and Perception. *Cengage Learning*. (p. 154)

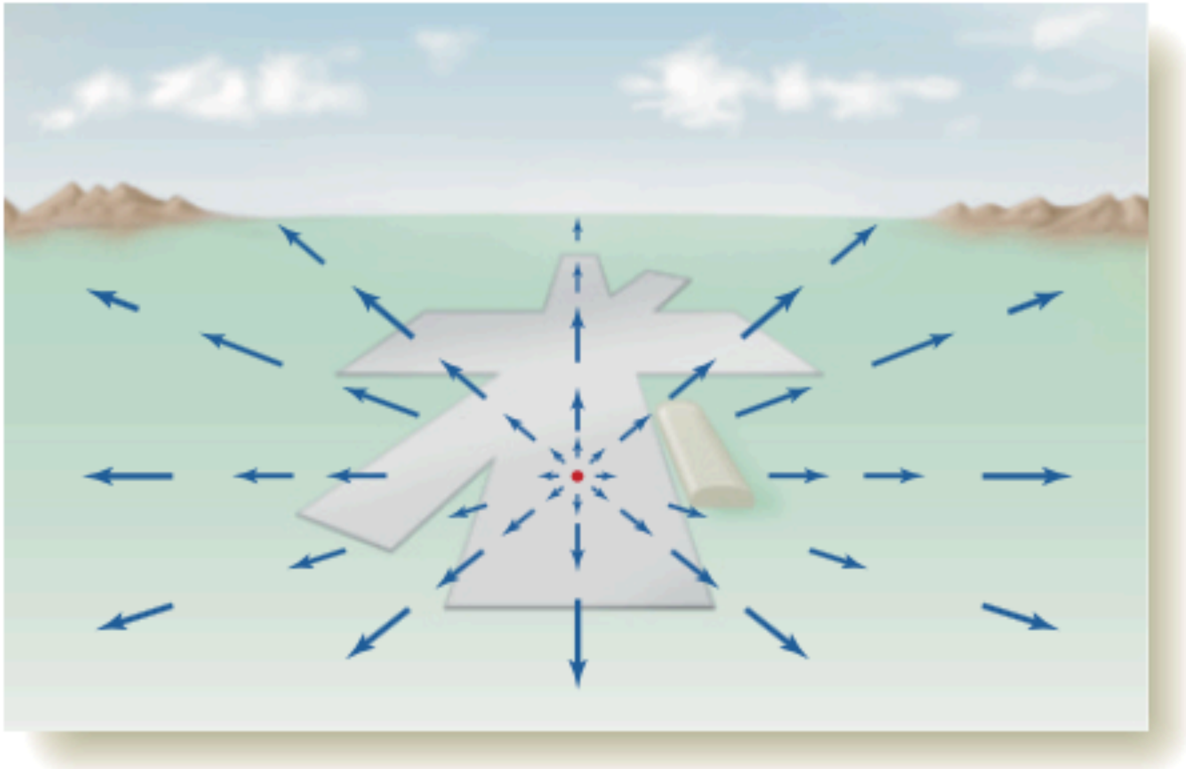


Figure 7.2 Optic flow created by an airplane coming in for a landing. The focus of expansion (FOE), indicated by the red dot, is the place where the plane will touch down on the runway. From Gibson, J. J. *The perception of the visual world*. Boston: Houghton Mifflin. 1950. Figure 58, page 128.

Goldstein (2013). Sensation and Perception. *Cengage Learning*. (p. 154)

- Another important aspect of the ecological approach is the - ***invariant information*** – information that does not change with respect to the moving observer.
    - as soon as the observer stops moving around the environment the flow information is not there anymore.
    - the FOE shifts as soon as the observer changes it's direction of movement.

How does this work?

- ***Self – produced information*** : information that is produced when the person makes some movement; which is in turn used to guide further movement.

- for e.g. when a person is moving along a street in the car, the movement of the car provides flow information which can be used to help guide the car in the correct direction.

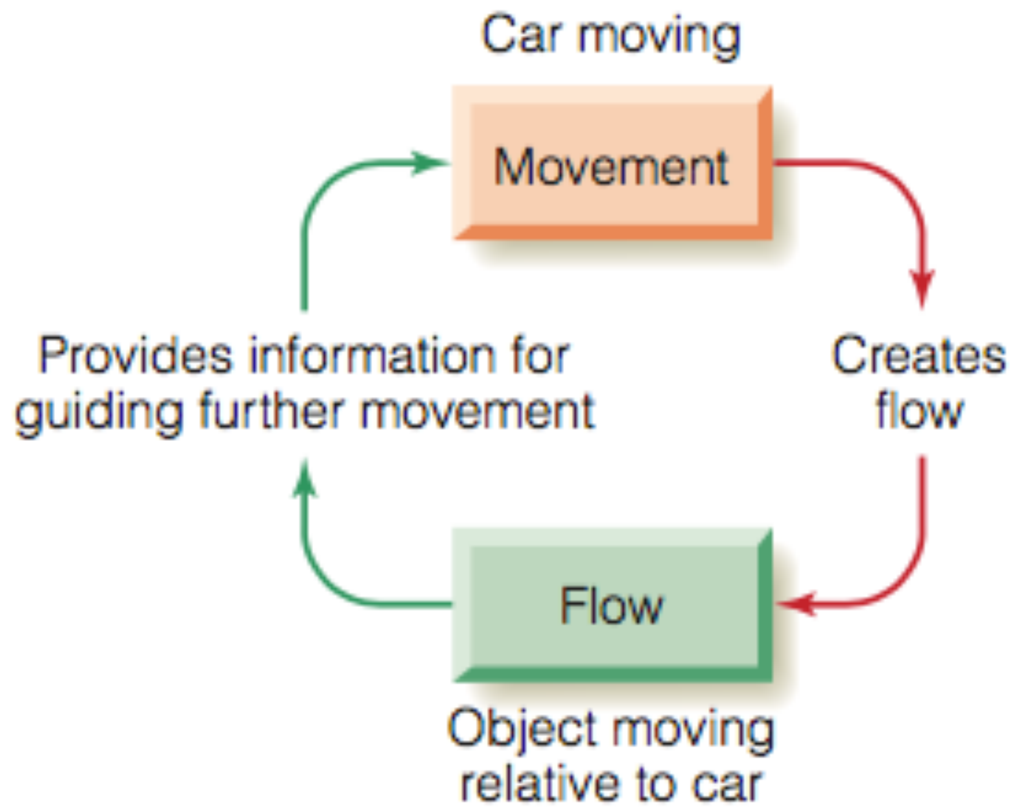


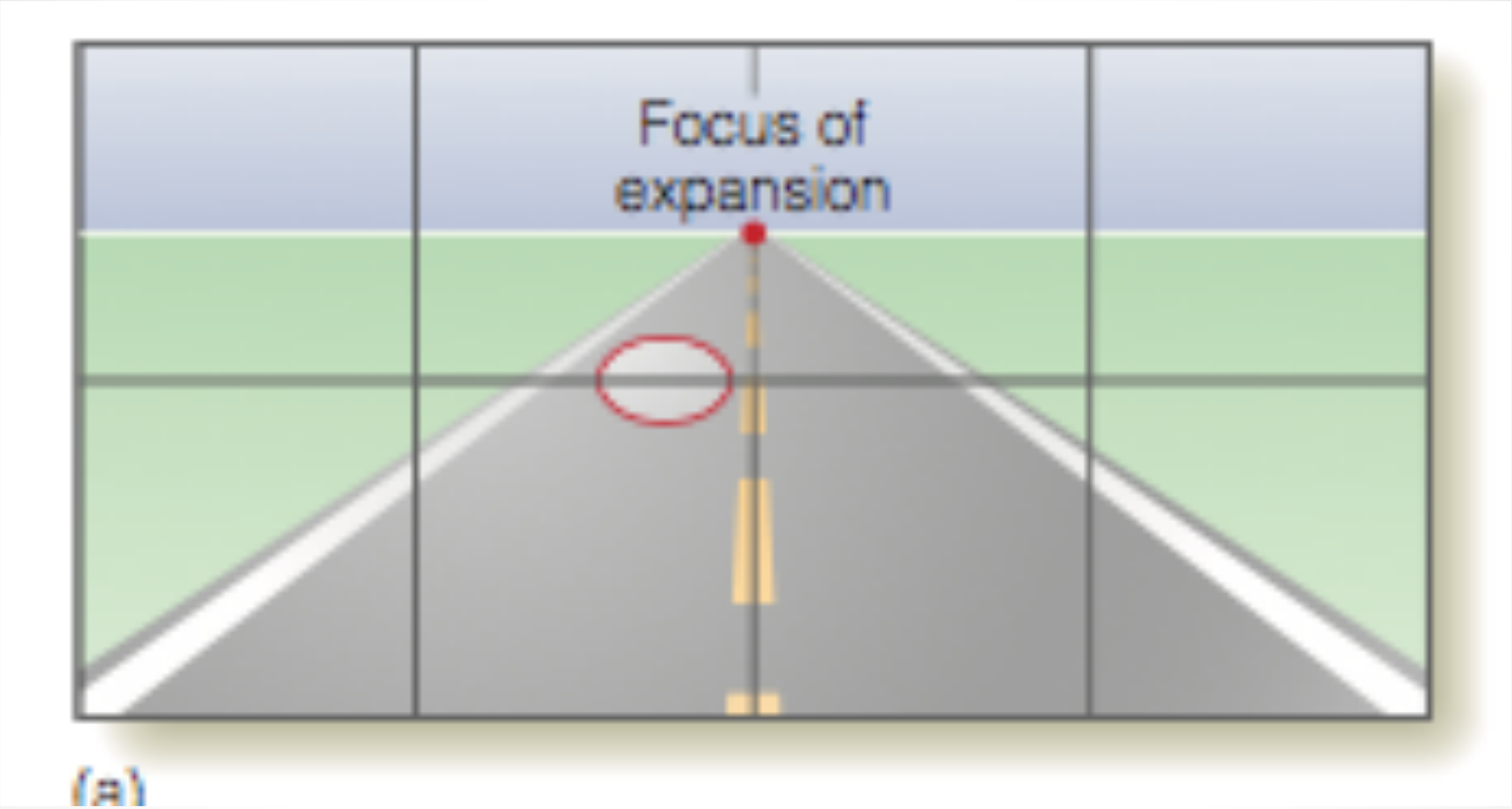
Figure 7.3 The relationship between movement and flow is reciprocal, with movement causing flow and flow guiding movement. This is the basic principle behind much of our interaction with the environment.

Goldstein (2013). Sensation and Perception. *Cengage Learning*. (p. 155)

- the Senses :
  - Gibson proposed that the five senses i.e. vision, hearing, touch, smell & taste work together to produce information to facilitate moving around & interacting with the environment.
  - For e.g. our ability to stand upright & maintain balance while still standing or even walking or running depends upon systems like the vestibular canals (in the inner ear) and receptors in joints & muscles to work together.
  - Lee and Aronson (1974) through their ***"swinging room"*** experiments demonstrated that vision is a powerful determinant of balance and can override the traditional sources of balance information provided by the inner ear & receptors from muscles and joints.

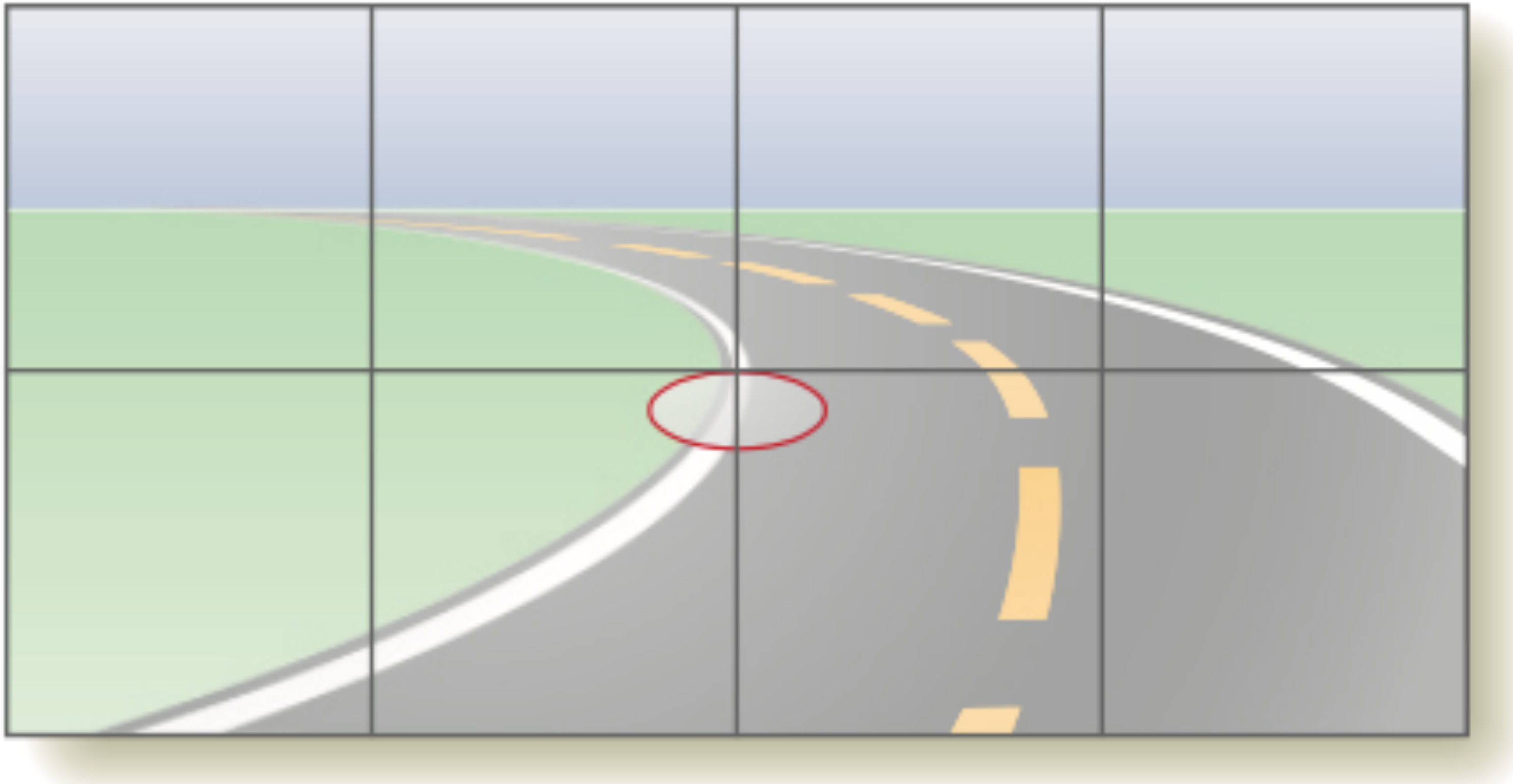
Navigating Through The Environment

- *Driving a Car*
    - Land & Lee (1994) wanted to study the information generally used by the people while driving a car.
    - So, they fitted a car with devices o record the angle of the steering wheel and the speed, & measured where the driver was looking with a video eye – tracker.
    - They found that although drivers look straight ahead while driving, they also look at a spot in front of the car rather than looking directly at the FOE.



Goldstein (2013). Sensation and Perception. *Cengage Learning*. (p. 159)

- Land & Lee also studied where drivers look while navigating a curve.
    - This is important as the FOE will keep changing as the driver's destination keeps changing as the car is moving around the curve.
    - Land & lee found that when going around a curve, the drivers don't look directly at the road, but at the tangent point of the curve on the side of the road.
    - As, the drivers are not looking directly at the FOE, Land & Lee suggested that drivers use information in addition to the optic flow to determine the direction of movement. For e.g. position of the car with respect to the lines at the center of the road.



(b)

Goldstein (2013). Sensation and Perception. *Cengage Learning*. (p. 159)

- ***Walking***

  - It has been argued that while walking people may not be using optic flow information.

    - For e.g. they might be following a ***visual direction strategy*** i.e. keeping their bodies pointed towards a target. If they go off – direction, the target shifts to the left or right and so, the walkers can use this information for course - correction.

    - Loomis & colleagues (Loomis et al., 1992; Philbeck, Loomis & Beall, 1997) demonstrated by making participants blind – walk towards a target, that people are able to walk directly towards a target & stop very close to it

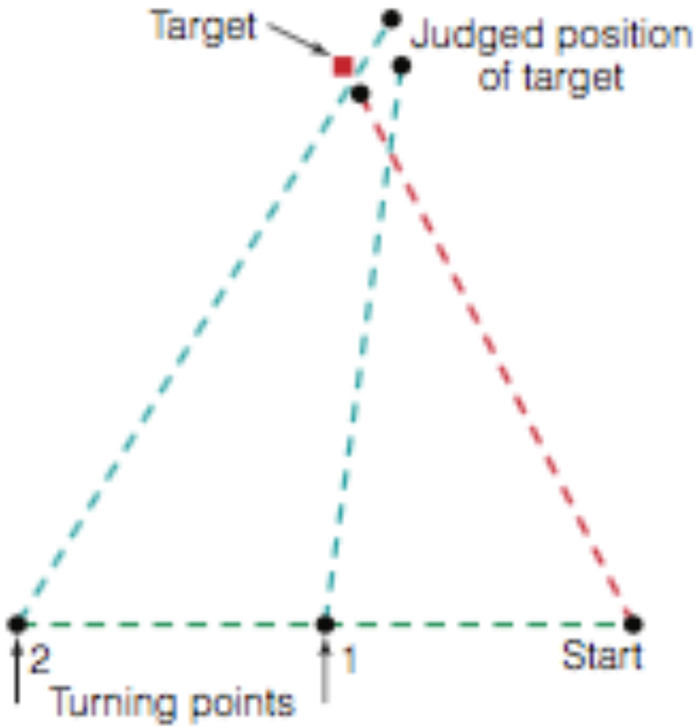


Figure 7.12 The results of a "blind walking" experiment (Philbeck et al., 1997). Participants looked at the target, which was 6 meters from the starting point, then closed their eyes and begin walking to the left. They turned either at point 1 or 2, keeping their eyes closed the whole time, and continued walking until they thought they had reached the target.

Goldstein (2013). Sensation and Perception. *Cengage Learning*. (p. 160)

- *Wayfinding*
  - refers to navigating for long distances towards object not in sight.
  - is a complex process that involves perception of objects in the environment, remembering objects and their place in the overall scene & also judging when & what direction to turn.
  - an important aspect of such navigation is ***landmarks*** – those objects on the route that serve as cues to indicate where to turn.

- Sahar Hamid & colleagues (2010) studied the use of landmarks by participants as they were negotiating a mazelike environment presented on a computer screen and while pictures of common objects were supposed serve as landmarks.
- Participants were first trained to go through the maze & then were told to travel from one point in the maze to another.
- Eye – movements were measured using a head-mounted eye – tracker.

- Eye – tracking measures indicate that participants spent more – time looking at more informative landmarks than uninformative landmarks.

- In a similar study (Schinazi & Epstein, 2010) it was shown that after the subjects had learned a particular route, they were more likely to recognize pictures of buildings at decision points that those located in the middle of the block.

- Also, it was shown that when in an fMRI scaner, the brain response in navigational areas of the brain (like parahippocampal gyrus, hippocampus, & retrosplenial cortex) was larger than the response to non – decision point buildings.

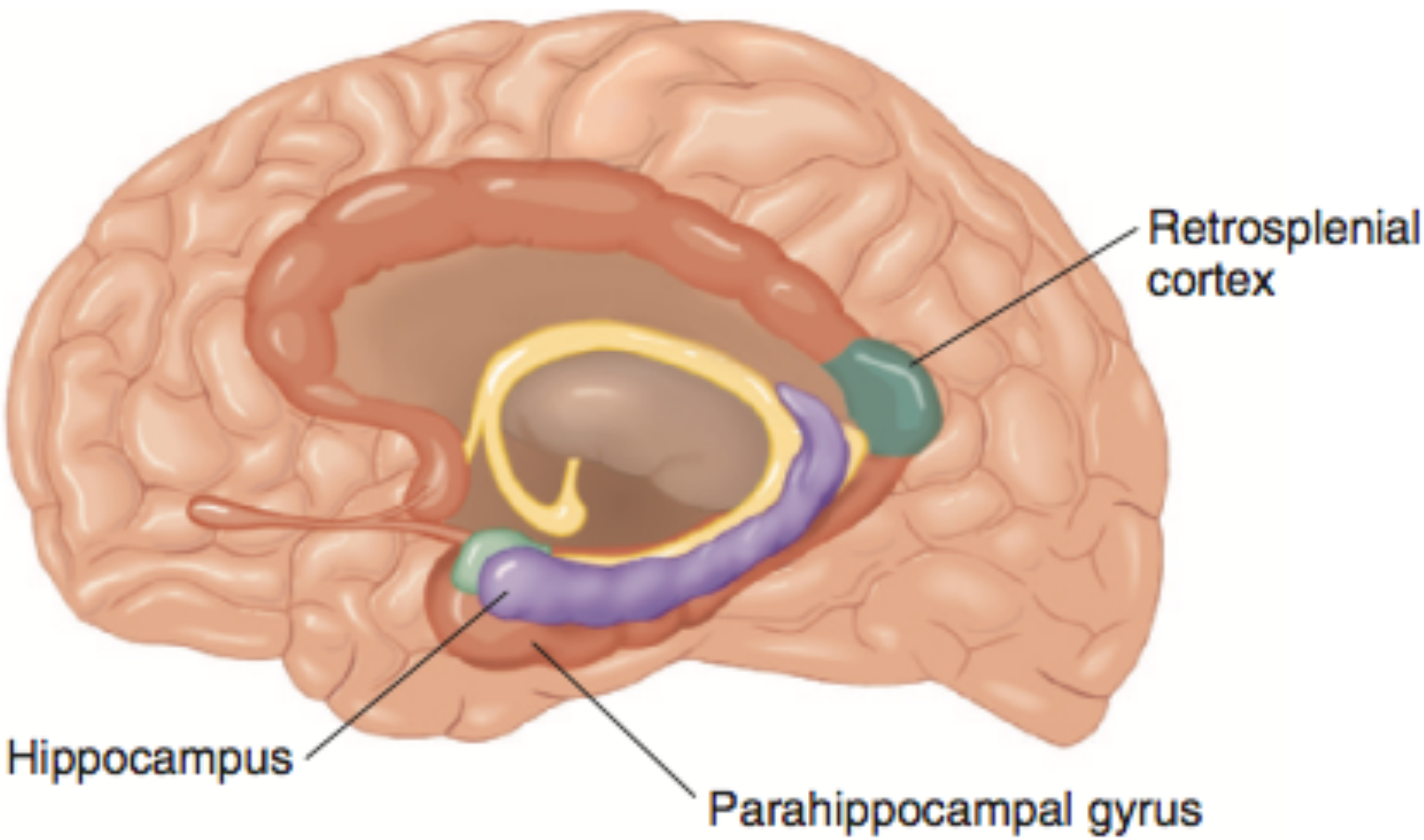


Figure 7.14 The human brain, showing three structures important to navigation: the parahippocampal gyrus, the hippocampus, and the retrosplenial cortex.

Goldstein (2013). Sensation and Perception. *Cengage Learning*. (p. 161)

Interacting with Objects

- We have now seen how movement within an environment can facilitate or influence it's perception.
- One of the most salient movements we perform within our environments is reaching out & grasping objects. For e.g. reaching out & holding a cup etc.
- An important concept related to *reaching* & *grasping* is that of ***affordances***.

- Gibson, in his ecological approach to perception had specified the idea of affordances –
  - *"The **affordances** of the environment are what it **offers** the animal, what it **provides** for or **furnishes**."* (Gibson, 1979)
  - a chair, or anything that is sit-on-able, affords sitting; an object that is of the right size and shape to be grabbed by a person's hand affords grasping; and so on. (Goldstein, 2013).

- So, this could imply that perception of an object not only includes physical properties, such as shape, size, colour and orientation, that might enable the person to recognize an object but our perception also includes information about how the object is to be used.

- One of the ways, affordances have been studied, is by investigating patients with brain – damage.
    - Humphreys & Riddoch (2001) studied a patient M.P., with damage to his temporal lobe that impaired his ability to name objects.

- M.P., was given one of two cues,i.e. (a) name of an object like a "cup" or (b) an indication of how the object worked (" an object that you could drink from").
- He was then shown 10 different objects and was told to press a key as soon as he found the object.
- It was found that M.P. identified the object more accurately & rapidly when the given cue referred to the object's function.
- Humphrey & Riddoch concluded that M.P was using information about the object's affordances to find the object.

- ***The Physiology of Perception and Action***

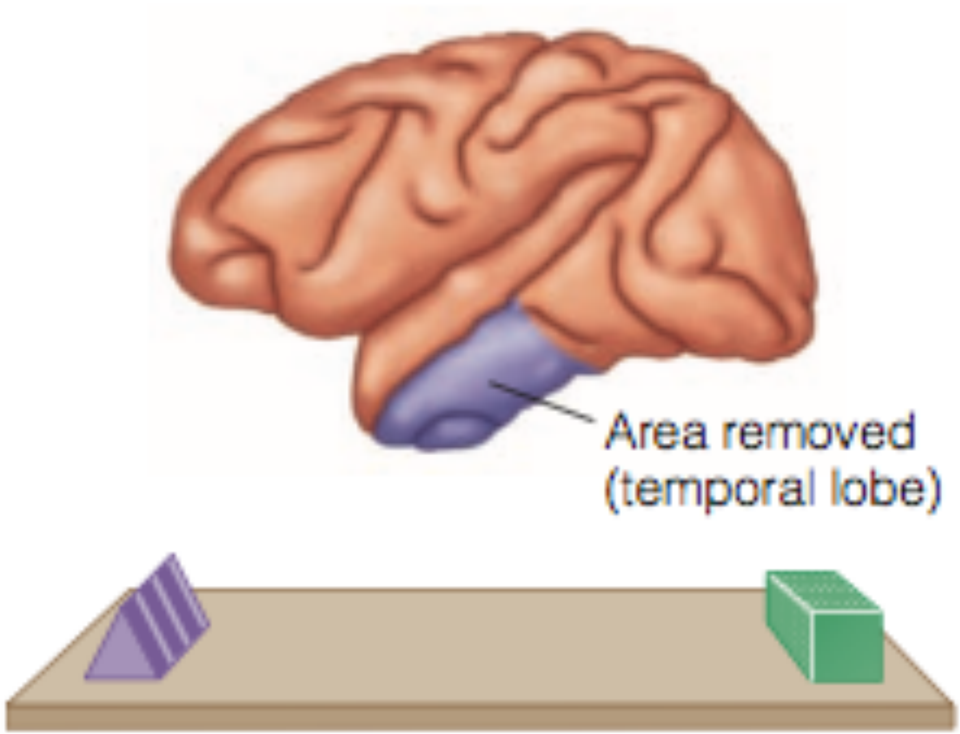
    - The link between perception & action was formalized with the discovery of the ventral & dorsal pathways of the brain.

    - Ungerleider & Mishkin 91982) studied a monkey's ability to identify an object and to determine an object's location; using the technique of brain ablation.

    - Ungerleider and Mishkin presented a monkey with two tasks: (1) an object discrimination problem and (2) a landmark discrimination problem.

- In the object discrimination problem: the monkey was shown one object, such as a rectangular solid, 7 was then presented with a two – choice task like the, wherein one of the objects was the "target object" and another stimulus.

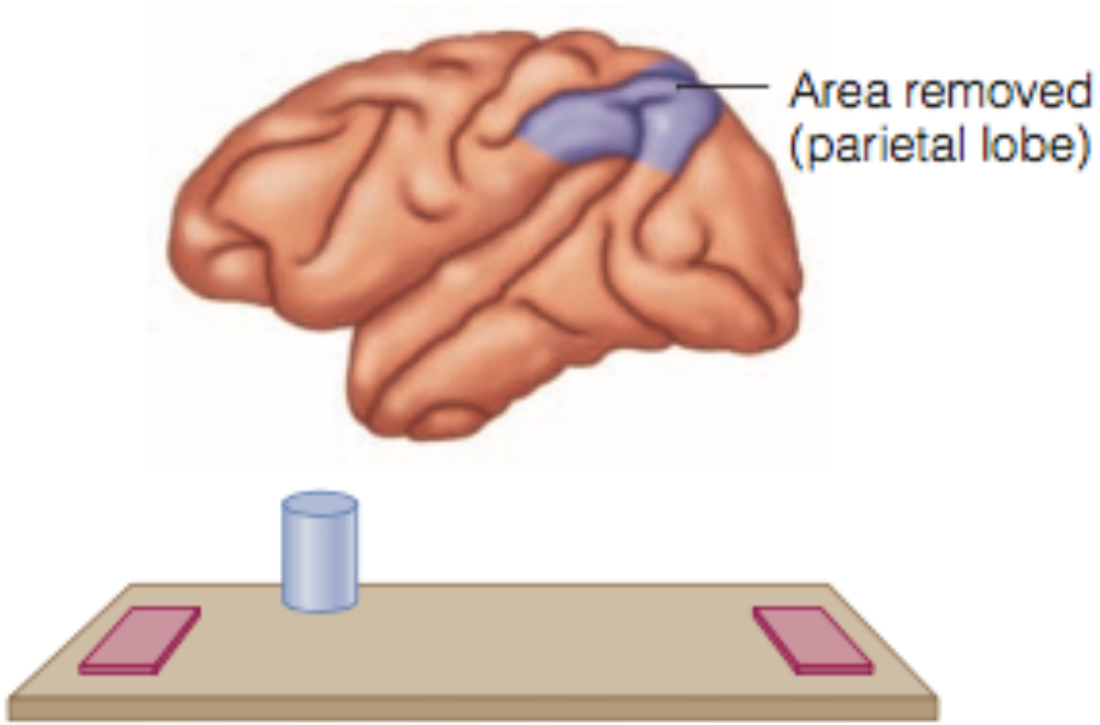
- If the monkey would push aside the target object, it received the food reward that was hidden under the object.



(a) Object discrimination

Image: Goldstein(2010). Cognitive Psychology_Connecting Mind, research and Everyday Experience. *Wadsworth Publishing*. 3rd Ed. Fig. 3.34 (p.72)

- In the landmark discrimination task, the monkey’s task was to remove the food well cover that is closer to a tall cylinder.
- In the ablation phase, a part of the temporal lobe was removed in some monkeys while for the others the parietal lobe was removed.



(b) Landmark discrimination

Image: Goldstein(2010). Cognitive Psychology_Connecting Mind, research and Everyday Experience. *Wadsworth Publishing*. 3rd Ed. Fig. 3.34 (p.72)

- Behavioral experiments showed that the object discrimination problem was very difficult for monkeys with the temporal lobes removed.
  - This was taken to imply that the pathways that reaches the temporal lobes is responsible for object identification.
- Ungerleider & Mishkin called this pathway as the ***what pathway***.

- Monkeys who had their parietal lobes removed, had difficulty solving the landmark discrimination problem.
  - This indicated that the pathway leading to the parietal lobe is responsible for determining an object's location.
  - Ungerleider & Mishkin called the pathway leading from the striate cortex to the parietal lobe the **where pathway.**

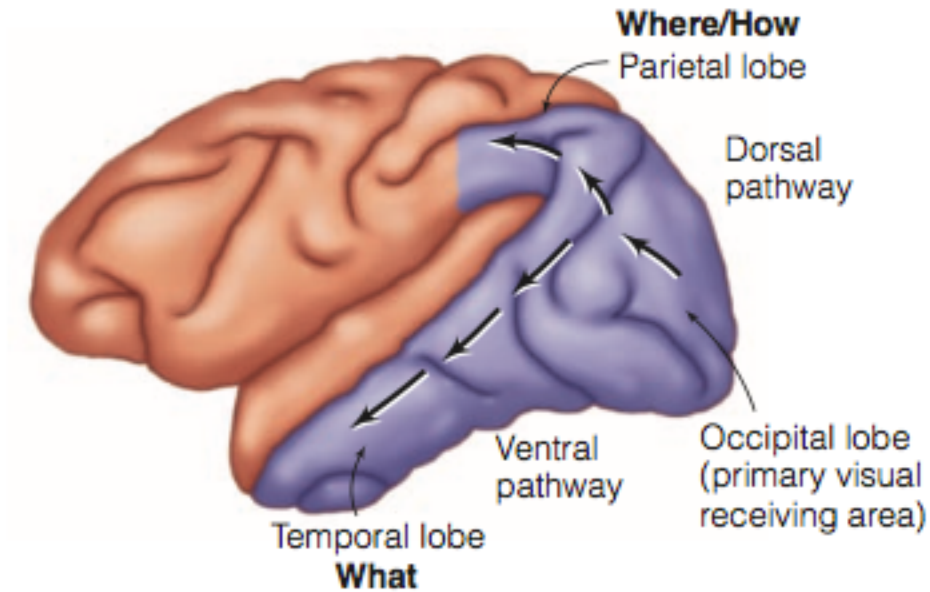


FIGURE 3.35 The monkey cortex, showing the *what* or *perception* pathway from the occipital lobe to the temporal lobe, and the *where* or *action* pathway from the occipital lobe to the parietal lobe. (Source: From E. B. Goldstein, *Sensation and Perception*, 8th ed., Fig. 4.27, p. 88. Copyright © 2010 Wadsworth, a part of Cengage Learning. Reproduced with permission. www.cengage.com/permissions. Adapted from Mishkin, Ungerleider, & Macko, 1983.)

Image: Goldstein(2010). Cognitive Psychology_Connecting Mind, research and Everyday Experience. *Wadsworth Publishing*. 3rd Ed. Fig. 3.34 (p.72)

- So, in a simple task of reaching & grasping cup, one could assume that the “what pathway” would be involved in the initial perception of the cup & the “where pathway” would be involved in determining the correct location of the cup, so that it could be picked up.

Putting Things in Perspective

- We have seen that Gibson's approach was pushing for 'perception for action' while Marr's theory was more for 'perception for recognition'.
- It seems that in some way the idea of ventral & dorsal pathways echoes similar ideas.
- However, while these two streams may appear to be functioning independently, it is needless to say that we need both of them working fine in order to recognise objects and perform actions to interact with the environment.

- for e.g. Gibson’s notion of affordance emphasises that we might need to detect what things are ‘for’ rather than what they actually ‘are’.

- affordances are linked to actions & the dorsal stream appears to be ideally suited for providing the sort of information we need to act in the environment.

- Earlier, we saw that Gibson saw no role for memory in perception & as the dorsal stream seems to have very little storage also confirms that the dorsal stream works as Gibson proposed.

- In contrast, the ventral stream appears to be ideally suited to the role of recognizing objects. It is specialized in analyzing the sort of fine detail that Marr saw as essential to discriminating between objects.

- Also it seems to draw on our existing knowledge to assist in identifying objects.

- It is also slower than the dorsal stream; which is conducive to the fact that no immediate action is required.

- To somewhat address these & other concerns; Norman (2002) & Neisser (1994) suggested the dual processing approach:

- there appears to be evidence that the ventral stream is primarily concerned with recognition while the dorsal stream drives visual behaviour (pointing, grasping etc.)

- the ventral system is generally better at processing fine detail while the dorsal system is better at processing motion.

- the ventral system is knowledge based & uses stored representations to recognise objects; while the dorsal system appears to have only very short term storage.

- the dorsal system received information faster than the ventral system.
- we are much more conscious of the ventral than the dorsal stream.
- it has been suggested that the ventral system recognised objects & is object centred while as the dorsal stream is action oriented it uses a viewer centred frame of reference (more on this later).

- Norman (2002) defines the two as synergistic and interconnected rather than independent.

- Busted & Carlton (2002), provide an illustration of the interaction between the ventral & dorsal streams using the example of skill acquisition.

- previous work (Fitts, 1964) suggests that the early stages of learning a skill (e.g. driving) are characterised by cognitive processes of the kind associated with the ventral stream; whereas once, the skill is highly practiced it is characterised by learned motor actions of the sort associated with the dorsal stream.

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Course Title:

Basic Cognitive Processes

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Lecture 23: Auditory Perception

Hearing: The Preliminaries

- Hearing, too begins with transduction.
  - sound waves are collected by our ears and converted into neural impulses, which are sent to the brain where they are integrated with past experience and interpreted as the sounds we experience.
- the human ear is sensitive to a wide range of sounds, ranging from the faint click of a clock to the roar of a rock band.
- but the human ear is particularly sensitive to the sounds in the same frequency range as the human voice.

- the Ear: detects sound waves.
  - vibrating objects (such as the human vocal chords or guitar strings) cause air molecules to bump into each other and produce sound waves, which travel from they source as peaks and valleys much like the ripples that expand outward when a stone is tossed into a pond.
  - sound waves are carried within medium such as air, water or metal, & it is the changes in pressure associated with these mediums that the ear detects.

- ***Physical Characteristics of Sound***
  - o we detect both the *wavelength* & the *amplitude* of sound waves.
    - the wavelength of the sound wave (known as frequency) is measured in terms of the number of waves that arrive per second and determines our perception of pitch, i.e. the perceived frequency of the sound.
    - longer sound waves have lower frequency & produce a lower pitch whereas shorter sound waves have higher frequency & higher pitch.
    - the amplitude, or height of the sound wave, determines how much energy it contains and is perceived as loudness (the degree of sound volume).

- larger waves are perceived as louder.
- loudness is measured using the unit of relative loudness known as ***decibel***.
    - zero decibels represent the absolute threshold for human hearing, below which we cannot hear a sound. each increase in 10 decibels represents a ten - fold increase in the loudness of the sound.
    - the sound of a typical conversation (about 60 decibels) is 1,000 times louder that the sound of a whisper (30 decibels).

- ***The Structure of the Ear***:

  - audition begins in the ***pinna***, the external & visible part of the ear, which is shaped like a funnel to draw in sound waves & guide them into a auditory canal,

  - at the end of the canal, the sound waves strike the tightly stretched, highly sensitive membrane known as the ***tympanic membrane (or eardrum)***, which vibrates with the waves.

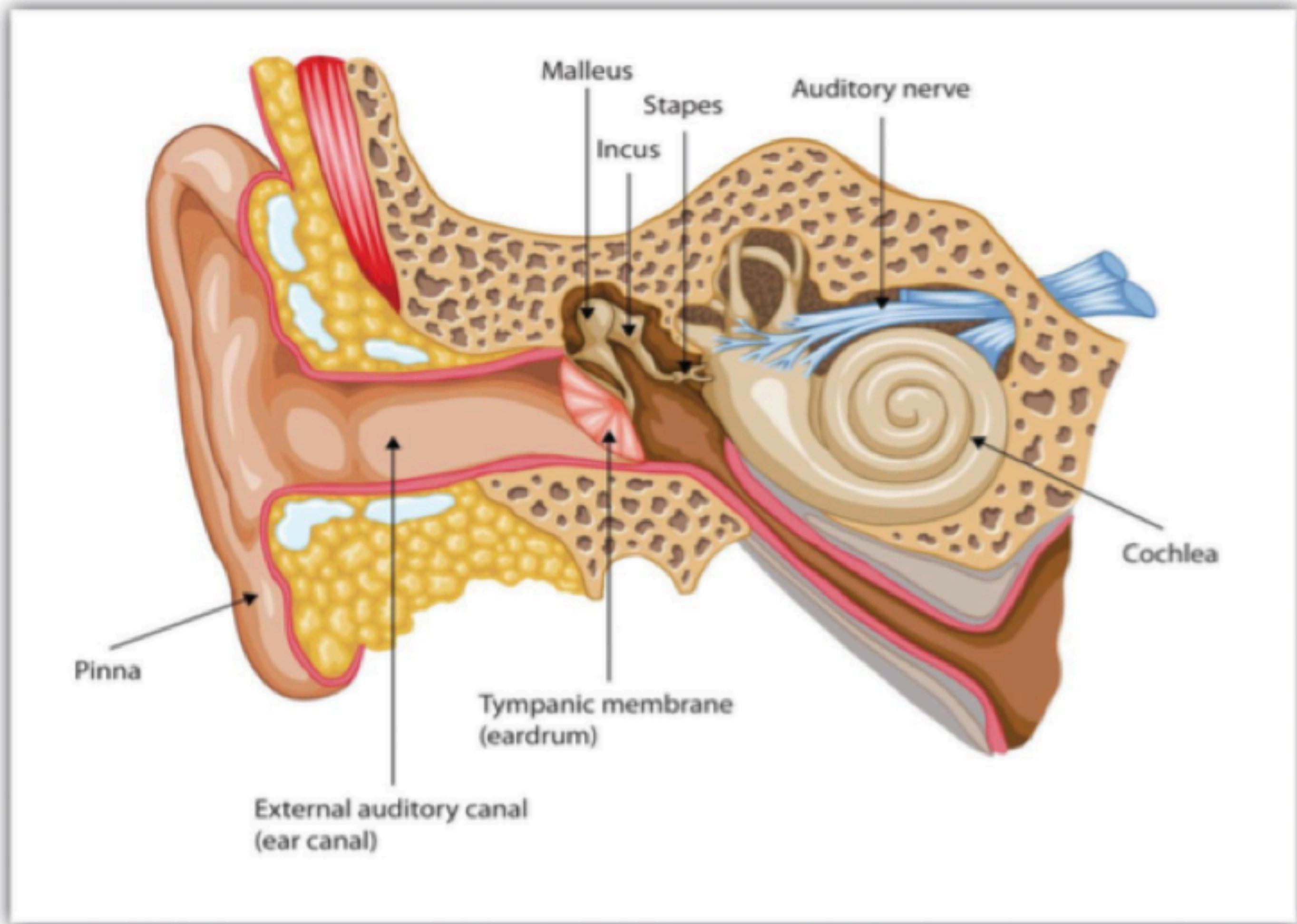
  - the resulting vibrations are relayed into the middle ear through three tiny bones, known as the ***ossicles - the hammer*** (malleus), ***the anvil*** (incus) and ***the stirrup*** (stapes) - to the ***cochlea***, a sail shaped liquid filled tube in the inner ear.

- the vibrations cause the oval window, the membrane covering the opening of the cochlea, to vibrate, disturbing the fluid inside the cochlea.

- the movements of the fluid in the cochlea bend the hair cells of the inner ear. the movement of the hair cells trigger nerve impulses in the attached neurons, which are sent to the auditory nerve and then to the auditory cortex in the brain.

- the cochlea contains about 16,000 hair cells, each of which hold a bundle of fibres known as *cilia* on its tip.

- the cilia are so sensitive that they can detect a movement that pushes them the width of a single atom or shifting the Eiffel Tower by half an inch (Corey et al., 2004).



Sound waves enter the outer ear and are transmitted through the auditory canal to the eardrum. The resulting vibrations are moved by the three small ossicles into the cochlea, where they are detected by hair cells and sent to the auditory nerve.

- Image: Stangor (2010). Introduction to Psychology. *Flat World Knowledge*. Creative Commons license. (p/ 203).

- the loudness of the sound is directly determined by the number of hair cells that are vibrating.

- two different mechanisms are used to detect pitch.

    - ***the frequency theory*** of hearing proposes that *whatever the pitch of a sound wave, nerve impulses of a corresponding frequency will be sent to the auditory nerve.* for e.g. a tone measuring 600 Hz will be transducer into 600 nerve impulses a second.
        - but for high pitched sounds this theory can't explain, because neurons won't be able to fire fast enough for higher frequencies.

    - a solution could be that to reach the necessary speed, the neurons work together in a sort of volley system in which different neurons fire in sequence, allowing us to detect sounds up to 4000 Hz.

- the place theory of hearing proposes that different areas of the cochlea respond to different frequencies.
    - higher tones excite areas closest to the opening of the cochlea (near the oval window). whereas lower tones excite areas near the narrow tip of the cochlea, at the opposite end.
- pitch is therefore determined in part by the area of the cochlea firing the most frequently.

- that the ears are placed on either side of the head enables us to benefit from stereophonic, or three dimensional hearing.

- if a sound occurs on your left side, the left ear will receive the sound slightly sooner than the right ear and the sound will receive will be more intense, allowing you to quickly determine the location of the sound.

    - although the distance between the two ears is barely 6 inches & sound waves travel at 750 miles an hour; the time & intensity differences are easily detected (Middlebrooks & Green, 1991).

- when a sound is equidistant from both ears (such as when it is directly in front or back, beneath or overhead; we have more difficulty pinpointing its exact location & we may maneuver to facilitate localization.

Speech Perception

- The most important class of stimuli that we perceive via auditory perception is speech stimuli.
- In that reference, speech perception deserves a more important mention.
- During speech perception, the auditory system needs to analyze the sound vibrations generated by someone's conversation.

- ***Characteristics of Speech Perception*** (Matlin, 2008)
  - When describing these speech sounds, psychologists & linguists use the term ***phoneme***.
    - a phoneme refers to the basic unit of spoken language, which includes basic sounds as *a, k, th*. The English language uses about 45 phonemes, including both consonants & vowels.
  - Listeners can impose boundaries between words, even when these words are not separated by silence. #speech segmentation

- Phoneme pronunciation varies tremendously. #phoneme variation

- Context allows listeners to fill in missing sounds. #role of context

- Visual cues from the speaker's mouth help us interpret ambiguous sounds. #multi – modal perception

Theories of Speech Perception

- The ***special mechanism approach*** proposes that speech perception is accomplished by a naturally selected module (Fodor, 1983).
  - this speech perception module monitors incoming acoustic stimulation and reacts strongly when the signals contains the characteristic complex patterns that make up speech.
  - when the speech module recognized an incoming stimulus as speech, it preempts other auditory processing systems, preventing their output from entering consciousness.

- So, while the non - speech sounds are analyzed according to the basic properties of frequency, amplitude, and timbre, and while we are able to perceive those characteristics of non-speech sounds accurately, when the speech module latches onto an acoustic stimulus; it prevents the kind of spectral analysis that general auditory processing mechanisms generally carry out for non - speech auditory stimuli.

- the preemption of normal auditory perceptual processes for speech stimuli can lead to *duplex perception* under special, controlled lab conditions (Liberman & Mattingly, 1989).
    - to create their experimental stimuli, researchers constructed artificial speech stimuli that sounded like /da/ or /ga/ depending upon whether the second formant transition decreased (/da/) in frequency over time or increased (/ga/).
    - next, they edited their stimuli to create separate signals for the transition and the rest of the syllable, which they called the *base*.
    - they played the two parts of the stimulus over headphones, with the transition going in one ear & the base going in one ear.

- the question was, how would people perceived the stimulus?

    - it turned out that people perceived two different things at the same time. at the ear that the transition was played into, people perceived a high - pitched chirp or whistle. But at the same they perceived the original syllable, just as if the entire, intact stimulus had been presented.

- Liberman & colleagues, argued that simultaneously perceiving the transition in two ways - as a chirp & as a phoneme - reflected the simultaneous operation of the speech module and general purpose auditory processing mechanisms.

- duplex perception happened because the auditory system could not treat the transition and base as coming from the same source (as they were played in two different ears).

- as the auditory system recognised two different sources, it had to do something with the transition that it would not normally do., i.e. it had to analyse it for the frequencies it contained and the result was hearing it as a chirp.

- but simultaneously, speech processing module recognised a familiar pattern of transitions and formants & as a result the auditory system reflexively integrated the transition & the base and led to the experience of hearing a unified syllable.

- ***the motor theory of speech perception*** :

    - that gestures, rather sound, represent the fundamental unit of mental representation in speech (Liberman & Whalen, 2000; Fowler, 2008).

        - i.e. when we speak, we attempt to move your articulators to particular places in specific ways. each of these movement constitutes a gesture.

- the motor part of speech production system takes the sequence of words we want to say & comes up with a *gestural score,* that tells our articulators how to move.

- acc. to the theory, if you can figure out what gestures created a speech signal, you can figure out what the gestural plan was, which takes you back to the sequence of syllables or words that went into the gestural plan in the first place.

- So, by knowing what the gestures are, you can tell what was the set of words that produced that set of gestures.
    - For e.g. the “core” part of the gesture to produce either “di” or “du” sounds is tapping the tip of your tongue against the back of your teeth (or your alveolar ridge).
- Other parts of the gesture, like lip position are affected by coarticulation, but the core component of the gesture is the same regardless of the phonological context.

- Thus, rather than trying to map acoustic signals directly to phonemes, Alvin Liberman & his colleagues proposed that we map acoustic signals to gestures that produced them, as there is a closer relationship between gestures and phonemes than there is between acoustic signals & phonemes.

- In their words, "The relation between perception & articulation will be considerably simple than the relation between perception and the acoustic stimulus."

- Further, "perceived similarities and differences will correspond more closely to the articulatory than the acoustic similarities among the sounds."

- So, differences between two acoustic signals will not cause you to perceive two different phonemes as long as the gestures that created those two different acoustic signals are the same.

- Another aspect of the motor theory proposes, ***categorical perception*** is another product of the speech perception module.
- categorical perception happens when a wide variety of physically distinct stimuli are perceived as belonging to one of a fixed set of categories.
    - for example: every vocal tract is different from every other vocal tract & as a result the sound waves that come out of your mouth when you say *pink* are very different that the sound waves that come out of my mouth when I say *pink,* and so on.
- nonetheless, your phonological perception is blind to the physical differences and perceives all of those signals as containing an instance of the category /p/.

- Further, it may be noted that all of our voices have different qualities than each other, but we categorize the speech sounds from each of us, in much the same way. This is because, all of those different noises map to the same set of 40 phonemes (in English).
- In addition, although the acoustic properties of speech stimuli can vary across a wide range, our perception does not change in little bitty steps with each little bitty change in the acoustic signal.
- We are insensitive to some kinds of variation in the speech signal, but if the speech signal changes enough , we perceive that change as the difference between one phoneme and another (Liberman et al., 1957).

- An example:
  - o the difference between /b/ & /p/ is that the /b/ is voiced while the /p/ is not.
  - o other than voicing the two phonemes are essentially identical; in that they are both *labial plosives*, meaning that we make these sounds by closing our lips & allowing air pressure to build up behind our lip dam and then releasing the pressure suddenly, creating a burst of air that rushes out of the mouth.
  - o the difference between the two phonemes has to do with the timing of the burst and the vocal fold vibrations that create voicing.
    - for the /b/ sound, the vocal folds begin vibrating while your lips are closed or just after; but for the /p/ sound, there is a delay between the burst and the point in time when the vocal folds begin to vibrate. This gap is the *voice onset time*.

- the VOT is a variable that can take any value whatsoever, so it is called a continuous variable. but even though VOT can vary continuously in this way, we do not perceive much of that variation.
  - for e.g. we can not greatly hear the difference between a bot of 2ms and 7ms or between 7 ms & 15ms.
- instead we map a range of VOTs on the same percept.
  - Those different acoustic signals are called *allophones* - different signals that are perceived as being the same phoneme.
  - so the experience with a range of short VOTs is as /b/ & long VOTs is as /p/; the difference point being 20ms.

References

- Traxler, M. J. (2013). Introduction to Psycholinguistics: Understanding Language Science. *Wiley – Blackwell*.

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Course Title:

Basic Cognitive Processes

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Lecture 24: Auditory Perception - II

The McGurk Effect

- Acc. to the motor theory of speech perception, understanding speech requires you to figure out which gestures created a given acoustic signal.
- the system therefore uses any sort of information that could help identify gestures.
- while acoustic stimuli offer cues to what those gestures are, other perceptual systems could possibly help out, and if they can, motor theory says that the speech perception system will take advantage of them.

- Infact, two non - auditory perceptual systems - vision & touch - have been shown to affect speech perception.
- The most famous demonstration of *multi - modal perception* is the McGurk Effect (McGurk & MacDonald, 1976).
- The McGurk effect happens when people watch a video of a person talking, but the audio portion of the tape has been altered. for e.g. the video might show a person saying /ga/ but the audio signal is of a person saying /ba/. What people actually perceive is someone saying /da/.

- If the visual information is removed (when the observing individual shuts his/her eyes), the auditory information is accurately perceived and the person hears /ba/

- The McGurk effect is incredibly robust: It happens even when people are fully warned that the auditory & visual information do not match; and it happens even if one tries to play close attention to the auditory information and ignore the visual.

- The McGurk effect happens because our speech perception system combines visual and auditory information when perceiving speech, rather than relying on auditory information alone.

- Of course the auditory information by itself is sufficient for perception to occur, but the McGurk effect shows that the visual information influences speech perception when that visual information is available.

- The McGurk effect is an example of multi -kodal perception because two sensory modalities, hearing & vision, contribute to the subjective experience of the stimulus.

- Another way to create a variant of the McGurk effect is by combing haptic information with auditory information to change the way people perceive a spoken syllable (Fowler & Dekle, 1991).

- This kind of speech perception occurs outside the laboratory from time - to - time in a specialised mode called *tadoma*.

- Hellen Keller & other hearing & vision - impaired individuals have learned to speak by using their sense of touch to feel the articulatory information in speech.

- Acc. to the motor theory, information about speech gestures should be useful regardless of the source, auditory or otherwise.

- That being the case, information about articulatory gestures that is gathered via the perceiver’s sense of touch should affect speech perception.

- to test this: Carol Fowler had experimental participants feels her lips while they listened to a recording of a female speaker speaking a variety of syllables.

- Blindfolded and gloved, experimental participants heard the syllable /ga/ over a speaker while CF simultaneously mouthed the syllable /ba/.

- As a result, the experimental participant felt the articulatory gestures appropriate to one syllable but heard the acoustic signal appropriate to a different syllable.

- As in the visual version of the McGurk effect, what participants actually perceived was a compromise between the auditory signal & the haptic signal.

- So, instead of perceiving the spoken signal /ga/ or the mouthed syllable /ba/ they perceived the hybrid syllable /da/.

- the motor theory explains both versions of the McGurk effect, the visual one & the haptic one; as stemming from the same basic processes.

- The goal of the speech production system is not a spectral analysis of the auditory input; rather, it is figuring out what set of gestures created the auditory signals in the first place.

- Motor theory handles the visual & haptic effects on speech perception by arguing that both the modalities can contribute information that helps the perceiver figure out what gesture the speaker made.

- Under natural conditions, the visual, touch & auditory information will all line up perfectly, meaning that all secondary sources will be perfectly valid cues; in conditions as we saw that was not the case.

- *Mirror Neurons:* the motor theory has been enjoying a renaissance recently sparked off by new evidence about monkey neurons (Gallesese et al., 1996; Gentilucci & Corballis, 2006).

- i.e. researchers working on macaque monkeys discovered neurons in a part of the monkey's frontal lobes that responded when a monkey performed a particular action, or when the monkey watched someone else perform that action or when the monkey heard a sound associated with that action.

- These neurons were called *mirror neurons*.

- the existence of mirror neurons in monkeys was established by the invasive single - cell recording techniques; and similar experiments in humans are not plausible; so, the existence of mirror neurons in humans remains an hypothesis rather than an established fact.
- However, the part of the brain of the macaques that have the mirror neurons (area F5) is similar to the Broca's area in the human brain.
- Neuroimaging and research involving direct recording from neurons in the Broca's area both show that it participates in speech perception (Sahin et al., 2009).

- Researchers who discovered mirror neurons propose that the mirror neurons could be the neurological mechanism that the motor theory of speech perception requires. i.e. mirror neurons in the Broca's area could fire when an individual produces a particular set of phonemes, or hear the same set of phonemes; providing the bridge between speaking & listening.

- Experiments have been conducted to non - invasively find evidence for the participation of the motor cortex in speech perception.

- the motor theory says the accessing representations of specific speech gestures underlies speech perception.

- those representations of speech gestures must be stored in the parts of the brain that control articulatory movements.
- The parts of the brain that control articulation are the motor cortex in the frontal lobes of the brain & the adjacent premotor cortex when we perceive speech.
- proponents of the mirror neurons argue that mirror neurons are the neural mechanism that establishes the link between the heard speech & the motor representation that underlie speech production.

- Now, mirror neurons have recently been fund in the monkey equivalent of the motor cortex and so, the proponents of the mirror neurons view this as evidence that the motor cortex responds to speech as supporting their view of speech perception.

- Some mirror neuron theorists argue further that mirror neurons play a role in modern humans because our speech production and perception processes evolved from an older manual gesture system (Gentilucci & Corballis, 2006).

- Evidence for mirror neurons in humans:
  - In Pulvermuller & colleagues study, participants listened to syllables that resulted from bilabial stops (/pa/, /ba/) or alveolar stops (/ta/, /da/) on listening trials.
  - On silent production trials, participants imagined themselves making those sounds.
  - Measurement of their brains activity were gathered using fMRI.

- Listening to speech caused substantial activity in the superior parts of the temporal lobes on both sides of the participant's brains, but it also caused a lot of brain activity in the motor cortex in the experimental participant's frontal lobes.

- Further, brain activity in the motor cortex depended upon what kinds of speech sounds the participants were listening tro.
    - whether the sound was a bilabial stop or alveolar stop.

- motor theory explains these results by arguing that the same brain areas that produce speech are involved in perceiving it.

- In another study, when TMS was applied to a participant’s motor cortex, participants were less able to tell the difference between two similar phonemes.
- Further, when people listen to speech sounds that involve tongue movements, & have TMS applied to the parts of the motor cortex tat control the tongue; increased MEP are observed in the participants tongue muscles.
- All of these experiments show that the motor cortex generates neural activity in response to speech; consistent with motor theory of speech perception.

- ***Challenges to the Motor Theory of Speech Perception***

  - some challenges to motor theory are rooted in the strong connection it makes between perception & production.

  - infants for example, are fully capable of perceiving the differences between many speech sounds, despite the fact that they are thoroughly incapable of producing those speech sounds (Eimas et al., 1971).

  - to account for this result, we either have to conclude that infants are born with an innate set of speech - motor representations or that having a speech - motor representations is not necessary to perceive phonemes.

- additional experiments have also cast doubt on whether speech - motor representations are necessary for speech perception.
    - no one would suggest, for example that non - human animals have a supply of speech - motor presentations, especially if those animals are incapable of producing anything that sounds like human speech. Two such animals are Japanese Quail & chinchillas.
    - Once they are trained to respond to one class of speech sounds & refrain from responding to another class; they demonstrate aspects of speech perception tat resemble human performance; i.e. categorical perception & compensation for co -articulation.

- because these animals lack the human articulatory apparatus, they cannot have the speech motor - representations; but as they respond to aspects of speech very much like humans do, motor theory’s claim that speech motor representations are necessary for speech production is threatened.

- further, research with aphasic patients casts further doubt on the motor theory.
  - Broca & Wernicke showed that some brain damaged patients could not produce speech but understand it & vice - versa.
  - the existence of clear dissociations between speech perception & speech production provides strong evidence that intact motor representations are not necessary for perceiving speech.

- Also, if speed perception requires access to intact motor representations, then brain damage that impair spoken language output should also impair spoken language comprehension; but this pattern does not appear much of the time.

- Another problem for either account is that there is a many -to -one mapping between gestures and phonemes.
  - i.e. the same speech sound can be produced by different articulatory gestures (MacNeilage, 1970).
  - more specifically, different people can produce the same phoneme by using different configurations of the vocal tract; because the vocal tract offers a number of locations where the air flow can be restricted & because different combinations o air - flow restrictions have the same physical effect; they wind up producing acoustic signals that are indistinguishable to the perceiver.

- this means that there is no single gesture for syllable like /ga/.
- Studies involving the production bite - block vowels also show that very different gestures can lead to the same or nearly the same set of phonemes.
- The motor theory can account for this set of findings in one of two ways:
    - either by proposing that more than one speech - motor representation goes with a given phoneme or that there is a single set “prototype” of speech -motor representations & that an acoustic analysis of speech signals determines which of these ideal gesture most closely matched the acoustic input.
- Both, violate the spirit of the theory!

Other Theories of Speech Perception

- **The General Auditory Approach to Speech Perception**
  - starts with the assumption that speech perception is not special (Diehl & Kluender, 1989; Pardo & Remez, 2006); instead "speech sounds are perceived using the same mechanisms of audition and perceptual learning that have evolved in humans… to handle other classes of environmental sounds" (Diehl et al., 2004).

- Researchers in this tradition look for consistent patterns in the acoustic signal for speech that appear whenever particular speech properties are present.

- further, they seek to explain commonalities in the way different people and even different species react to aspects of speech.

    - for e.g. some studies have looked at the way people and animals respond to *voicing contrasts* (the difference between unvoiced consonants like /p/ and voiced consonants like /b/).

    - these studies have suggested that our ability to perceive voicing is related to the fundamental properties of the auditory system.

- i.e. we can tell whether two sounds occurred simultaneously if they begin more than 20ms apart.
    - if two sounds are presented within 20 ms of each other, we will perceive them as being simultaneous in time. if one starts 20ms before than the other, we perceive as occurring in a sequence, one before the other.
    - the voicing boundary for people & quail sits right at the same point.
    - if vocal fold vibration starts within 20ms of the burst, we perceive the phoneme as voiced; but if there is more than a 20ms gap between the burst & the vocal fold vibration, we perceived an unvoiced stop.
- Thus, this aspect of phonological perception could be based on a fundamental property of auditory perception, rather than the peculiarities of the gestures that go into the voiced & unvoiced consonants.

- the general auditory approach does not offer an explanation of the full range of human (or animal) speech perception abilities.
- it's chief advantage lies in its ability to explain common characteristics of human & non - human speech perception & production.
- since the theory is not committed to gestures as the fundamental unit of phonological representations, it is not vulnerable to many of the criticisms leveled at the motor theory.

- *The Fuzzy Logic Model of Speech Perception (FLMP)*
- one of the better known approaches within the general auditory tradition, incorporates the idea that there is a single set of "ideal" or "prototype" representations of speech sounds, as determined by their acoustic characteristics (Massaro & Chen, 2008).
- Acc. to the FLMP, speech perception reflects the outcomes of two kinds of processes:
  - *bottom - up & top - down*: the bottom up processes are those mental operations that analyse the acoustic properties of a given speech stimulus. these processes activate a set of potentially matching phonological representations

- stores representations of phonemes are activated to the degree that they are similar to acoustic properties in the speech stimulus; more similar phonemes attain higher degrees of activation, less similar phonemes attain lower degrees of activation.

- top - down processes are this mental operations that use information in the long - term memory to try & select the best possible candidate from among the set of candidates activated by the bottom up processes.

  - this may be specially important if the incoming information is ambiguous or degraded. for e.g. when the /n/ phoneme precedes the /b/ sound (as in *lean bacon*), often times coarticulation makes the /n/ phoneme comes out sounding more like /m/.

- So, when someone listens to *lean bacon,* bottom - up processes will activated both the prototype /n/ & /m/ phoneme, because the actual part of the signal will be intermediate between the two types.

- Acc. to the FLMP, our knowledge the *lean bacon* is a likely representation in English should cause us to favour the /n/ interpretation.

- However, if the /n/ sound were in a non - word, such as *pleat bacon,* a listener would be more likely to favour the /m/ interpretation, because the opening sound would not receive any support from top - down processes. This tendency to perceive the ambiguos speech stimuli as real words if possible is known as the *Ganong Effect,* after William Ganong (1980).

- FLMP, also offers a mechanism that can produce *phonemic restoration effects* (Sivonen et al., 2006).
    - phonemic restoration happen when speech stimuli are edited to create gaps. for example. remember the legi(cough)lators experiment.
    - these phonemic restoration effects are stronger for longer than shorter words and they are stronger for sentences that are grammatical and make sense than sentences that are ungrammatical & don’t make sense.
    - further, the specific phoneme that is restored can depend on the meaning of the sentence that the edited word appears in.

- for e.g. if you hear *The Wagon lost its (cough)eel*, you will most likely hear the phoneme /w/ in place of the cough. But if you hear *The circus has a trained (cough)eel*, you will more likely hear the phoneme /s/.

- Research involving ERPs show that the nervous system does register the presence of the cough noise very soon after it appears in the stimulus (about 200ms).

- All of these suggest that a variety of possible sources of top - down information affects the way the acoustic signal is perceived.

- Further they suggest that the perception of speech involves analysing the signal itself as well as biasing the results of this analyses based on how well different candidate representations fit in with other aspects of the message.

- These other aspects could include whether the phonological representations results in a real word or not, whether the semantic interpretations of the sentence makes sense or how intact the top - down information is.

To Sum Up

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Course Title:

Basic Cognitive Processes

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Lecture 24: Attention - I

Some Key Questions…

- Is it possible to selectively focus on one object/event, while many others are simultaneously going on?
- If yes, then under what conditions?
- What does research on attention tell us about multi – tasking?
- Is it that we are not attending to all other information that we are not focusing on?

Preliminary Definitions…

- *Attention*: the ability to focus on specific stimuli or spatial locations.

- *Selective Attention:* focusing attention on a specific object, event or location.

- *Overt Attention*: the process of shifting attention from one place to another by moving of eyes to those specific objects or locations.

- *Covert Attention*: when attention is shifted without the actual movement of the eyes.

- *Divided Attention*: the ability of attending two objects at the same time.

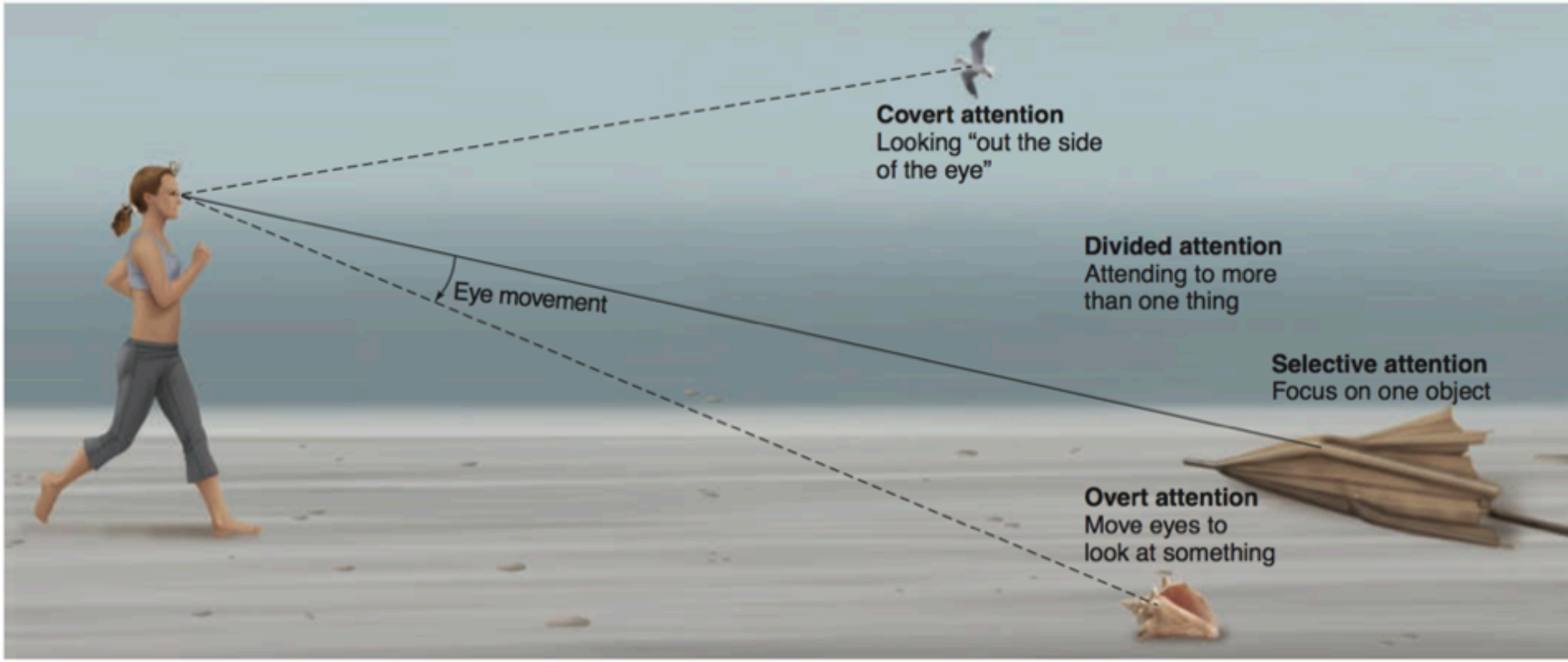


FIGURE 4.1 Crystal attends to various objects on the beach, illustrating a number of different types of attention.

Image Source: Goldstein (2011). Cognitive Psychology_Connecting Mind, research & Eveyday Experience. *Cengage Learning*

Attentional Processes: Visual Search

- *Search* refers to our behaviour of scanning the environment looking for particular features – i.e. actively looking for something when one is not aware of the location it will appear.

- *Search* becomes more difficult by ***distracters,*** i.e. non – target stimuli that divert our attention away from the target stimulus.
  - False alarms usually arise when we encounter such distracters while looking for the target stimulus. for e.g. counterfeits.

- the number of targets & distracters affects the difficulty of the task.
    - e.g. try to find T in the two figures, Panel A & B
- An interesting finding is the *display size* (i.e. the number of items in a given visual array) *effect,* which is the degree to which the number of items in a display hinders the search process).

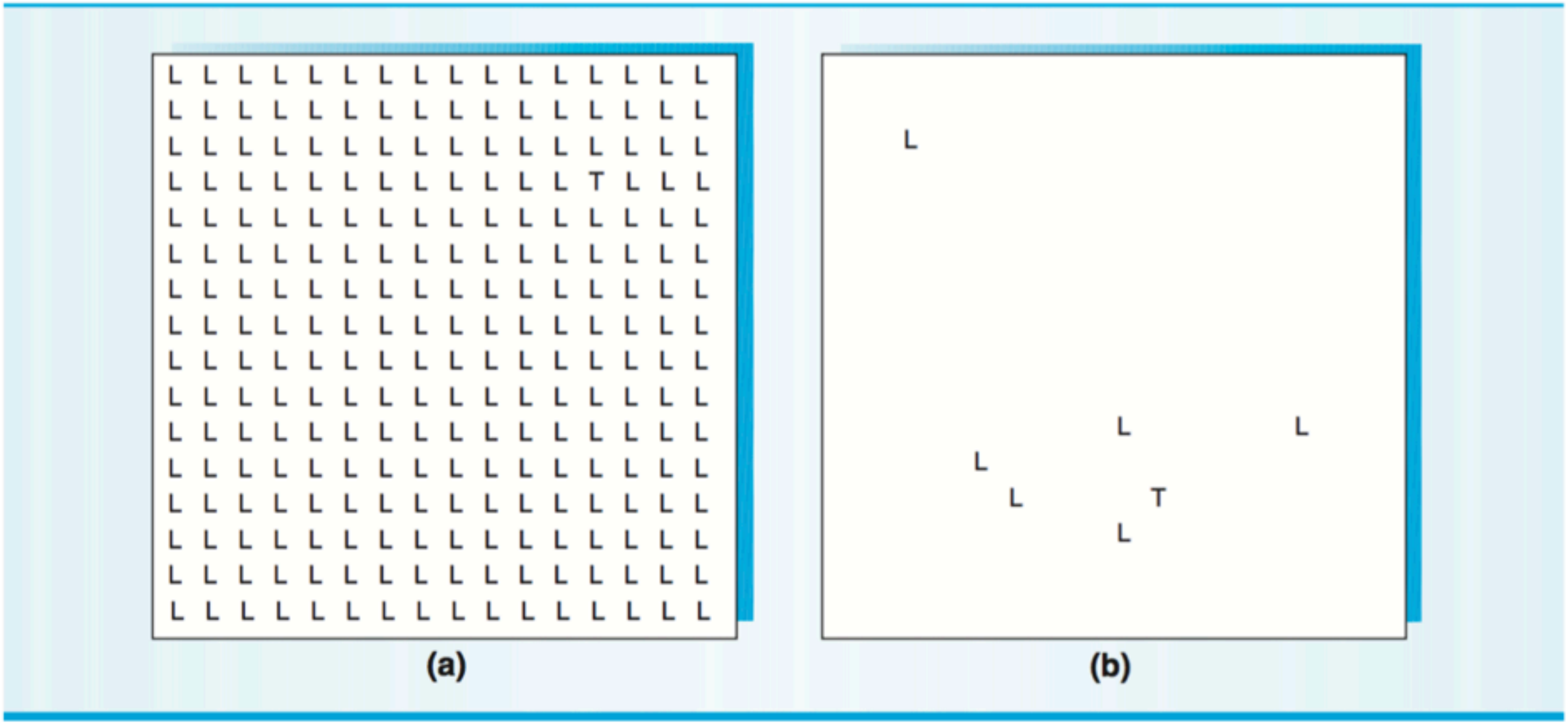


Figure 4.2 **Display Size.**
Compare the relative difficulty in finding the T in panels (a) and (b). The display size affects your ease of performing the task.

Image Source: Sternberg & Sternberg (2011). Cognitive Psychology. *Wadsworth Publishing.* 6th Ed. (p. 143).

- Distracters cause more trouble under some conditions than under others.
  - we conduct a **feature search**, when we simply scan the environment for a specific feature (Treisman, 1993). Distracters play little role in slowing our search in this case. for example, finding O in the panel c.
- because O has a distinctive form as compared to the rest of the items in the display; it pops out.
- Features singletons, i.e. items with distinctive features stand out in the display (Yantis, 1993); when feature singletons are targets, they seem to grab our attention; even those that may be distracting.

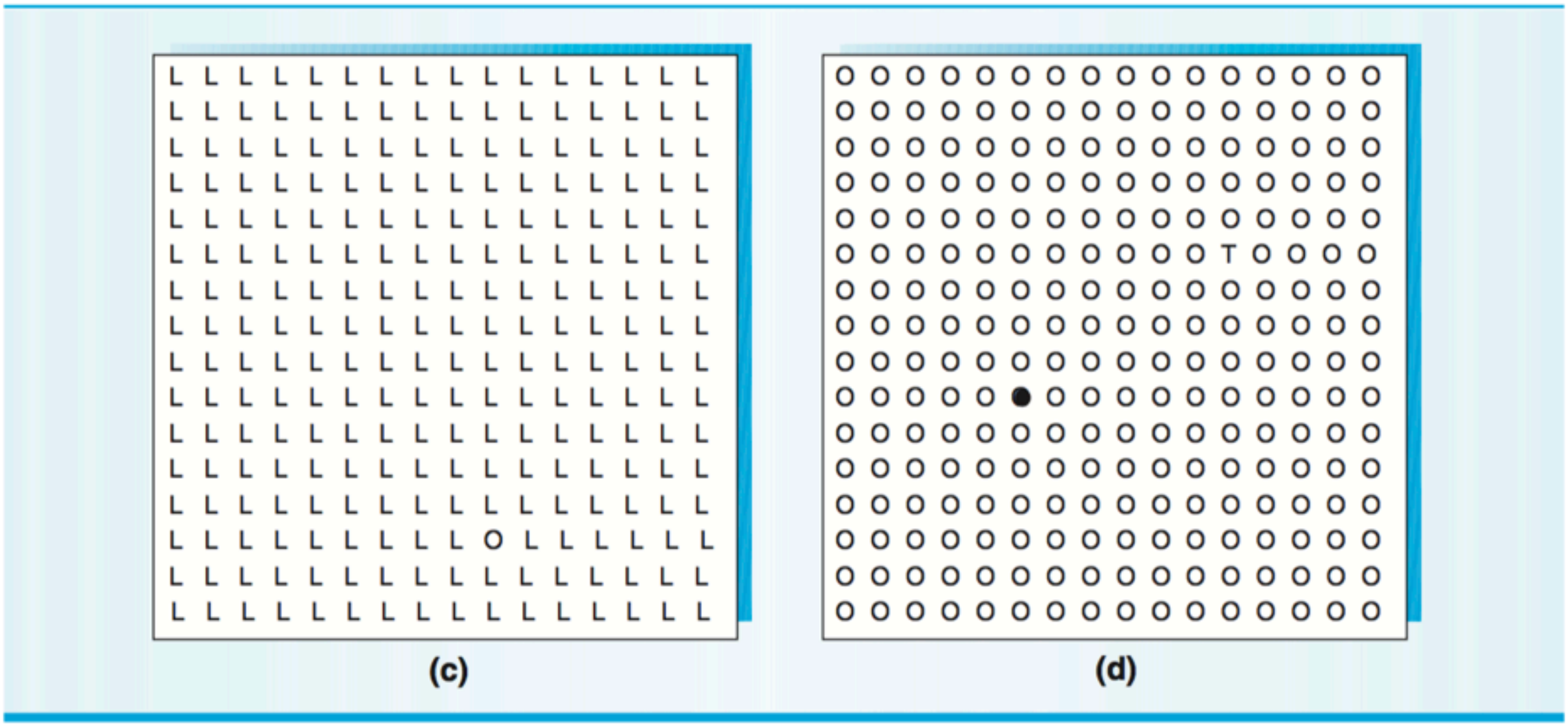


Figure 4.3 **Feature Search.**
In panel (c), find the O, and in panel (d), find the T.

Image Source: Sternberg & Sternberg (2011). Cognitive Psychology. *Wadsworth Publishing.* 6th Ed. (p. 144).

- on the other hand, when the target stimulus has no unique or even distinctive features.

- In these situations, the only way we can find such items is by **conjunction search**, i.e. we look for a particular combination (conjunction) of features. for e.g. the only difference between a T & a L is the particular integration of line segments. Both letters comprise a horizontal line and a vertical line.

- The dorsolateral prefrontal cortex as well as both frontal eye fields & the posterior parietal cortex play a role only in conjunction searches, but not so in feature searches (Kalla et el., 2009).

- **Theories of Visual Search**

  - **Feature - Integration Theory** explains the relative ease of conducting feature searches and the relative difficulty of conducting conjunction searches.

  - Going by Treisman's (1986) model of visual search, for each possible feature of a stimulus, each of us has a mental map for representing the given feature across the visual field. Say, there is a map for every colour, size, shape or orientation. there is no added time required for additional cognitive processing. Thus during feature searchers, we monitor the relevant feature map for the presence of any activation anywhere in the visual field.

  - This monitoring process can be done in parallel (all at once). This will therefore show no display size effects.

- However, during conjunction searchers; an additional stage of processing is needed. During this stage, we must use our attentional resources as a sort of mental glue; where in the two or more features are conjoined into an object representation at a particular location. In this stage, we can conjoin the features representation of only one object at a time. This stage, must be carried out sequentially, conjoining each object one by one. Effects of display size (i.e. a larger number of objects with features to be conjoined) therefore appear.

- Such a model of visual search is supported by the work of Hubel & Wiesel, (1979), who identified specific neural feature detectors.
    - o these are cortical neurons that respond differentially to visual stimuli of particular orientations (e.g. vertical, horizontal, or diagonal).
- More recent research has indicated that the best search strategy is not for the brain to increase the activity of neurons that respond to the particular target stimuli; in fact the brain seems to use the more nearly optimal strategy of activating neurons that best distinguish the targets from the distracters, while at the same time ignoring the neurons that are tuned best to the target (Navalpakkam & Itty, 2007).

- **Similarity Theory:** According to similarity theory, Treisman's data can be reinterpreted; as being a result of the fact that as the similarity between target & distracter stimuli increases, so does the difficulty in detecting the target stimuli (Duncan & Humphreys, 1992).

- Thus targets that are highly similar to distracters are relatively harder to detect. Targets that are highly disparate from distracters are relatively easy to detect. (e.g. finding the black circle in panel E).

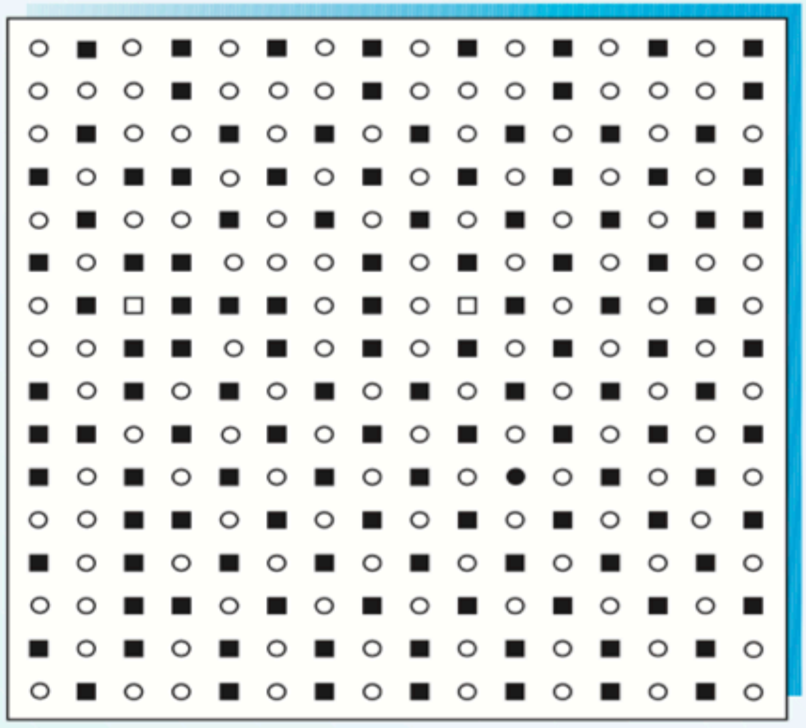


Figure 4.4 Similarity Theory.
In panel (e), find the black circle.

Image Source: Sternberg & Sternberg (2011). Cognitive Psychology. *Wadsworth Publishing*. 6th Ed. (p. 146).

- The target is highly similar to the distracters (black squares or white circles); therefore it is very difficult to find.

- Further, the difficulty of search tasks depends upon the the degree of disparity among the distracters; but it does not depend on the number of features to be integrated. for instance, one reason it is easier to read long strings of text written in lower case letters than text written in capital letters is that capital letters tend to be more similar to one another in appearance. Lowercase letters, in contrast, have more distinguishing features. e.g. try to find R in panels F & G.

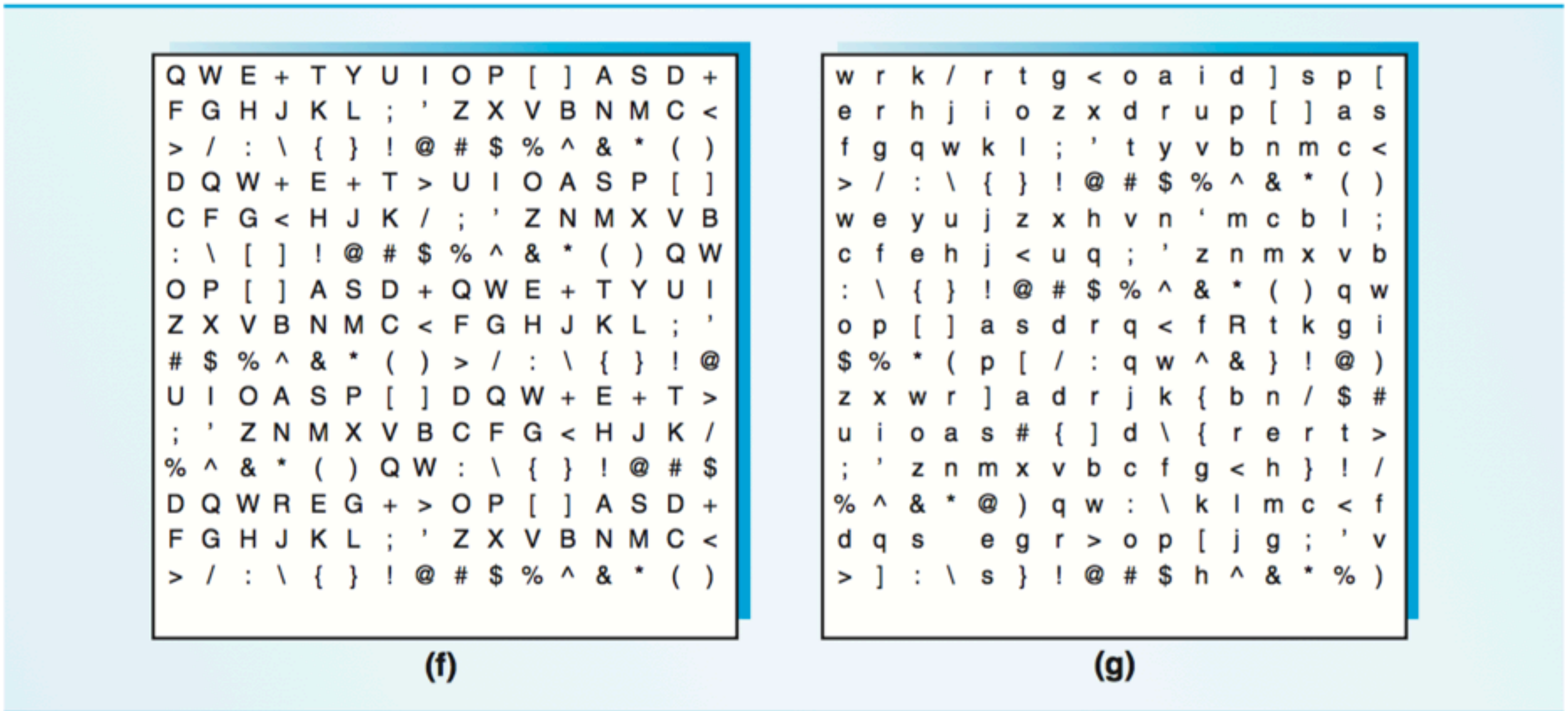


Figure 4.5 **Similarity Theory.**
In panels (f) and (g), find the R.

Image Source: Sternberg & Sternberg (2011). Cognitive Psychology. *Wadsworth Publishing*. 6th Ed. (p. 146).

- **Guided Search Theory**: An alternative to Treisman's model is offered as the *guided search theory* (Cave & Wolfe, 1990; Wolfe, 2007).

- The guided search model suggests that all searches, whether feature searchers or conjunction searchers involve two consecutive stage. The first is a parallel stage: the individual simultaneously activates a mental representation of all the potential targets. The representation is based on the simultaneous activation of each of the features of the target.

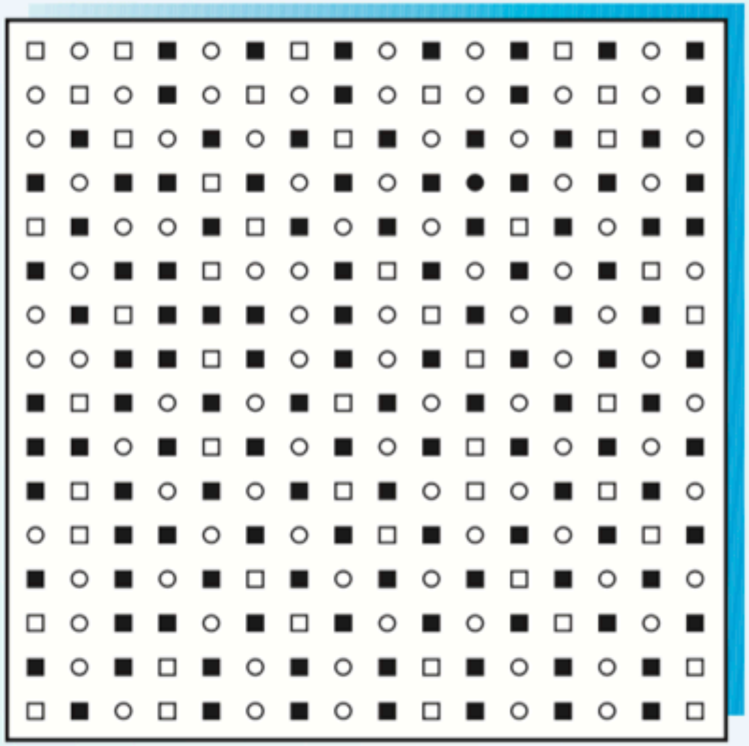
- In a subsequent serial stage, the individual sequentially evaluates each of the activated elements, according to the degree of activation. After that, the person chooses the true targets from the activated elements.

- Acc. to this model, the activation process of the parallel initial stage helps to guide the evaluation and the selection process of the serial second stage of the search.

  - For example; try to find the black circle in panel H.

    - the parallel stage will activate a mental map that contains all the features of the target (circle, black). Thus black circles, white circles & black squares will be activated.

    - during the serial stage, one will first evaluate the black circle, which was highly activated. You will also evaluate the black squares & white circles as they are less activated & dismiss them as distracters.



(h)

4.6 Guided Search Theory.

h), find the black circle.

Image Source: Sternberg & Sternberg (2011). Cognitive Psychology. *Wadsworth Publishing*. 6th Ed. (p. 147).

To Sum Up

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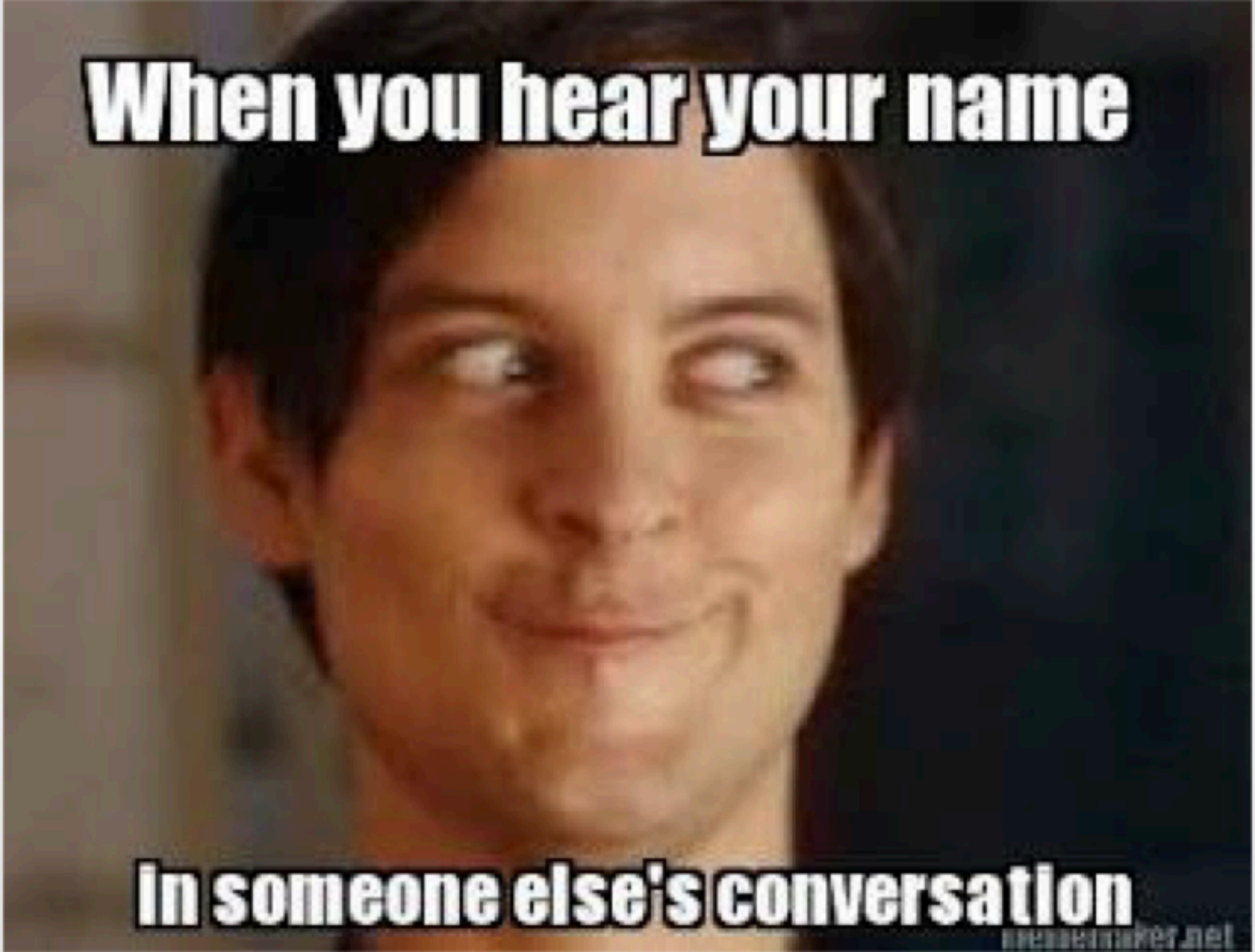
Lecture 25: Attention - II

Selective Attention

- it often happens in public gatherings like in parties or restaurants etc.; that some other ongoing conversations than the one you are currently involved in grabs our attention.
- Colin Cherry (1953) referred to this phenomenon as the **cocktail party effect**, i.e. the process of tracking one conversation in the face of the distractions from other conversations.
- Cherry observed that cocktail parties are often settings in which selective attention is salient.


When you hear your name
in someone else's conversation

- Cherry studied selective attention in a carefully controlled experimental setting; task known as **shadowing**.

- In shadowing, one listens to two different messages. Cherry presented a separate message to each ear; known as **dichotic presentation**; and asked the participants to repeat back only one of the messages as soon as possible after hearing it.

- Cherry's participants were quite successful in shadowing distinct messages in dichotic listening tasks, although such shadowing required a significant amount of concentration.

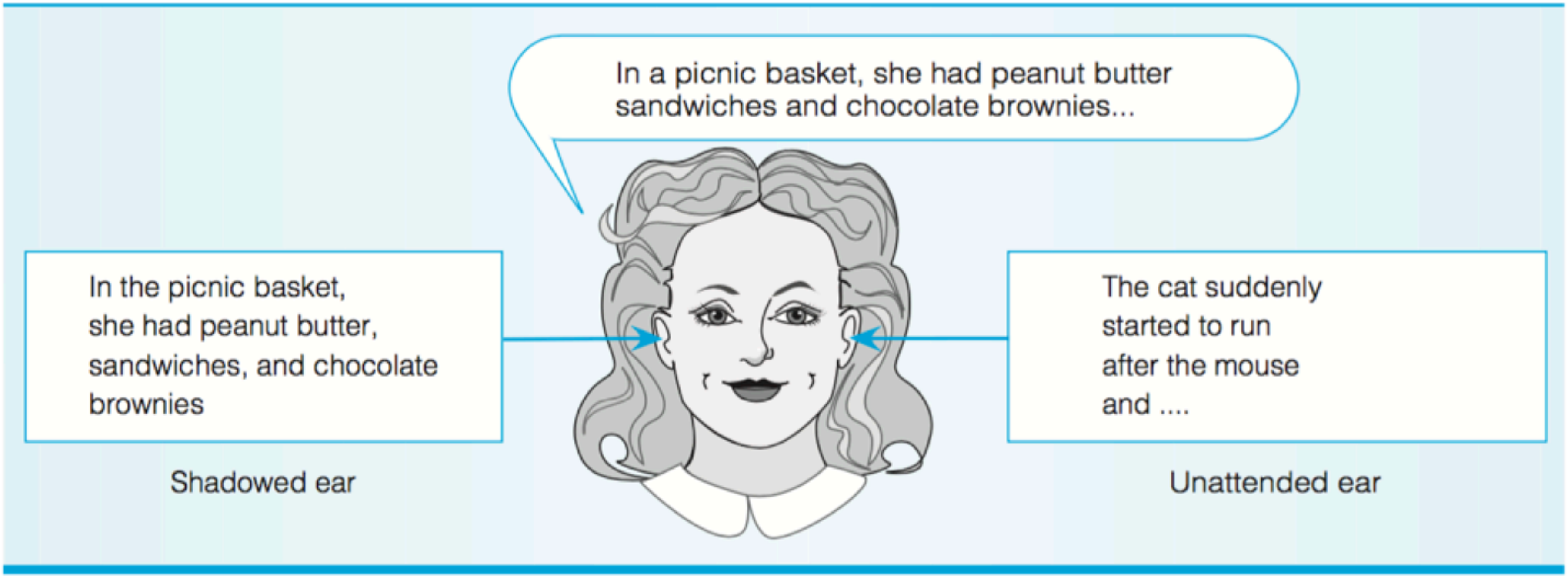


Figure 4.8 **Dichotic Presentation.**
In dichotic presentation, each ear is presented a separate message.

Image: Sternberg & Sternberg (2011) Cognitive Psychology. *Wadsworth Publishing*. 9th ed. (p. 149).

- The participants were also able to notice physical, sensory changes in the unattended message - for example, when the message was changed to a tone or the voice changed from a male to female voice.

- However, they did not notice they semantic changes in the unattended message. They also failed to notice even when the unattended message shifted from English to German or was played backward.

- Conversely, about 1/3 of the people, when their name is presented during these situations shifted their attention to their name. Some researchers have noticed that those who hear their name in the unattended message have limited working memory capacity & are thus easily distracted (Conway, Cowan & Bunting, 2000).

- Three factors could help one to selectively attend the target speaker, if you are caught in a busy restaurant among many conversations:
  - distinctive sensory characteristics of the target's speech. e.g. high vs low pitch, pacing & rhythm.
  - sound intensity (loudness)
  - location of the sound source (Brungard & Simpson, 200&0.

- **Theories of Selective Attention**

  - The theories of selective attention can be grouped into **filter** & **bottleneck** theories.

    - A filter blocks some of the information going though and thereby selects only a part of the total information to pass through the next stage.

    - A bottleneck slows down information passing through.

- Two questions:
  - Whether there is a distinct filter for incoming information?
  - Where in the processing does filtering occur, Early or Late?

- **Broadbent's Model**: Acc. to one of the earliest theories of attention, we filter information right after we notice it at the sensory level (Broadbent, 1958).

- Multiple channels of sensory input reach an attentional filter; those channels can be distinguished by their characteristics like loudness, pitch, or accent.

- The filter permits only one channel of sensory information to proceed and reach the process of perception.

- We thereby assign meaning to our sensations.

- Other stimuli will be filtered out at the sensory level and may never reach the level of perception.

- Broadbent's theory was supported by Colin Cherry's findings that sensory information sometimes may be noticed by an unattended ear if it does not have to be processed elaborately (e.g. voice shifts to tone); but information requiring higher perceptual processes is not noticed if not attended to (e.g. English shifts to German).

- **Selective Filter Model**: Moray found that even when participant's ignore most other high level aspects of an unattended message, they frequently still recognise their names in an unattended ear (Moray, 1959).

- He suggested that the reason for this effect is that messages that are of high importance to a person may anyways breakthrough the filter of selective attention; though other messages may not.

- To modify Broadbent's metaphor, one could say that, according to Moray, the selective filter blocks out most information at the sensory level; but some personally relevant information can still burst through.

- **Attenuation Model**: Treisman explored why some unattended messages pass through the filter by conducting some experiments.
- She had participants shadowing coherent messages, and at some point, switched the remainder of the message to the unattended ear.
- Participants picked up the first few words of the message they had been shadowing in the unattended ear (Treisman, 1960); so they somehow must have been somehow processing the content of the unattended message.

- Moreover, if the unattended message was identical to the amended one; all participants notice it. They noticed even if one of the messages was slightly out of temporal synchronisation with the other.

- Trainman also observed that some fluently bilingual participants noticed the identity of the messages if the unattended message was a translated version of the attended one.

- Her findings suggested that at least some information about unattended signals is being analysed.
- Treisman proposed a theory of selective attention that involves a later filtering mechanism.
- Instead of blocking stimuli out, the filter merely weakens the strength of the stimuli other than the target stimulus.
- So, when stimuli reach us, we analyse them at a low level for target properties like loudness & pitch; if the stimuli process those target properties, we pass the signal on to the next stage; if they do not posses the target properties a weakened version is passed on to the next stage.

- In a next step, we perceptually analyse the meaning of the stimuli and their relevance to us, so that even a message from the unattended ear that is supposedly irrelevant can come into awareness and influence actions if it has some meaning for us.

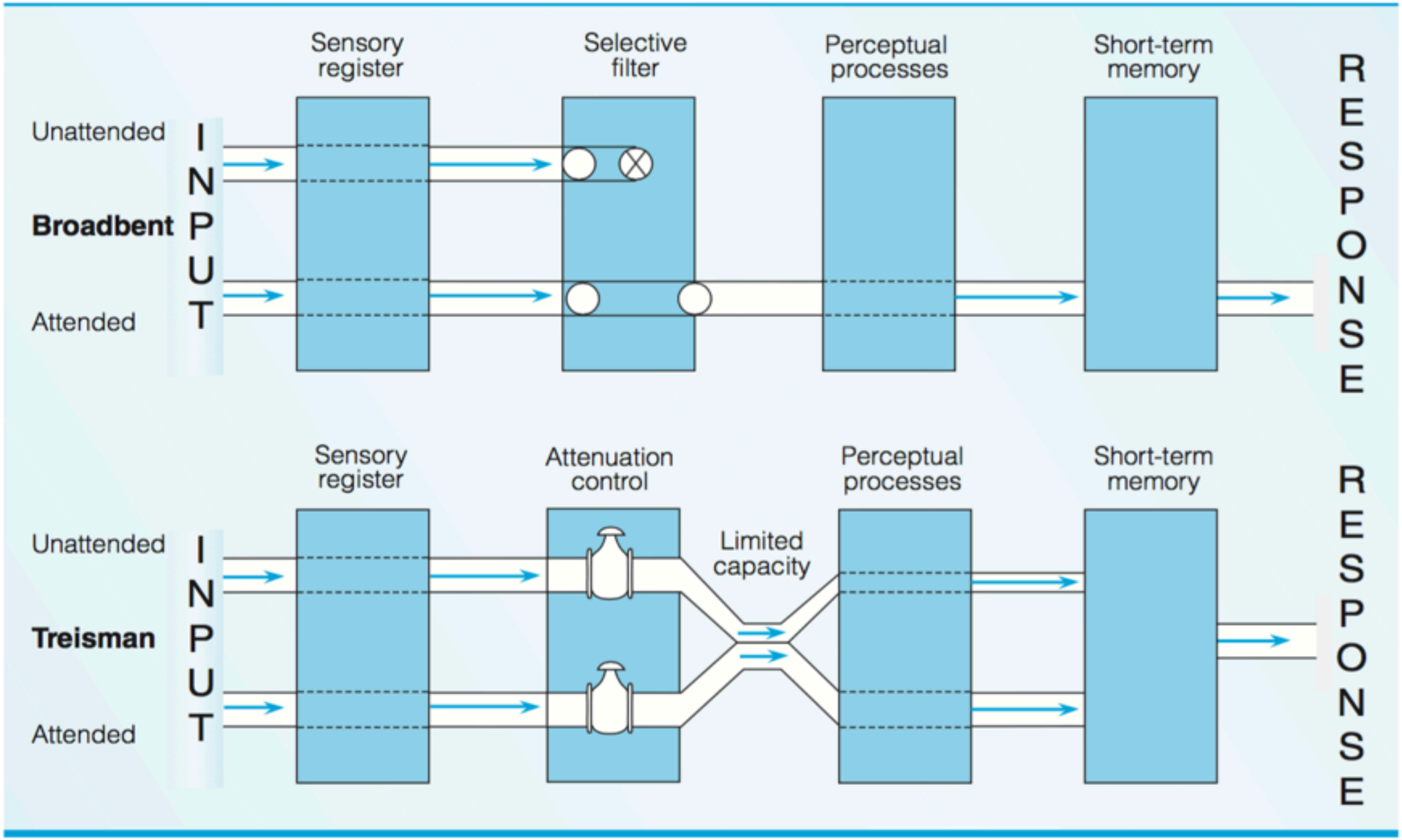


Figure 4.9 **Broadbent and Treisman's Models of Attention.**
Various mechanisms have been proposed suggesting a means by which incoming sensory information passes through the attentional system to reach high-level perceptual processes.

Image: Sternberg & Sternberg (2011) Cognitive Psychology. *Wadsworth Publishing*. 9th ed. (p. 150).

- **Late - Filter Model**: Deutsch & Deutsch (1963) developed a model in which the location of the filter is even later.

- They suggested that stimuli are filtered out only after they have been analysed for both their physical properties and their meaning.

- This late filtering would allow people to recognise information entering the unattended ear. for e.g. they might recognise the sound of their own names or a translation of the attended version.

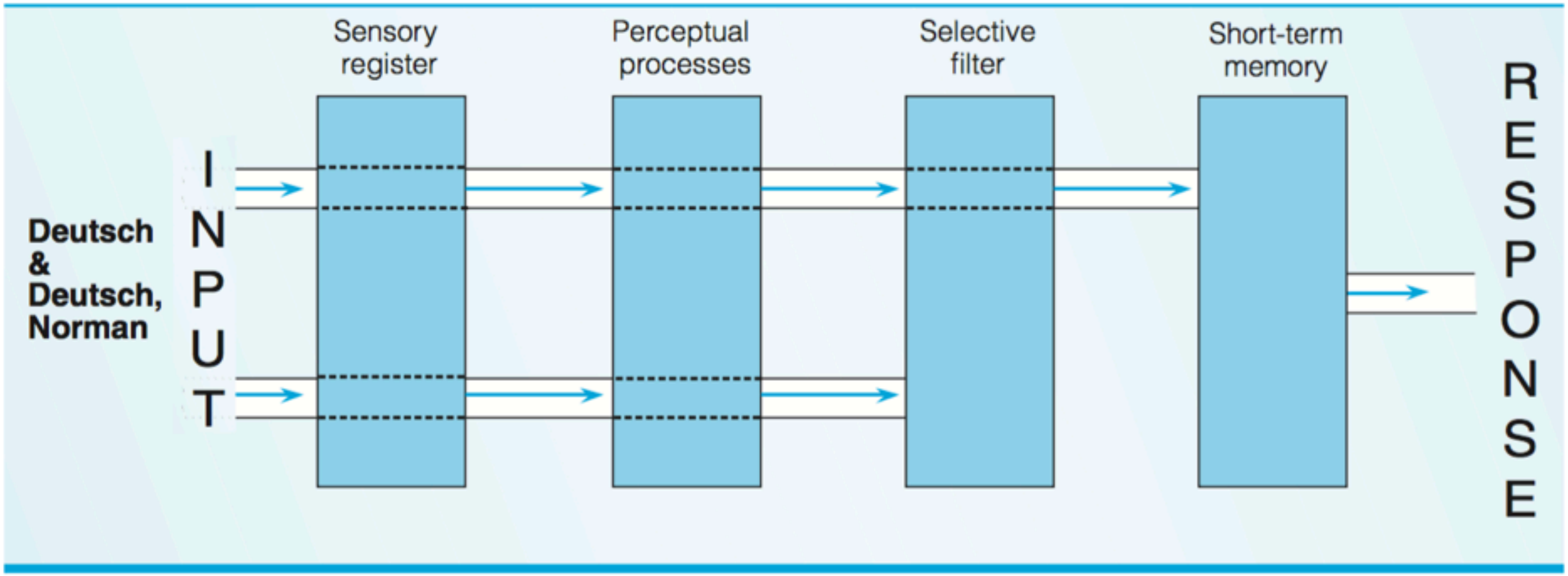


Figure 4.10 **Deutsch & Deutsch's Late-Filter Model.**
According to some cognitive psychologists, the attentional filtering mechanisms follow, rather than precede, preliminary perceptual processes.

Image: Sternberg & Sternberg (2011) Cognitive Psychology. *Wadsworth Publishing*. 9th ed. (p. 152).

- **A synthesis:**

  - Ulric Neisser synthesised the early filter and the late filter models and proposed that there are two processes governing selective attention:

    - **Pre attentive Processes:** These automatic processes are rapid & occur in parallel. They can be used to notice only physical sensory characteristics of the unattended message; but they do not discern meanings.

    - **Attentive, controlled processes:** These processes occur later. They are executed serially and consume time and attentional resources, such as working memory. They can cue used o observe relationships among features; synthesise fragments into mental representation of an object.

- This two - step model could easily account fro Cherry’s, Moray’s, & Treisman’s data.

- Also, this model nicely incorporates aspects of Treisman’s signal attenuation theory & her feature integration theory.

- Acc. to Treisman, discrete processes for feature detection & for feature integration occur during searches.

- **Neuroscience of selective attention**

  - Hillyard & colleagues (1973) conducted a ground - breaking study, exposing participants to two streams of tones; one in each ear.

  - Participants were asked to detect occasionally occurring target stimuli; when the target stimuli occurred in the attended ear, the first negative component of the ERP was larger than when the target occurred in the unattended ear.

    - The N1 wave is a negative wave appearing about 90ms after the onset of the target stimulus,

  - The researchers hypothesised that the N1 wave was a result of the enhancement of the target stimulus. At the same time here was a suppression of the other stimuli(distracters).

- This result is consistent with the filter theories of attention.

- Later studies (Woldorff et al., 1993) found an even earlier reaction to the target stimulus in the form of a positive wave that occurs about 20 - 50ms after the onset of the target. This wave originates in the Heschl’s gyro, located in the auditory cortex.

- Similar effects have also been found for visual attention.

    - If a target stimulus appears in an unattended region of the visual field, the occipital P1is larger than when the target appears in an unattended region (Van Voorhies & Hillyard, 1977).

To Sum Up

References

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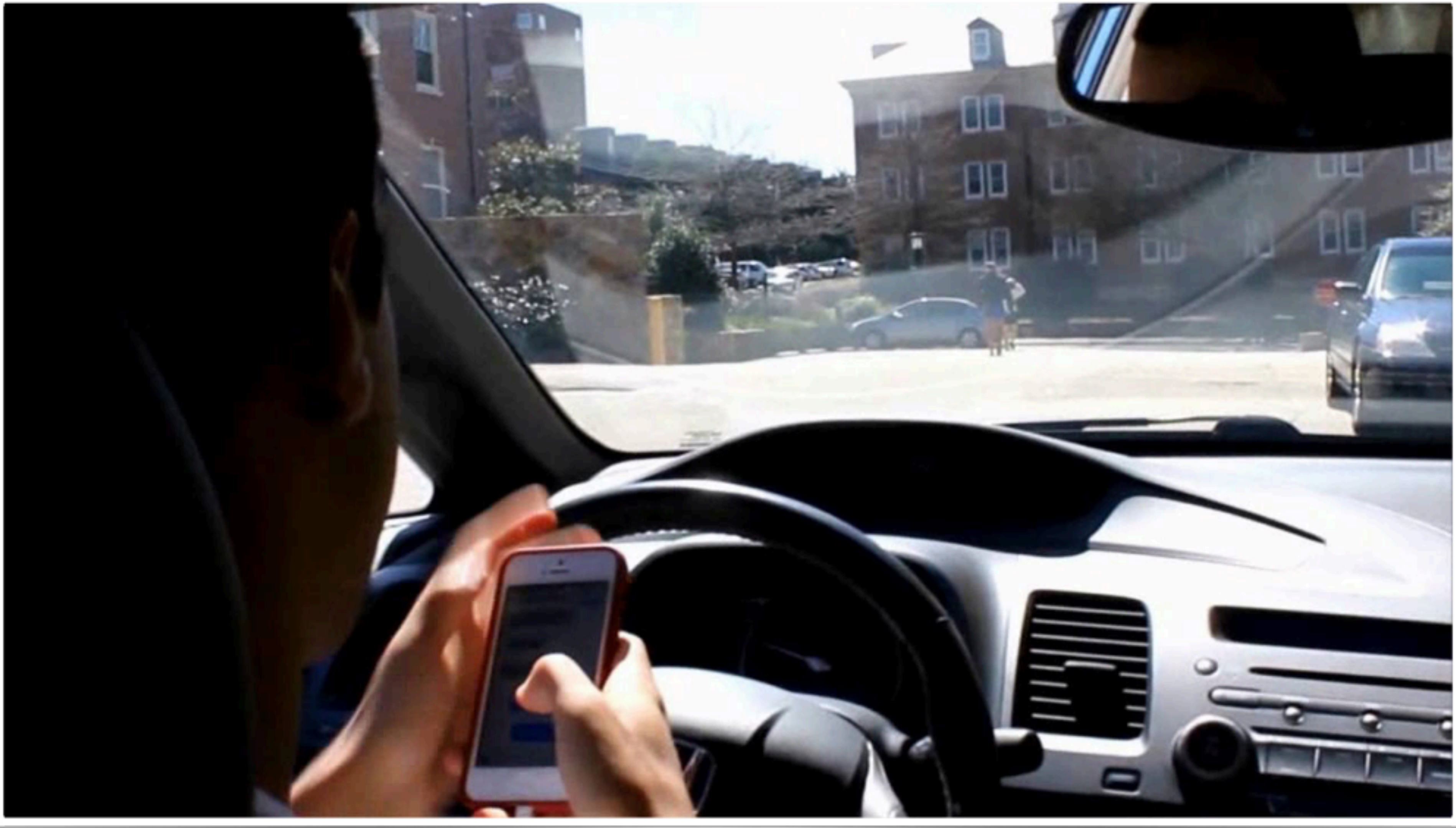
Lecture 26: Attention - III

Divided Attention



- **Investigating Divided Attention in the Lab**
  - One of the early works in the area of divided attention had participants view a videotape in which the display of a basketball game on the display of a hand slapping game.
  - Participants could successfully monitor one activity and ignore the other; but they had great difficulty in monitoring both activities at once; even if the basket ball game was watched by one eye & the hand - slapping game by the other eye (Neisser & Becklen, 1975).
  - Neisser & Becklen hypothesised that the improvement in performance would have occurred as a result of practice & also that the performance of multiple tasks was based on skill resulting from practice.

- the following year, investigators used a dual - task paradigm to study divided attention during the simultaneous performance of two activities: reading short stories and writing down dictated words (Spelke et al., 1976).

- the researchers would compare and contrast the response times and accuracy of performance in each of the three conditions.

- As expected, initial performance was quite poor for the two tasks, when they had to be performed at the same time.

- However, Spelke & colleagues had their participants practice to perform these two tasks 5 days a week for many weeks (85 sessions in all).

- To the surprise of many, the performance improved on both tasks after practice.

  - They showed improvements in their speed of reading and accuracy of reading comprehension, as measured by comprehension tests; also, they showed increases in their recognition memory for words they had written during dictation.

  - Eventually, participants performance on both tasks reached the same levels as when the participants had performed the tasks alone. They soon could perform both the tasks at the same time without a loss in performance.

- Speke and colleagues suggested that these findings showed that controlled tasks can be automatised so that they consume fewer attentional resources. Also, two discrete controlled tasks may be automatised to function together as a unit. However, they still continue to be intentional & conscious and involve high levels of cognitive processing.

- A rather different approach to study divided attention involves focussing on extremely simple tasks that require speedy responses.

- When people try to perform two overlapping speeded tasks, the responses for one or both tasks are almost always slower (Pashler, 1994).

- When a second task begins soon after the first task has started, speed of performance usually suffers; the slowing resulting from simultaneously engagement in speeded tasks; called the *psychological refractory period* effect, also called attentional blink.

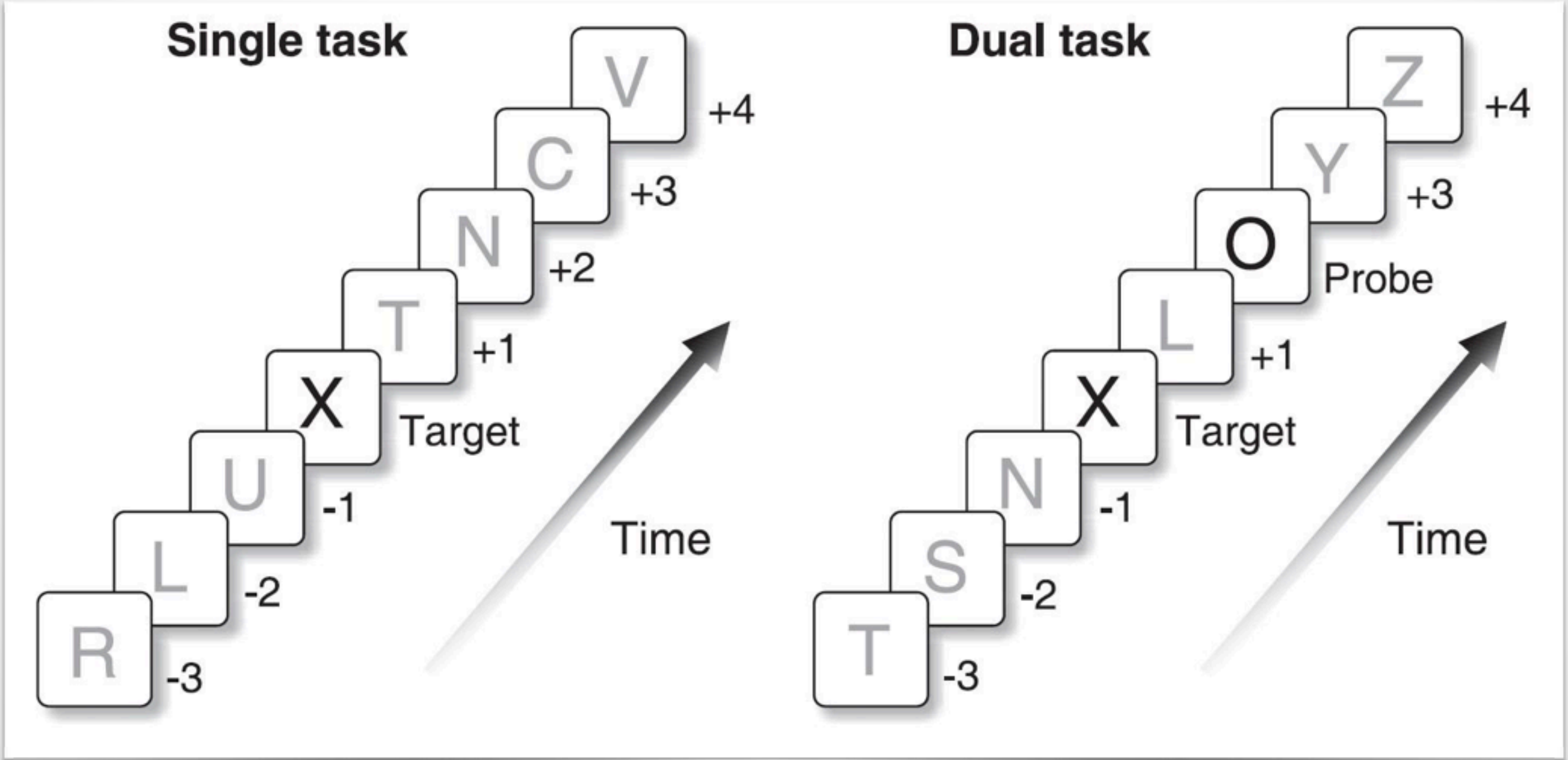


Image: Amador-Campos, Casanova, Bezerra, Torro-Alves & Sanchez (2015). Attentional Blink in Children With Attention deficit Hyperactivity Disorder. *Revista Brasileira de Psiquiatria. 37 (2).*

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- However, they cannot readily accomplish more than one cognitive task requiring them to choose a response, retrieve information from memory, or engage in various other cognitive operations; one or both the tasks will show the PRP effect.

- **Theories of Divided Attention**
  - a number of researchers have developed capacity models of attention to understand our ability to divide our attention.
  - these models explain how we can perform more than one attention - demanding task at a time. they posit that people have a fixed amount of attention that they can choose to allocate according to what the task requires.
  - there are two different kinds: one kind of model suggests that there is one single pool of attentional sources that can be divided freely, and the other model suggests that there are multiple sources of attention.

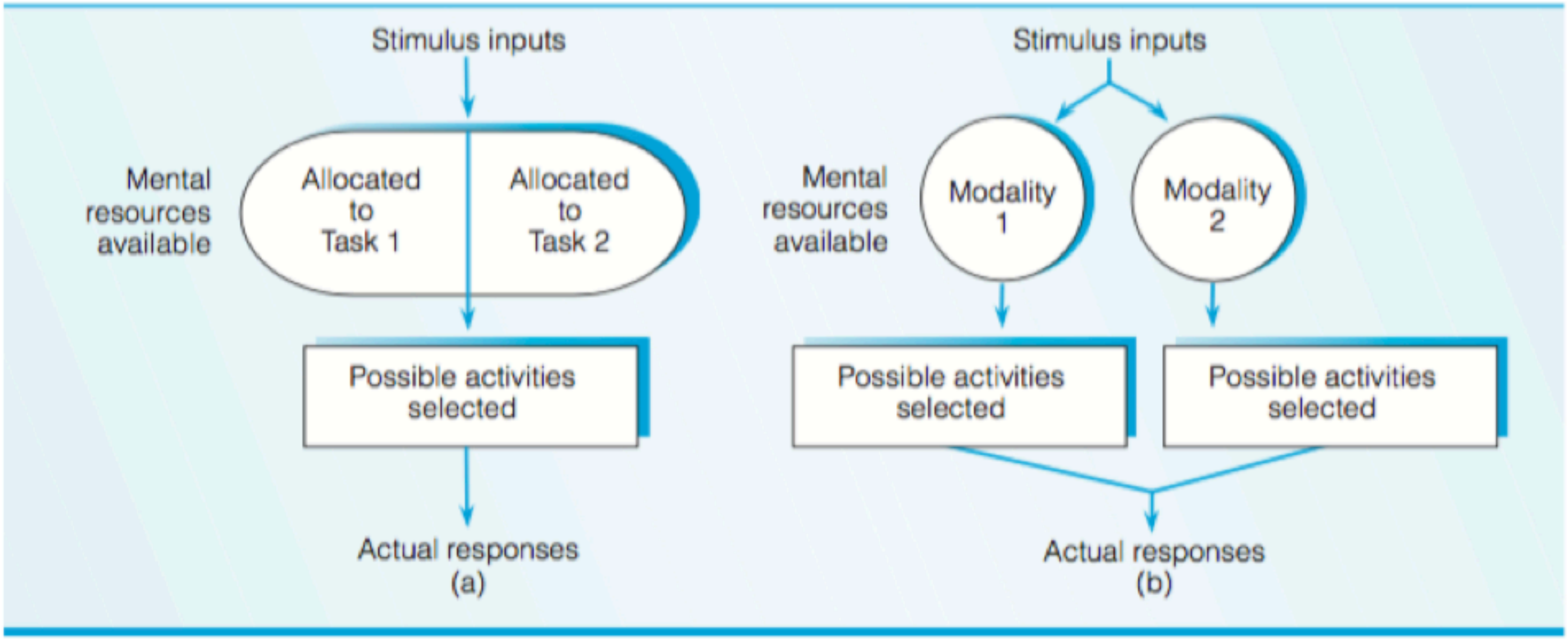

Figure 4.11 **Allocation of Attentional Resources.**
Attentional resources may involve either a single pool or a multiplicity of modality-specific pools. Although the attentional resources theory has been criticized for its imprecision, it seems to complement filter theories in explaining some aspects of attention.

Image: Sternberg & Sternberg (2011). Cognitive Psychology. *Wadsworth Publishing*. 6th Ed.(p. 156)

- it now appears that such models represent an oversimplification.
- people are much better at dividing their attention when competing tasks are in different modalities. at least some attentional resources may be specific to the modality (e.g. verbal or visual) in which a task is presented. for example: most people easily can listen to music and concentrate on writing simultaneously (the two being different tasks modality - wise).

- But it is harder to listen to the news station and concentrate on writing at the same time. because both are verbal tasks.

- Similarly two visual tasks are more likely to interfere with each other than are a visual task coupled with an auditory one.

- attentional resources theory has been criticized heavily as being overly broad & vague (Navon, 1984).

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- Acc. to this metaphor, as each of the complex tasks becomes increasingly automatized, performance of each task makes fewer demands on limited capacity attentional resources.

- **Factors that Influence Our Ability to Pay Attention**
    - There are many other variables that have an impact on our ability to concentrate and pay attention:
        - **Anxiety:** Being anxious, either by nature (trait - based anxiety) or by situation,(state - based anxiety) places constraints on attention (Reinholdt - Dunne et al., 2009).
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- **Alerting:** Alerting is defined as being prepared to attend to some incoming event, and maintaining this attention. Alerting also includes the process of getting to this state of preparedness.
    - The brain areas involved in alerting are the right frontal and parietal cortices as well as the locus coeruleus. The neurotransmitter norepinephrine is involved with the maintenance of alertness. If the alerting system does not work properly, people may develop symptoms of ADHD; in the process of regular raging dysfunctions of the alerting system may develop as well.

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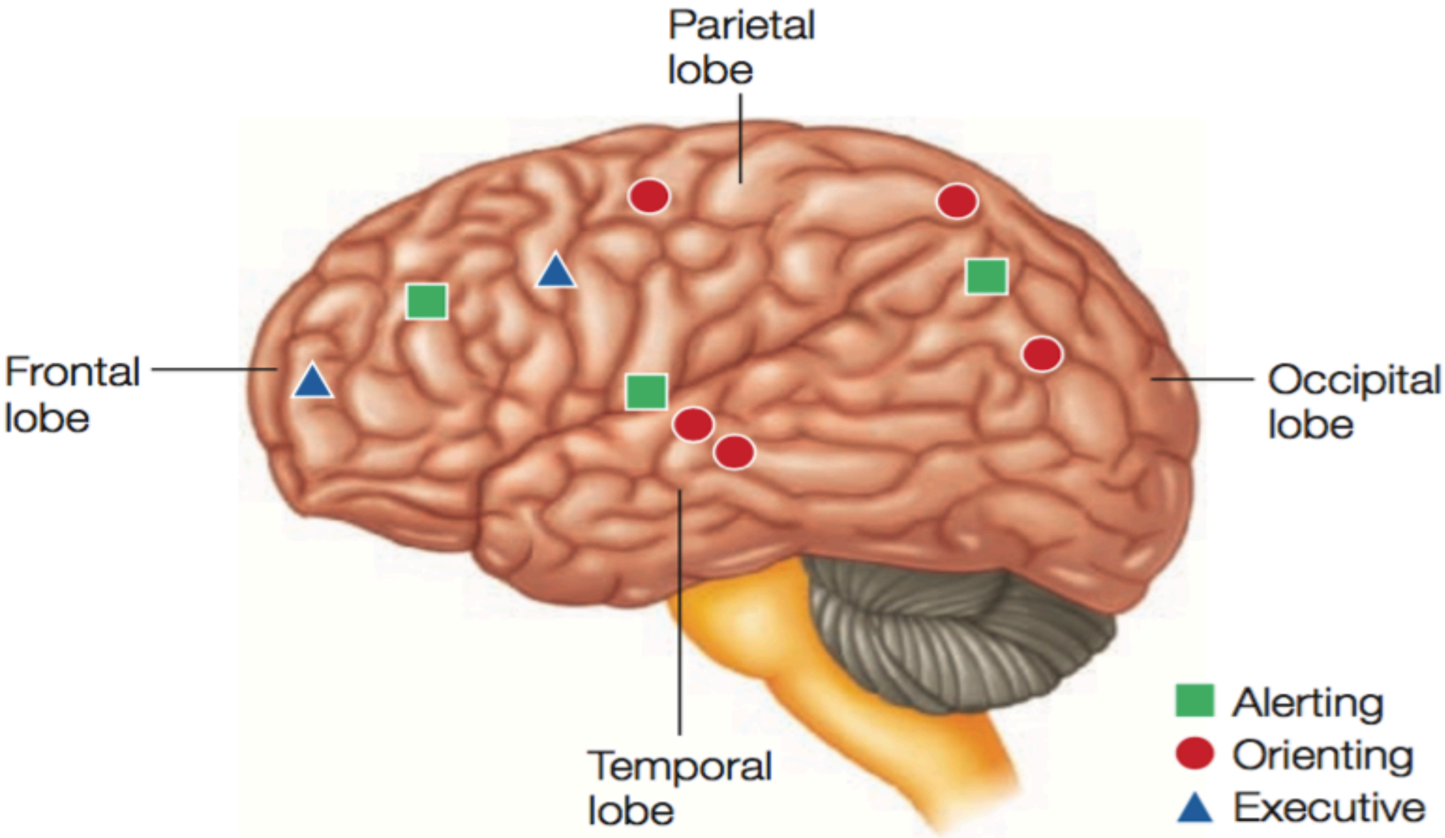

FIGURE 4.39 **Areas that are associated with different kinds of attention.** (Source: From M. I. Posner & M. K. Rothbart, "Research on Attention Networks as a Model for the Integration of Psychological Science," *Annual Review of Psychology, 58,* 1–23, Figure 2, p. 6, 2007. Reprinted by permission.)

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Distractions While Driving

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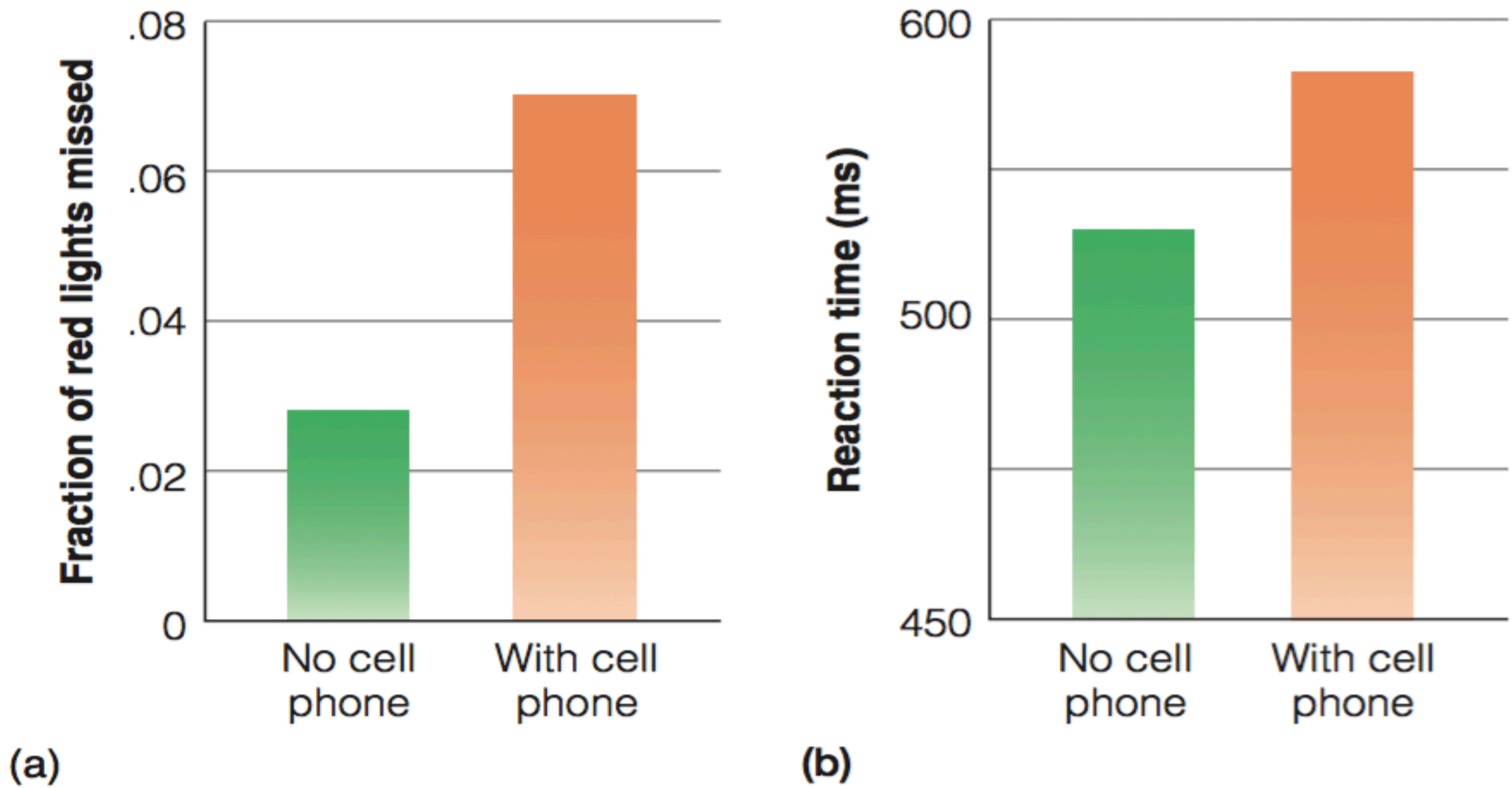

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Lecture 26: Attention - III

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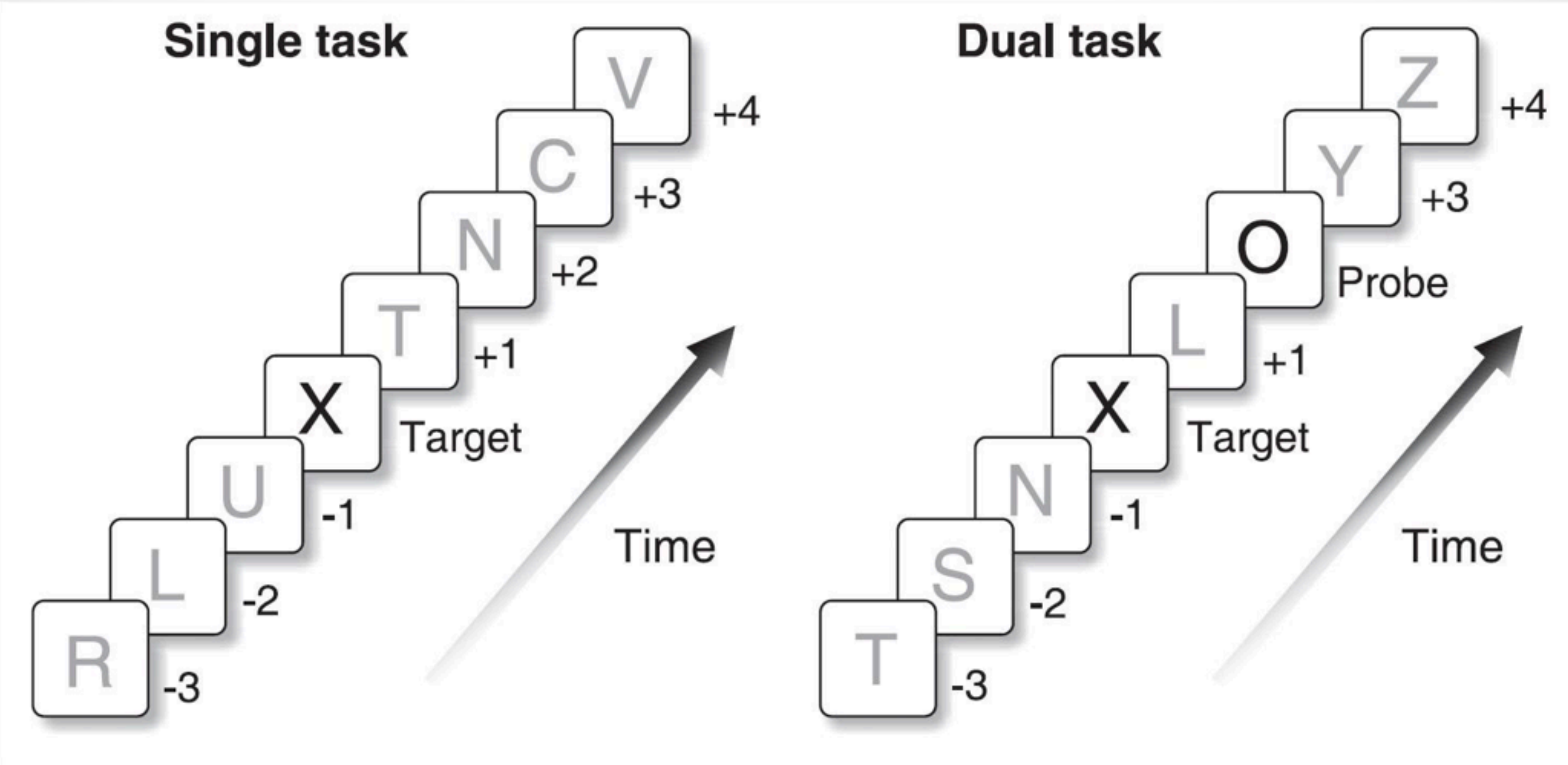

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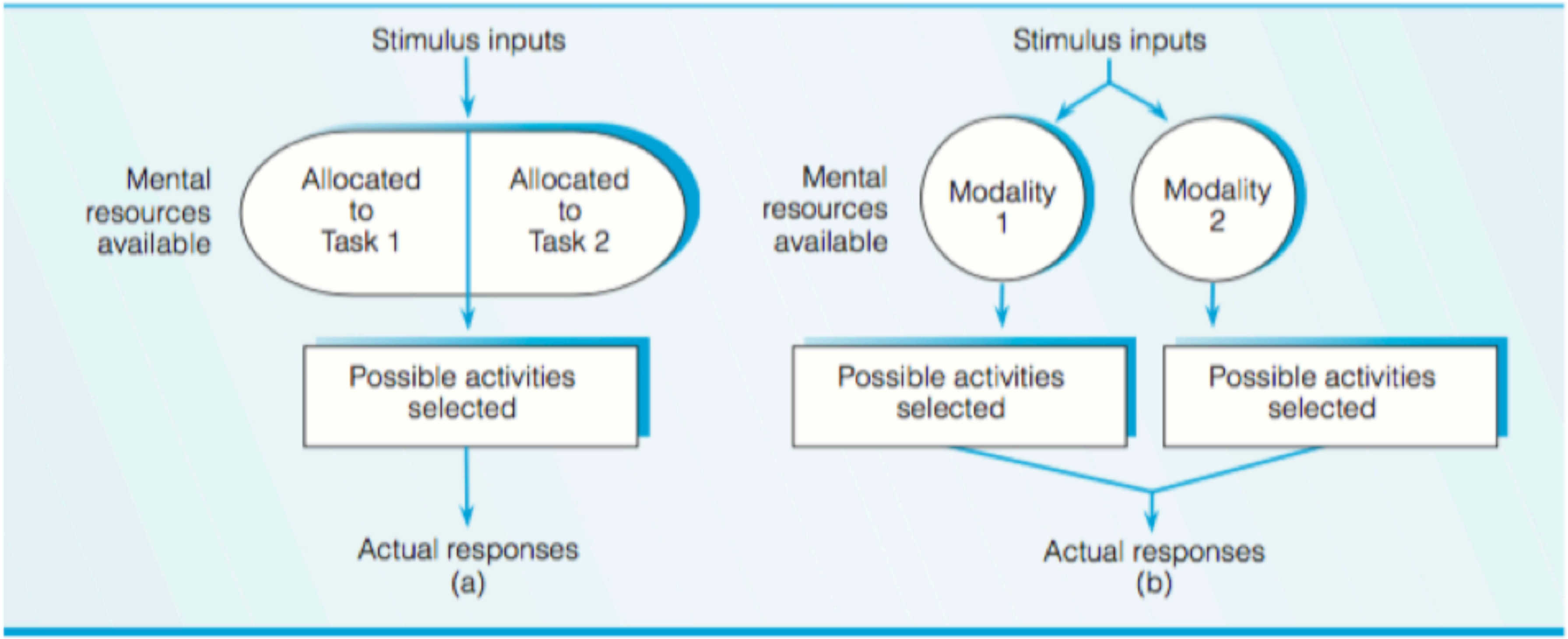

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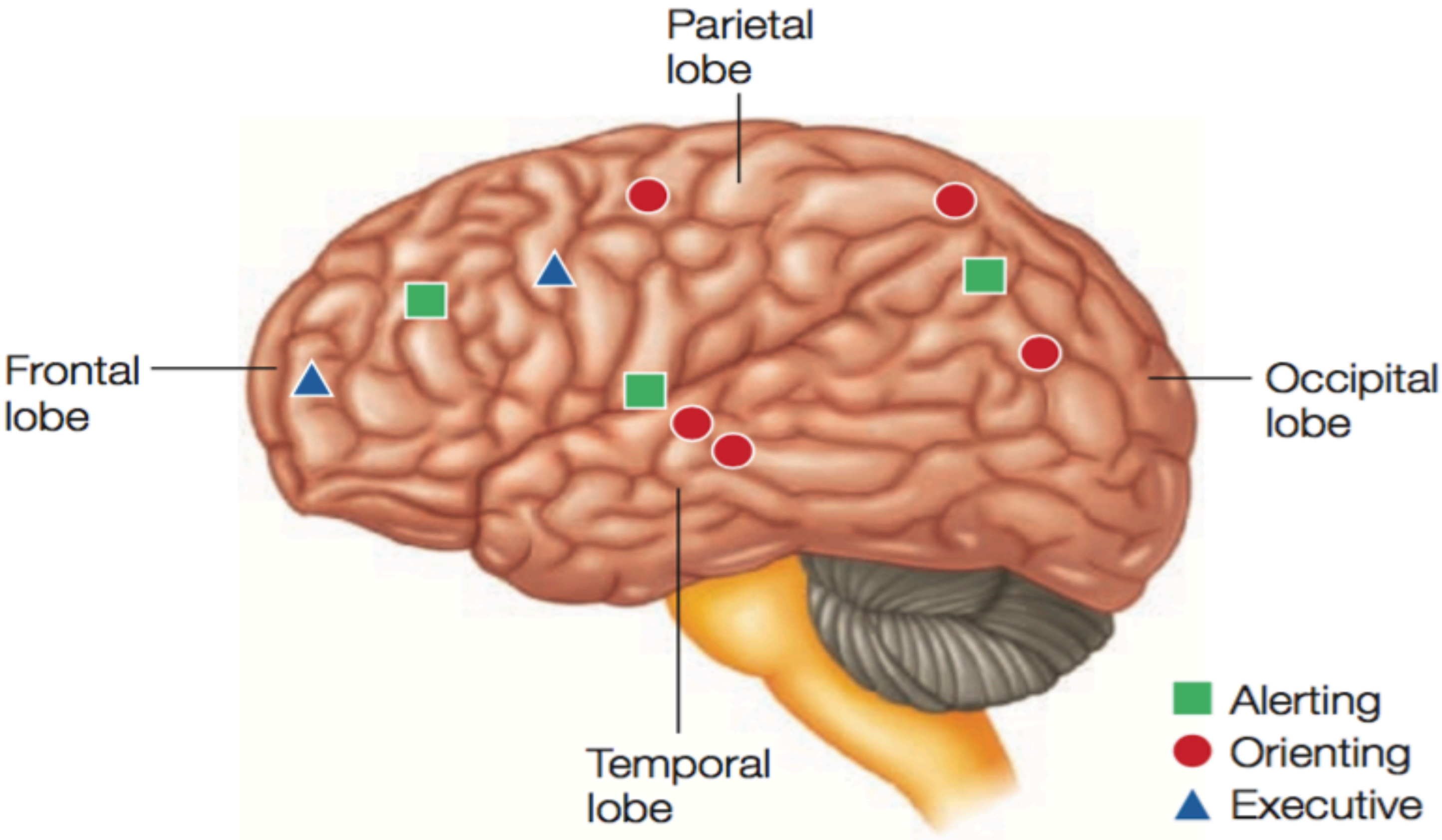

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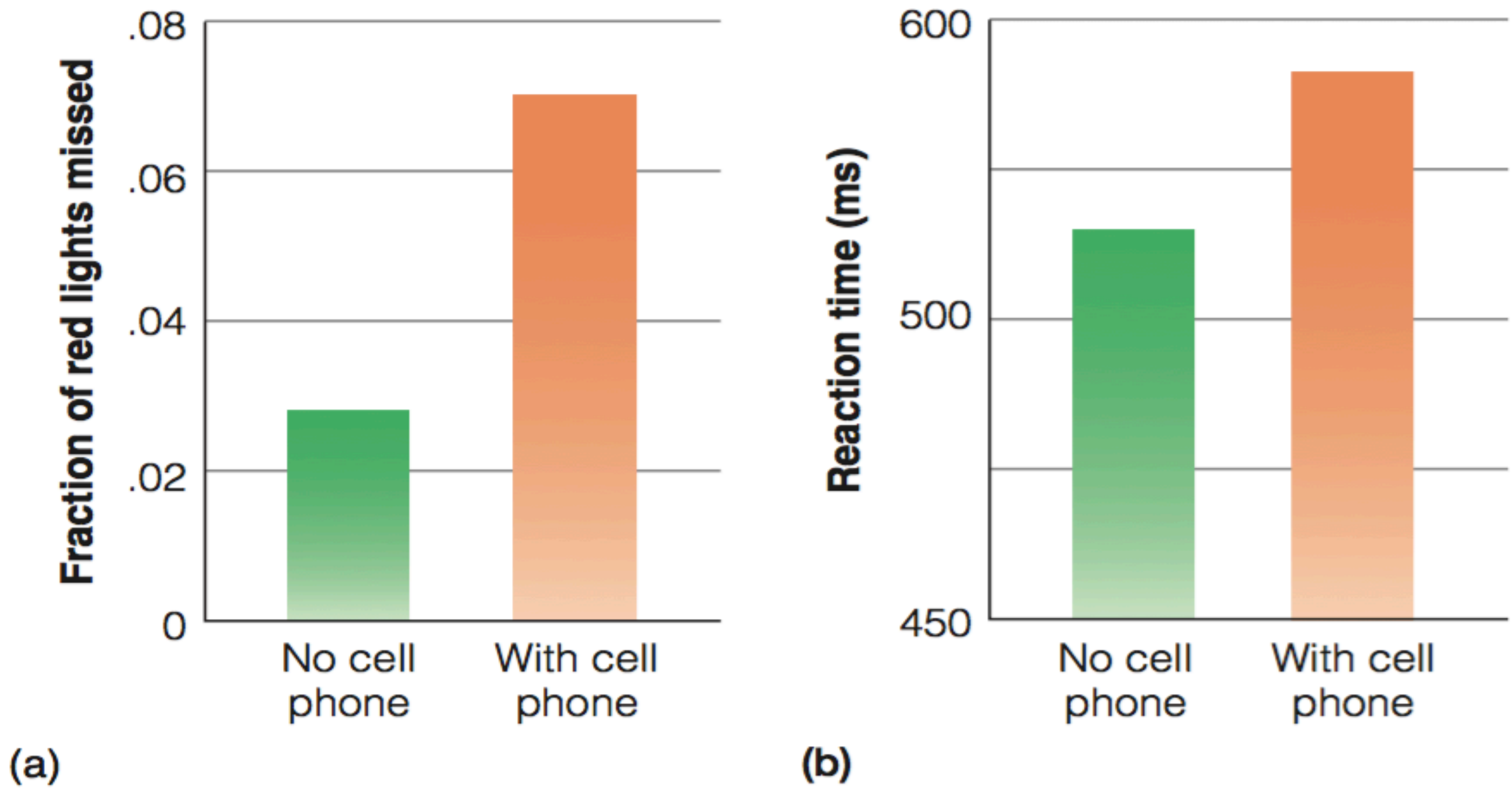

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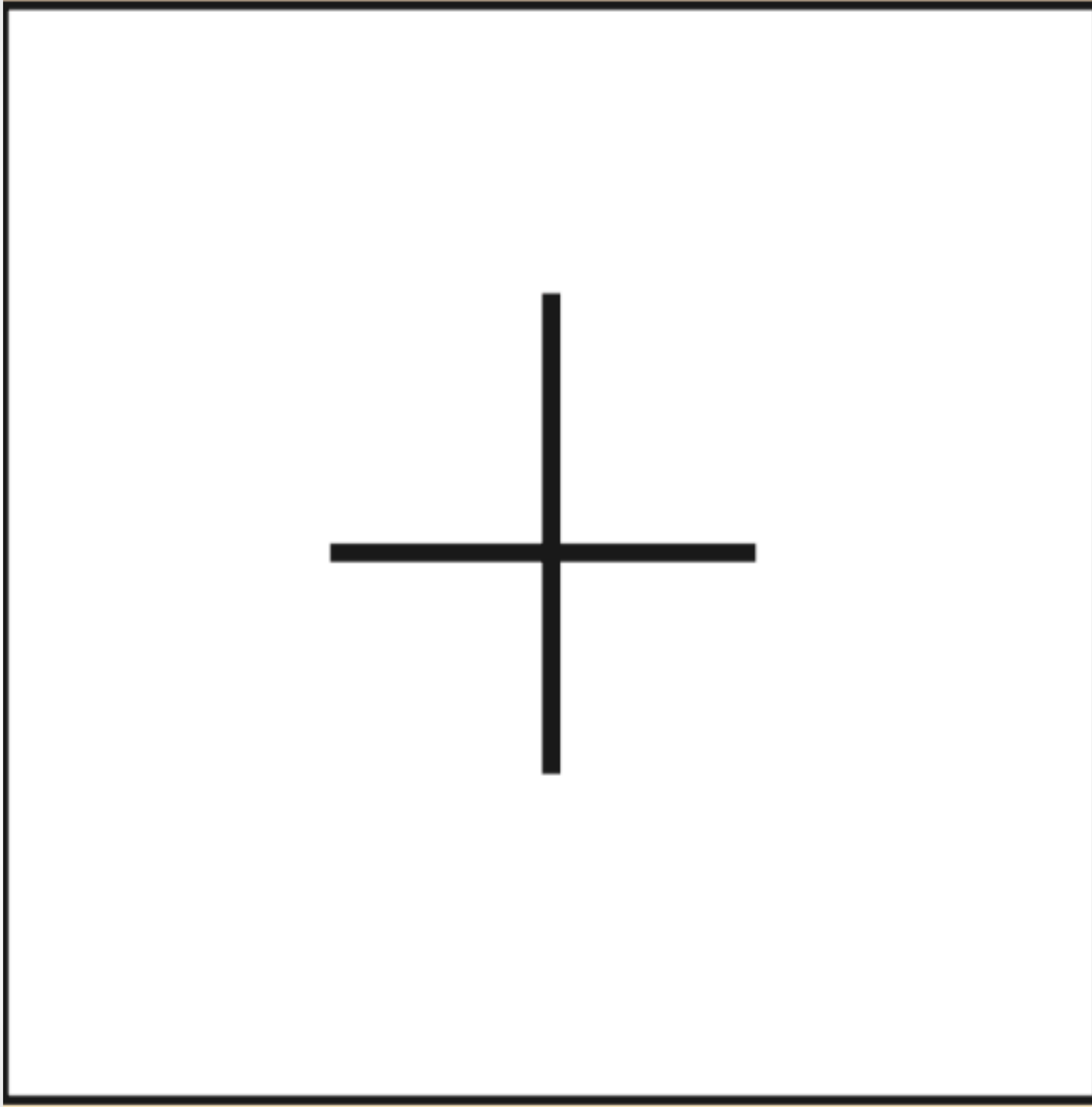
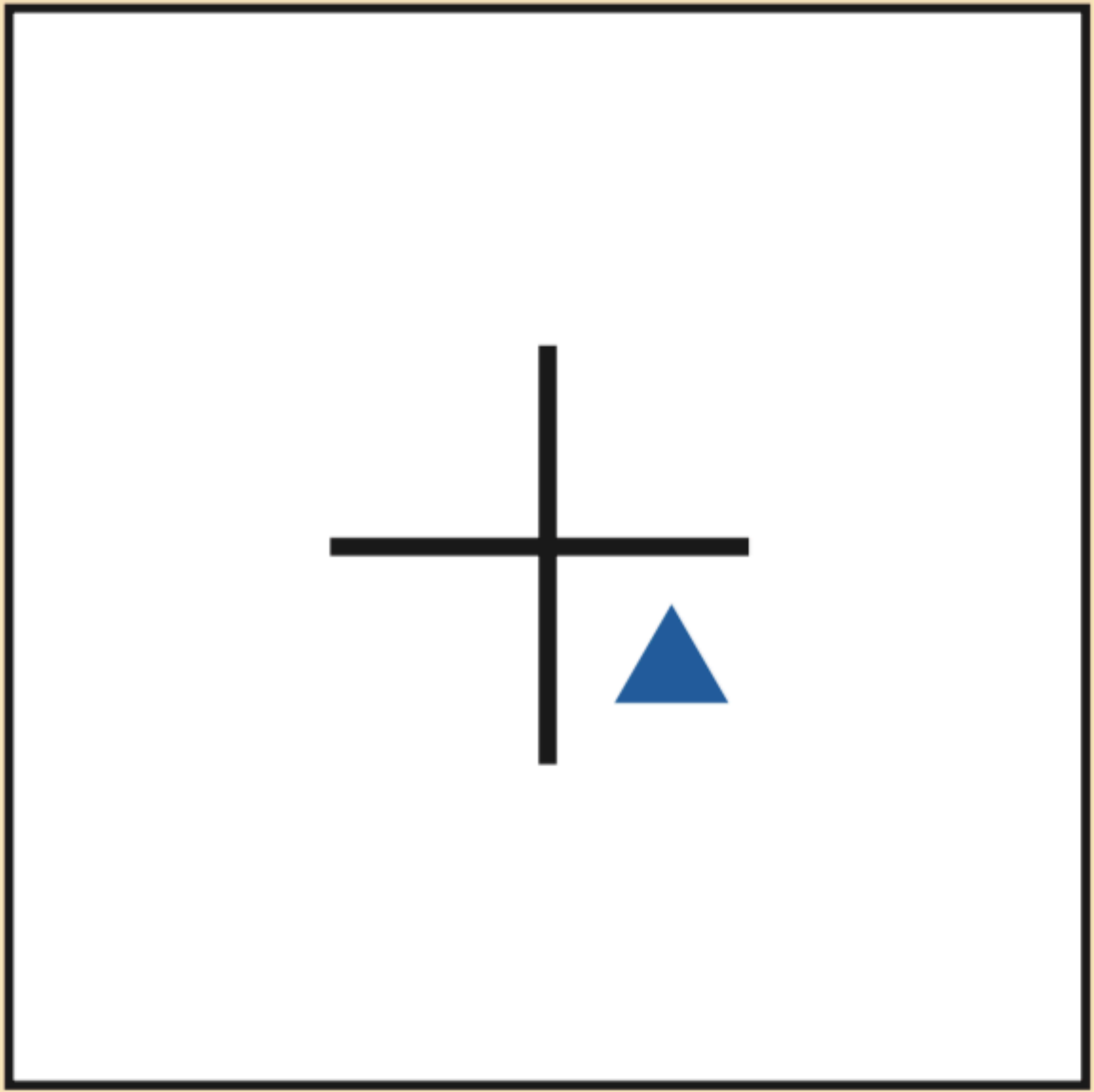
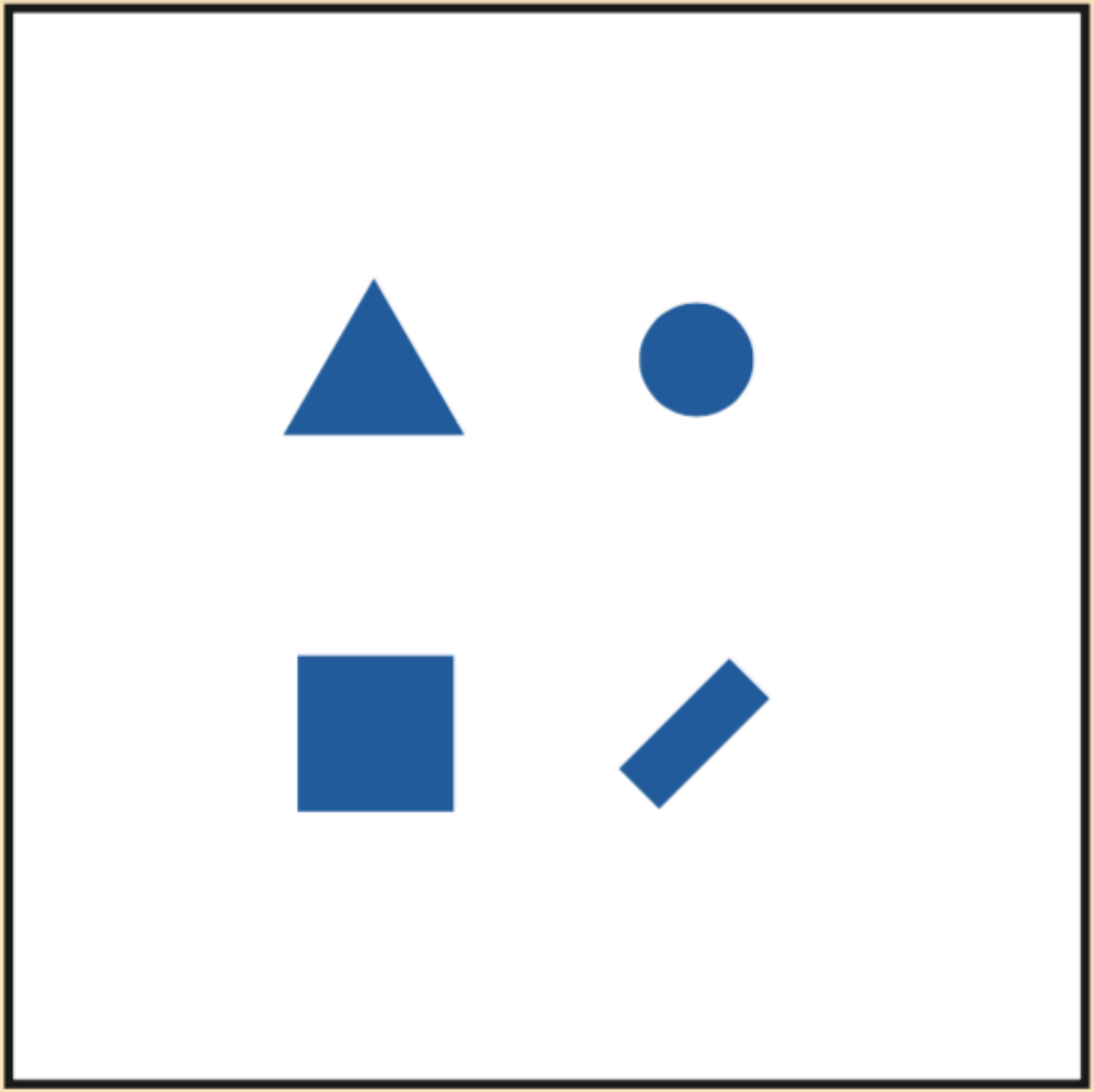
Lecture 27: Attention - IV

Attention and Visual Perception

- **Inattentional Blindness:** Mack & Rock (1998) created a situation in which a person's attention is focused on one task and then determined whether the person perceived an easily visible nearby stimuli.
- The observer's task was to indicate which arm of the cross was longer, the horizontal arm or the vertical arm.
- Then, on one trial, a small test object, which was within the observer's field of clear vision, was added to the display.
- When observers were then given a recognition test in which they were asked to pick the object that had been presented, they were unable to do so.







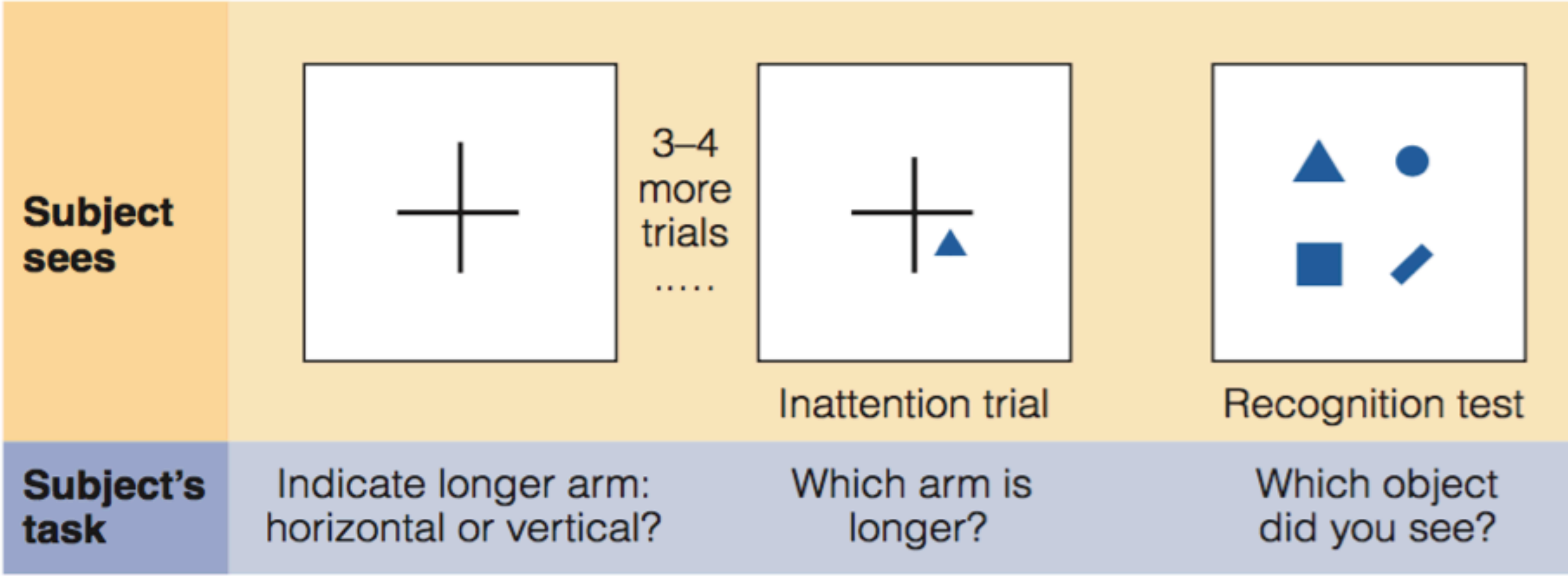


FIGURE 4.17 Inattentional blindness experiment. (a) On each trial, participants judge whether the horizontal or vertical arm is longer. (b) After a few trials, the inattention trial occurs, in which a geometric object is flashed along with the arms. (c) In the recognition test, the participant is asked to indicate which geometric object was presented. (Source: From E. B. Goldstein, *Sensation and Perception*, 8th ed., Fig. 6.9, p. 139. Copyright © 2010 Wadsworth, a part of Cengage Learning. Reproduced with permission. www.cengage.com/permissions.)

Image: E. B. Goldstein, *Cognitive Psychology_ Connecting Mind, Research and Everyday Experience.* Wadsworth Publishing. 3rd Ed. Fig. 4.17., (p. 95)

- Paying attention to the vertical and horizontal arms apparently made observers “blind” to the unattended test object. The phenomenon is termed **inattentional blindness.**

- Mack & Rock demonstrated inattention blindness using rapidly flashed geometrical stimuli; but other research has shown that similar effects can be achieved in more natural scenarios as well.

- Simons & Chabris (1999) created a situation in which one part of a scene is attended and the other is not. They created a 75 second film that showed two teams of 3 players each; & the one in white passing a basketball around. The other dressed in black was not handling the ball.

- Observers were told to count the number of passes, a task that focused their attention on the team in white.

- After about 45s, an event that took 5 seconds occurred, i.e. one of these events was a person dressed in a gorilla suit, walking through the scene.
- After seeing the video, observers were asked whether they had seen anything unusual happen or whether they see more than six players.
- Nearly half - 46% - of the observers failed to report having seen the event, even though it was clearly visible.

● **FIGURE 4.18** Frame from the film shown by Simons and Chablis in which a person in a gorilla suit walked through the "basketball" game. (Source: D. J. Simons & C. F. Chabris, "Gorillas in Our Midst: Sustained Inattentional Blindness for Dynamic Events," *Perception, 28,* 1059–1074, 1999. Figure provided by Daniel Simons.)

Image: E. B. Goldstein, *Cognitive Psychology_ Connecting Mind, Research and Everyday Experience.* Wadsworth Publishing. 3rd Ed. Fig. 4.17., (p. 95)

Further ...

Bruce Goldstein

FIGURE 4.19 Look at this picture for about a second, cover it, and look at Figure 4.20 (at the top of the next page).

Image: E. B. Goldstein, *Cognitive Psychology_ Connecting Mind, Research and Everyday Experience.* Wadsworth Publishing. 3rd Ed. Fig. 4.17., (p. 96)

● **FIGURE 4.20** What is different in this picture?

Image: E. B. Goldstein, *Cognitive Psychology_ Connecting Mind, Research and Everyday Experience.* Wadsworth Publishing. 3rd Ed. Fig. 4.17., (p. 97)

- **Change Detection:** Could you detect the change in the picture?
    - Rensink & colleagues did a similar experiment; where the pictures were alternated in the same way until observers were able to determine what was different about the two pictures and found that the pictures had to be alternated back & forth a number of times before the difference was detected.
    - This difficulty in detecting changes in scenes is called **change blindness (Rensink, 2002).**
    - But when Rensink added a cue indicating which part of the scene had been changed, participants detected the changes much more quickly (Rensink, 2002).

- It’s not always we miss out on such changes in the environment, there are cues to help us orient attention to such stimuli in the environment. These cues automatically attract our attention & increase the detection accuracy & speed.

- Automatic attraction of attention by a sudden visual or auditory stimulus is called **exogenous attention.**

- Attentional orientation that occurs when one consciously decides to scan the environment, to find a specific stimulus or just to track the environment is called **endogenous attention.**

- Both these types of attention can involve **overt attention**, i.e. shifting attention by moving the eyes (Carrasco, 2010).

Michael Ochs Archives/Getty Images

FIGURE 4.22 Find Bob Dylan's face in this group.

Image: E. B. Goldstein, *Cognitive Psychology_ Connecting Mind, Research and Everyday Experience.* Wadsworth Publishing. 3rd Ed. Fig. 4.17., (p. 99)

Overt Attention with Eye – Movements

- In order to look for Dylan's face, you would have had to move your eyes across the picture from face to face to see each one clearly.

- The shifting of eyes can be measured by using a device called an eye tracker, which tracks the movement of the eyes from one pint to another.

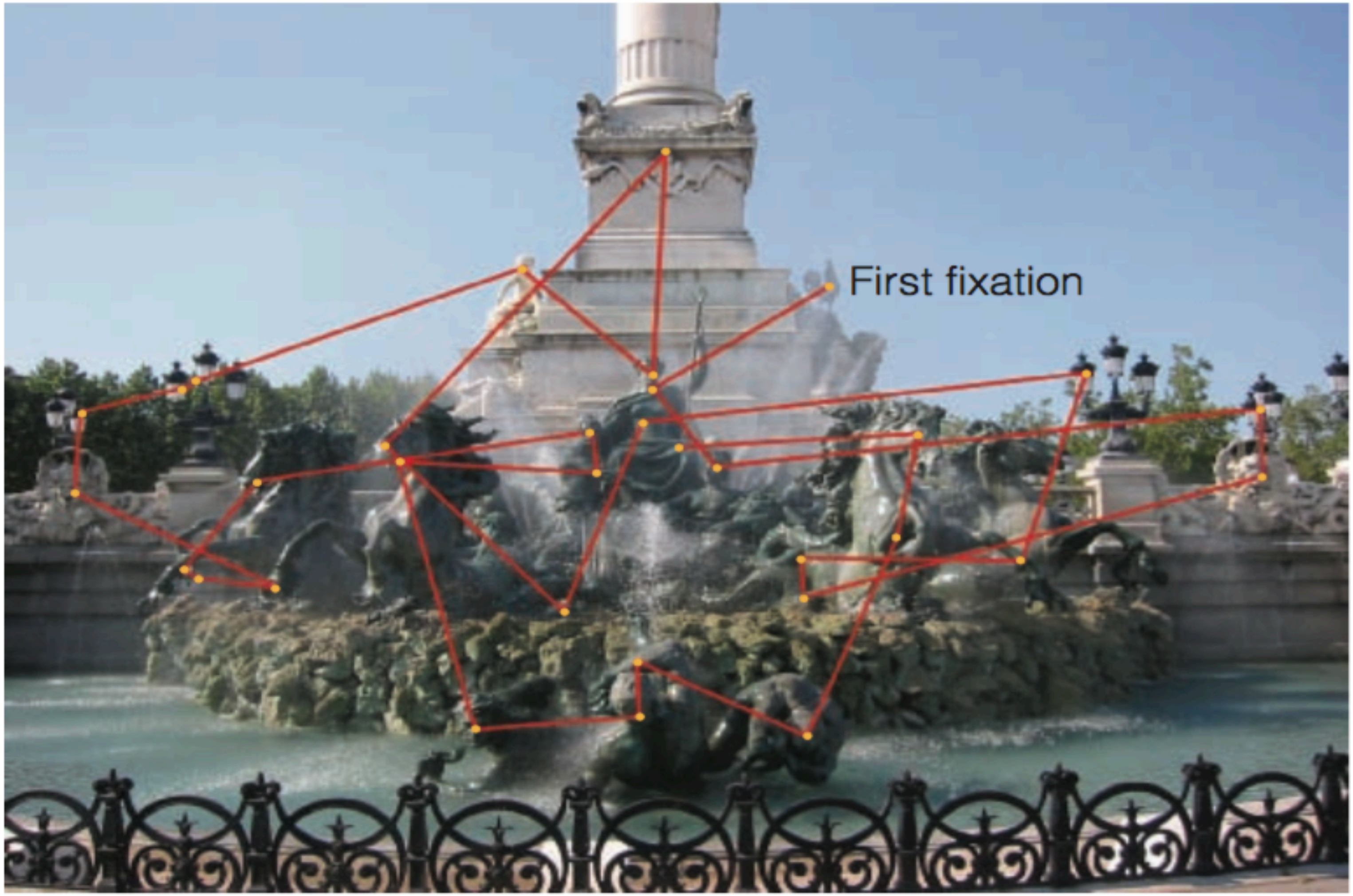


FIGURE 4.23 Scan path of a person viewing a fountain in Bordeaux, France.

Image: E. B. Goldstein, *Cognitive Psychology_ Connecting Mind, Research and Everyday Experience.* Wadsworth Publishing. 3rd Ed. Fig. 4.17., (p. 100)

- the small dots indicate **fixations**, places where the eyes briefly paused.
- the lines indicate **saccadic eye - movements**, i.e. movement of the eye from one fixation to the next.
- Typically, people make about 3 fixations per second when viewing an unfamiliar scene.

- Two kinds of factors determine how people shift their attention by moving their eyes:

  - **bottom - up,** based primarily on the physical characteristics of the stimulus &

  - **top - down,** based on the relation between the observer and the scene - i.e. what the person knows about the scene and the demands of a task that involves the objects in the scene.

- **Top - Down Determinants**

- **Scene Schemas -** an obserever's knowledge about what is contained in physical scenes.

    - For e.g. when Vo & Henderson (2009) showed observers pictures like the ones (next slide), observers looked longer at the printer than the pan.

Image: E. B. Goldstein, *Cognitive Psychology_ Connecting Mind, Research and Everyday Experience.* Wadsworth Publishing. 3rd Ed. Fig. 4.17., (p. 100)

Image: E. B. Goldstein, *Cognitive Psychology_ Connecting Mind, Research and Everyday Experience.* Wadsworth Publishing. 3rd Ed. Fig. 4.17., (p. 100)

- the fact that people look longer at things that seem out of place in a scene means that attention is being affected by their knowledge of what is usually found in the scene.

Covert Attention: Without Eye - Movements

- **Covert Attention** has been studies using a procedure called pre cueing, in which the participant is presented with a cue that indicates ahwer stimulus is most likely to appear.

- Pre cueing has been used to study two kinds of attention:

- **Location - Based Attention**: Michael Posner & colleagues were interested in answering the following question: Does attention to a specific location improve our ability to respond rapidly to a stimulus presented at that location?

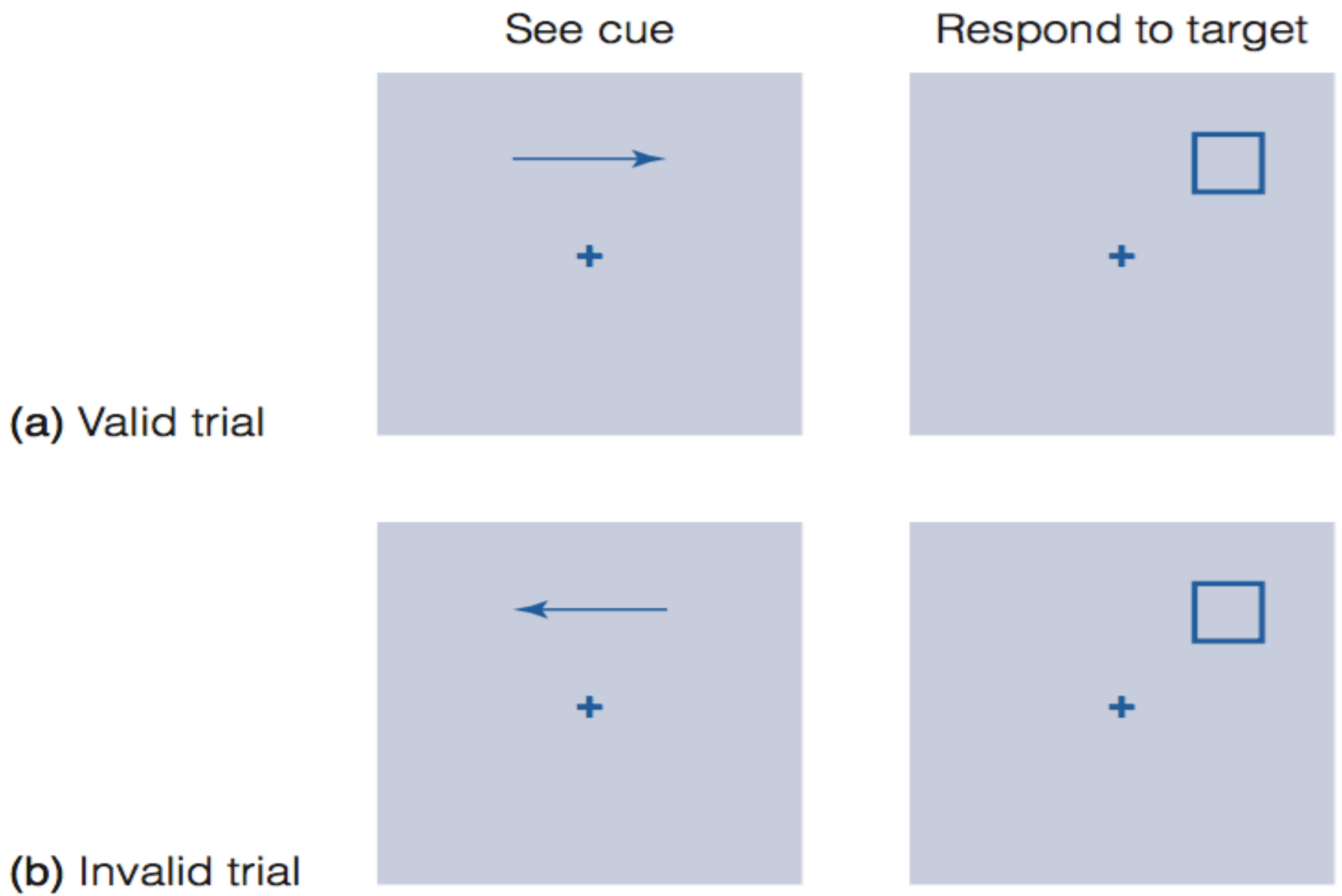


Image: E. B. Goldstein, *Cognitive Psychology_ Connecting Mind, Research and Everyday Experience.* Wadsworth Publishing. 3rd Ed. Fig. 4.17., (p. 102)

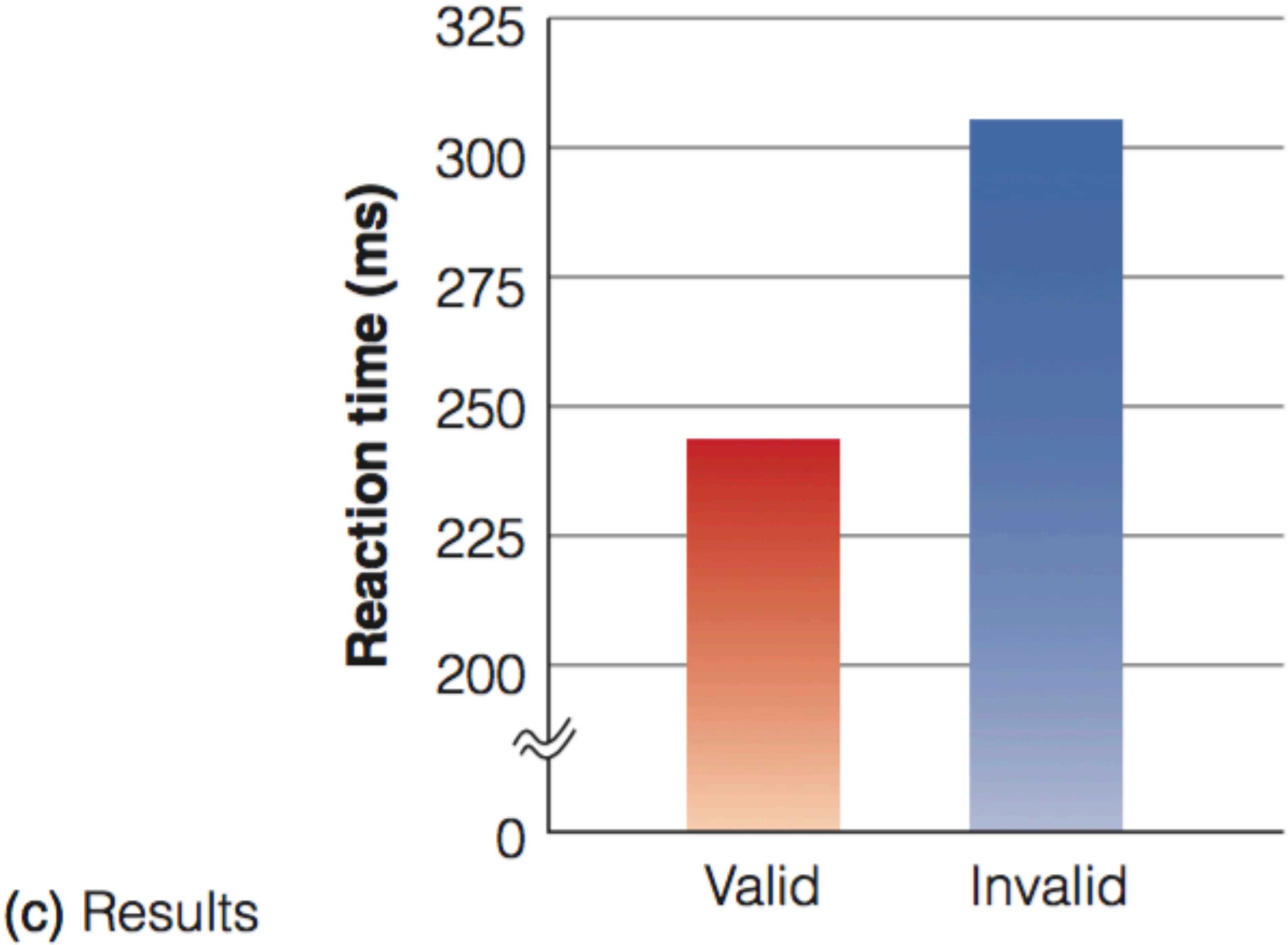


Image: E. B. Goldstein, *Cognitive Psychology_ Connecting Mind, Research and Everyday Experience.* Wadsworth Publishing. 3rd Ed. Fig. 4.17., (p. 102)

- The results of the experiment indicate that observers reacted more rapidly on valid trials than on invalid trials, leading to the conclusion that information processing is more effective at the place where attention is directed.

- These & similar results gave rise to the idea that attention is like a spotlight lens that improves processing when directed towards a particular location (Marino & Scholl, 2005).

- **Object - Based Attention:** Experiments have also shown that attention can also be associated with specific objects.

- Experiments studying object - based attention have shown that when attention is directed to one place on an object, the enhancing effect of this attention spreads throughout the object..

    - For e.g. Egly et al., (1994) asked participants to keep their eyes on the +, then one end of the rectangle was briefly highlighted.

- This was the cue signal that indicated where a target, a dark square would appear.

- The participant's task was to press a button when the target appeared anywhere on the display.

- Reaction Times were fastest when the target appeared where the cue signal predicted it would appear.

- However, the most important finding is that participants responded faster when the target appeared within the same rectangular object location B than when it appeared at another location C. Note that B & C are same distance from A.

- Apparently, the enhancing effect of attention had spread within the rectangle, so even though the cue was at A, some enhancement occurred at B as well, this is the **same object advantage.**

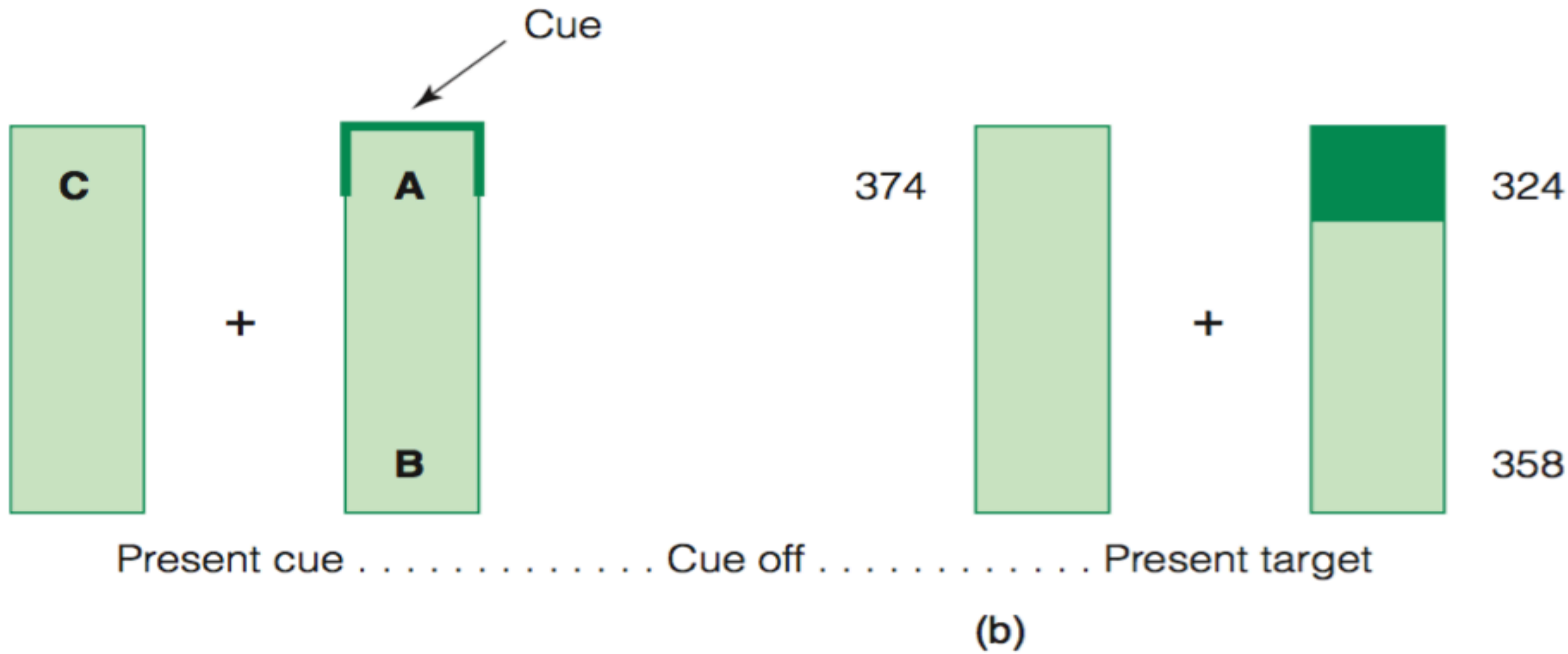
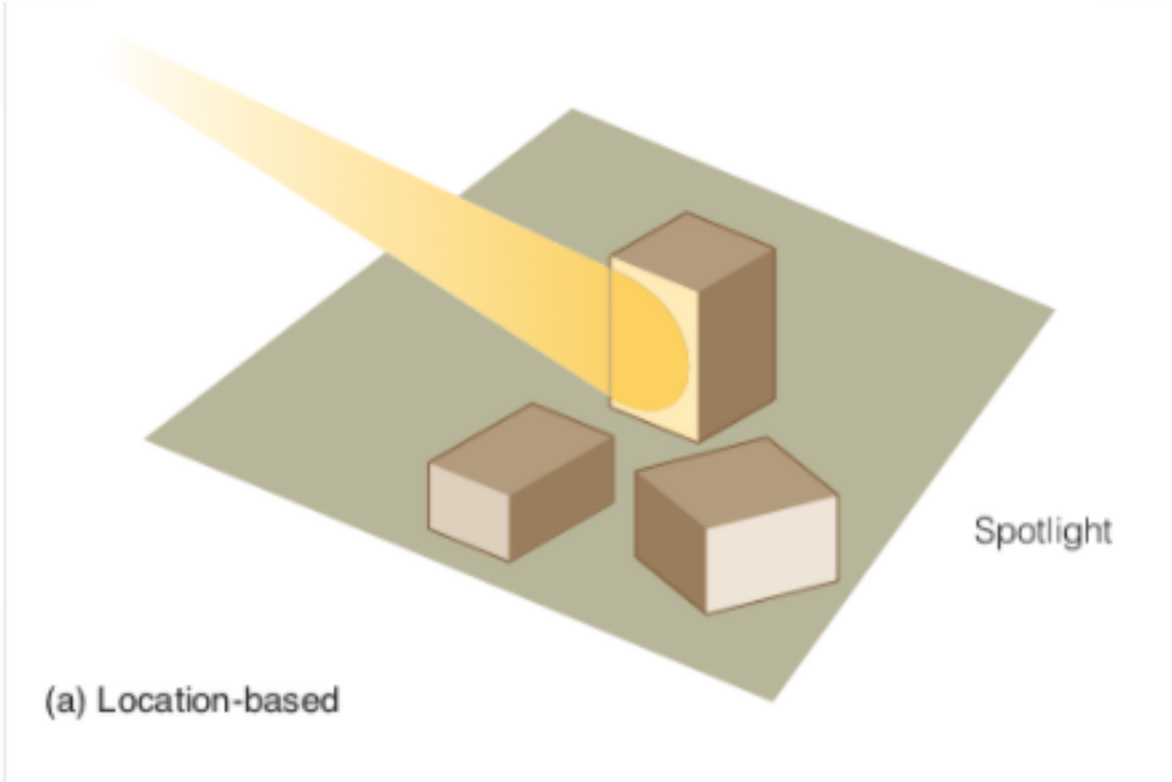


FIGURE 4.29 Stimuli for Egly et al.'s (1994) object-based attention experiment. (a) The cue signal, darkened lines, appears at the top or bottom of one of the rectangles to indicate where the target will probably appear. The letters were not present in the display viewed by participants. (b) The target, a darkened square, appears at one end of one of the rectangles. Numbers indicate how long it took, in milliseconds, to respond to targets presented at positions A, B, and C when the cue had appeared at position A.

Image: E. B. Goldstein, *Cognitive Psychology_ Connecting Mind, Research and Everyday Experience.* Wadsworth Publishing. 3rd Ed. Fig. 4.17., (p. 103)

Location and Object Based Attention



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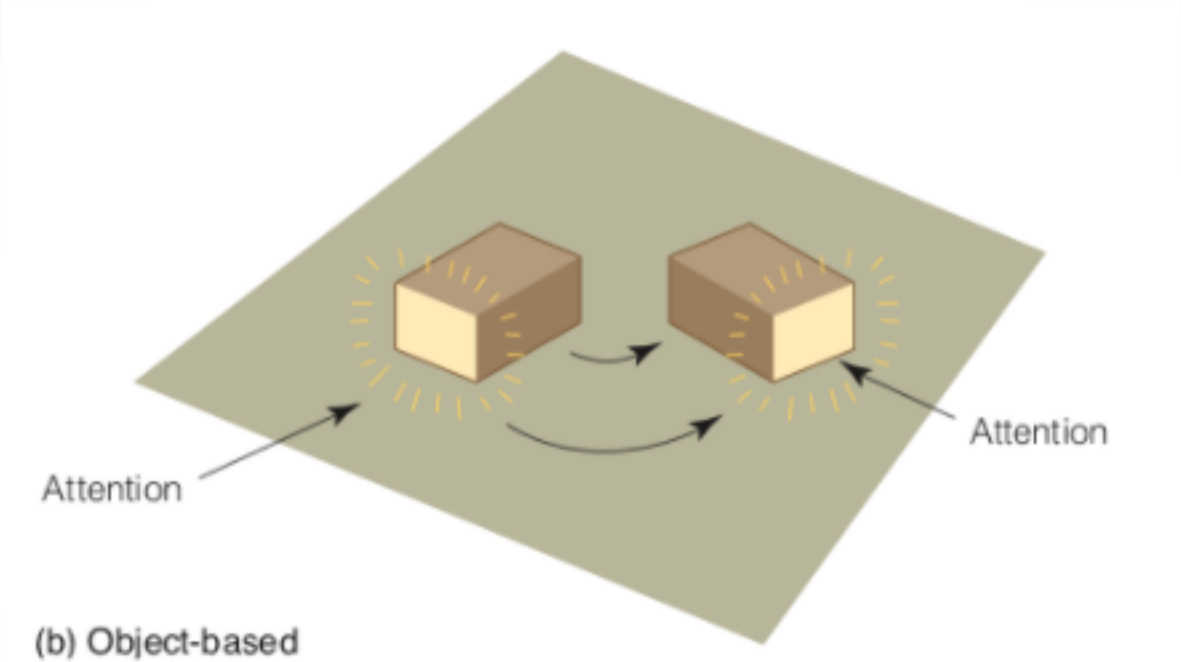

Image: E. B. Goldstein, *Cognitive Psychology_ Connecting Mind, Research and Everyday Experience.* Wadsworth Publishing. 3rd Ed. Fig. 4.17., (p. 103)

To Sum Up

References

- E.B. Goldstein (2010). Cognitive Psychology Connecting Mind, Research and Everyday Experience. *Wadsworth Publishing. 3rd Ed.*

Indian Institute of Technology
Kanpur

In Collaboration
with

National Program on Technology Enhanced Learning (NPTEL)

Presents

Course Title:

Basic Cognitive Processes

By: Dr. Ark Verma,
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Lecture 29: Memory - I

Memory

"Has it ever struck you…that life is all memory, except for the one present moment that goes by so quickly you hardly catch it going? It's really all memory except for each passing moment." – Tennessee Williams

- What is Memory?
    - memory is the processes involved in retaining, retrieving, & using information about stimuli, images, events, ideas, & skills after the original information is no longer present.

- An interestig case of Clive Wearing:

This feeling is made poignantly clear by Wearing's diary, which contains hundreds of entries like "I have woken up for the first time" and "I am alive" (• Figure 5.1). But Wearing has no memory of ever writing anything except for the sentence he has just written. When questioned about previous entries, Wearing acknowledges that they are in his handwriting, but because he has no memory of writing them, he denies that they are his. It is no wonder that he is confused, and not surprising that he describes his life as being "like death." His loss of memory has robbed him of his ability to participate in life in any meaningful way, and he needs to be constantly cared for by others.

Excerpt from: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & Everyday Experience. *Wadsworth Publishing*. 3rd Ed. (p.117).

- Let us try and structure memory:
  - Present (this moment, the moment just passed)
  - Past (that moment, that one)
  - Long Past (those moments that passed sometime back)

- Ok..make it simple:
  - Sensory + Short - term + Long - term Memory!!!

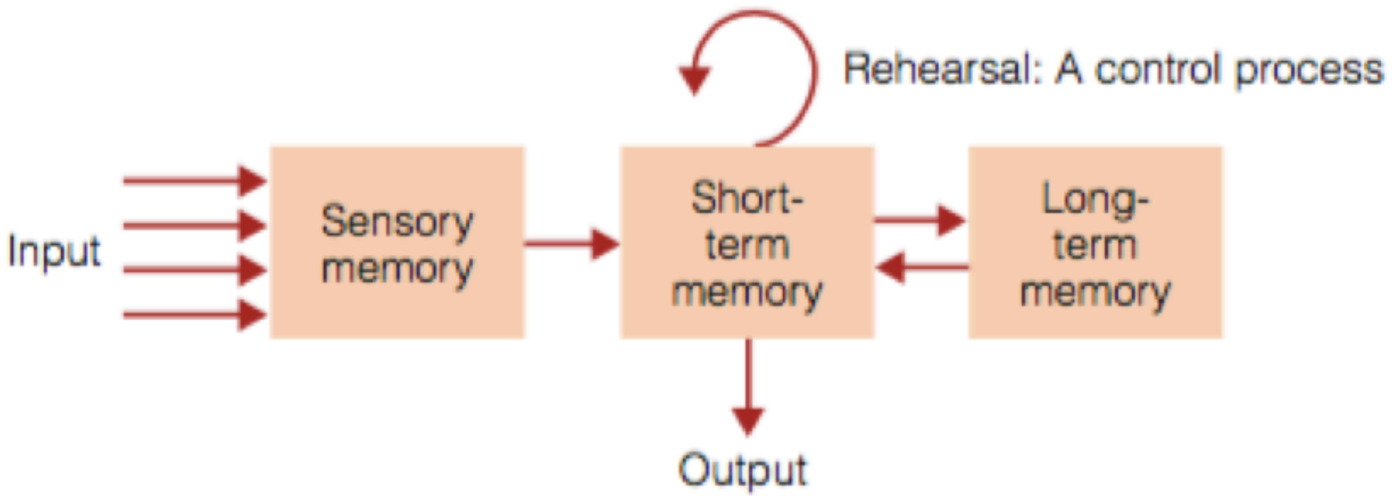


FIGURE 5.2 Flow diagram for Atkinson and Shiffrin's (1968) model of memory. This model, which is described in the text, is called the modal model because it contained features of many of the memory models that were being proposed in the 1960s.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. (p. 118)

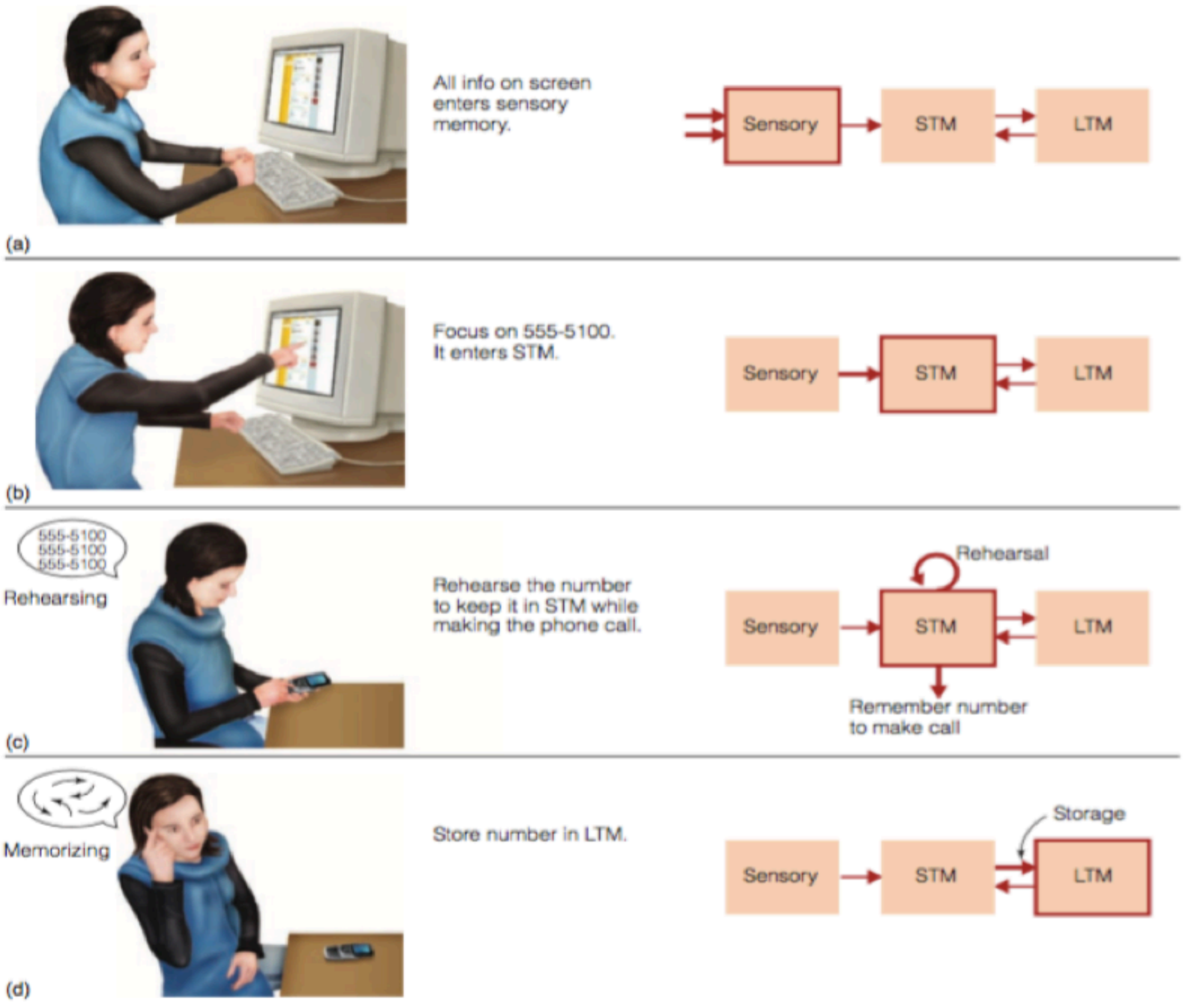
- Richard Atkinson & Richard Shiffrin (1968) proposed one of the earliest models in memory, called the **modal model of memory** because it included many of the features of memory models of the 1960s.

- This model became extremely influential and shaped research on memory for years.

- The stages in the model are called the **structural features.** They are:
  - *sensory memory* an initial stage that holds all incoming information for seconds or fractions of seconds.
  - *short - term memory* holds 5-7 items for about 15 - 30 seconds.
  - *long - term memory* can hold a large amount of information of information for years or decades.

- Atkinson & Shiffrin also described the memory system as including **control processes**, which are active processes that can be controlled by the person and may differ from one task to another. e.g. **rehearsal -** repeating a stimulus over and over, as one might repeat a telephone number in order to hold it in one's mind after looking it up in the phone book.

- let's see how it works…
  - if Rachel has to look up a pizzeria over internet to order Pizza.
  - when she first looks at the screen, all of the information that enters her eyes is registered in the **sensory memory**; she uses the control process of **selective attention** to focus on a number, so the number enter's **short term memory**.
  - She knows she might need the number again, so she decides that in addition to storing the number in her phone, she is going to memorise the number. the process she uses to memorise or store the number is called **encoding**.
  - a few days later, she wants to order Pizza again, so she **retrieves** the number again from long term memory.



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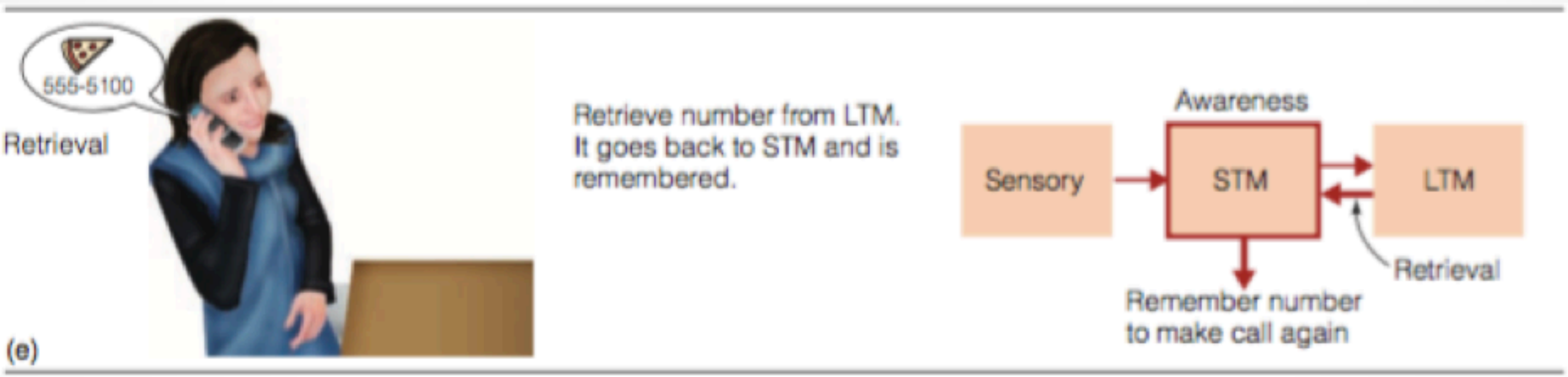

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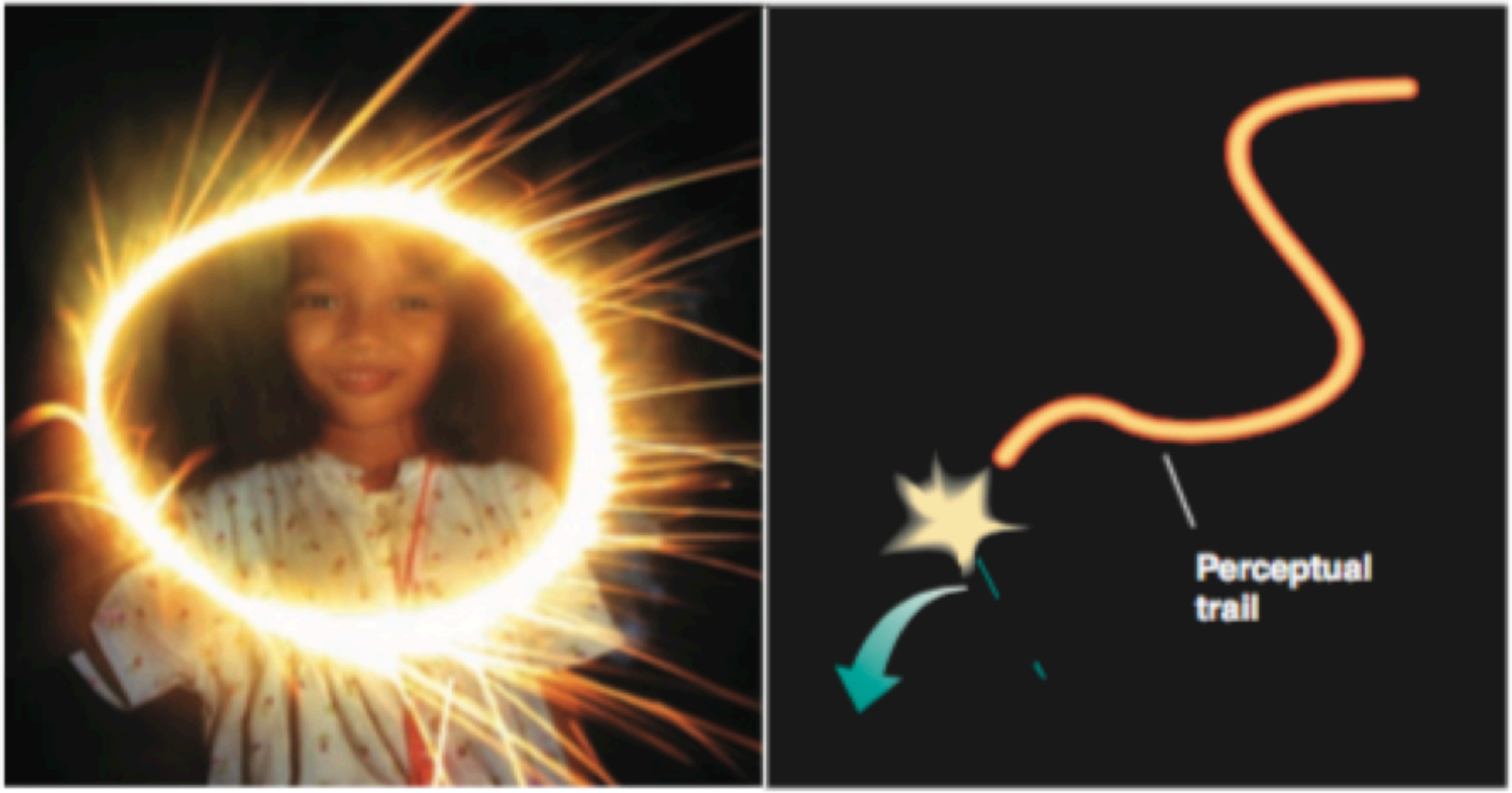
Sensory Memory

- Sensory Memory is the retention, for brief periods of time, of the effects of sensory stimulation. e.g. the moving sparkler & the experience of seeing a film.



BAZUKI MUHAMMAD/Reuters/Corbis

FIGURE 5.4 (a) A sparkler can cause a trail of light when it is moved rapidly. (b) This trail occurs because the perception of the light is briefly held in the mind.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. (p. 120)

- as you swing the sparkler through the air, creating a trail of light; you would realise that there is actually no light along this trail. The lighted trail for the most part, is a creation of your own mind. this retention of the perception of light in your mind is called the **persistence of vision**.

- Similarly, once you are watching a movie in a darkened theatre, you may see actions moving smoothly across the screen; but what is actually projected is quite different.

- first, a single frame is positioned in the front of the projector lens, and when the projector's shutter opens, the image on the film frame flashes on the screen. the shutter then closes, so the film can move to the next frame & during the time the screen is dark.

- when the next frame has arrived in front of the lens, the shutter reopens, flashing the next image on to the screen. this process is repeated rapidly, around 24 times per second; so 24 images are flashed on the screen every second separated by a brief period of darkness.

- a person viewing the film does not see the dark intervals between the images because the persistence of vision fills in the darkness by retaining the image of the last frame.

- Sperling’s Experiment!

    - George Sperling (1960) wondered *how much information* people can take in from briefly presented stimuli. He determined this in a famous experiment in which he flashed an array of letters, on the screen for 50ms and asked his participants to report as many of the letters as possible.

    - this part of the experiment used the **whole report method**; when participants were asked to report as many letters as possible from the whole matrix.

    - Given this task, participants were able to report an average of 4.5 letters out of the 12 letters.

- In the next version, Sperling devised the **partial report method**, i.e. he presented the matrix for 50 ms as before but sounded one of the following tones immediately after the matrix presentation, to indicate which row of letters the participants were to report:

- High Pitched: Top Row
- Medium Pitched: Middle Row
- Low Pitched: Bottom Row

- because the tones were presented after the letters were turned off, the participant's attention was directed not to the actual letters, which were no longer present but to whatever trace remind in the participant's mind after the letters were turned off.

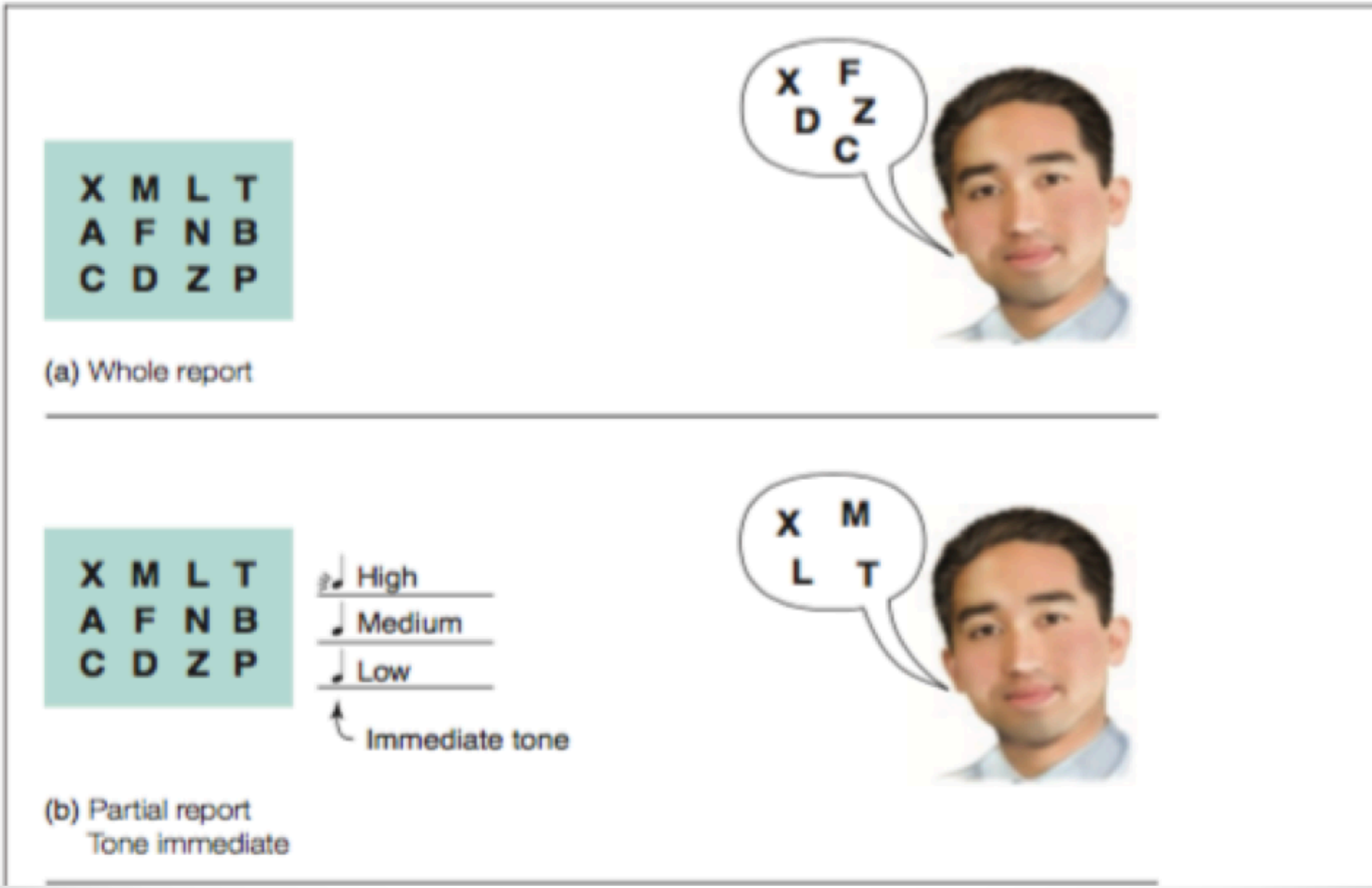


Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. (Fig. 5.5, p. 120)

- When the cue tones directed participants to focus their attention on one of the rows, they correctly reported an average of 3.3 of 4 letters in that row.
- Sperling concluded that the correct description of what was happening was that immediately after the display was presented, participants saw an average of 82% of letters in the whole display, but were not able to report all of these letters because they rapidly faded as the initial letters were being reported.

- Sperling then did an additional experiment to determine the time course of this fading.

- For this, Sperling devised a **delayed partial report method** in which the presentation of tones was delayed for a fraction of a second after the letters were extinguished.

- The result of the delayed partial report method wa that when the cue tones were delayed for 1 second after the flash, participants were able to report only slightly more than 1 letter in a row, the equivalent of about 4 letters for all three rows - the same number of letters they reported using the whole report method.

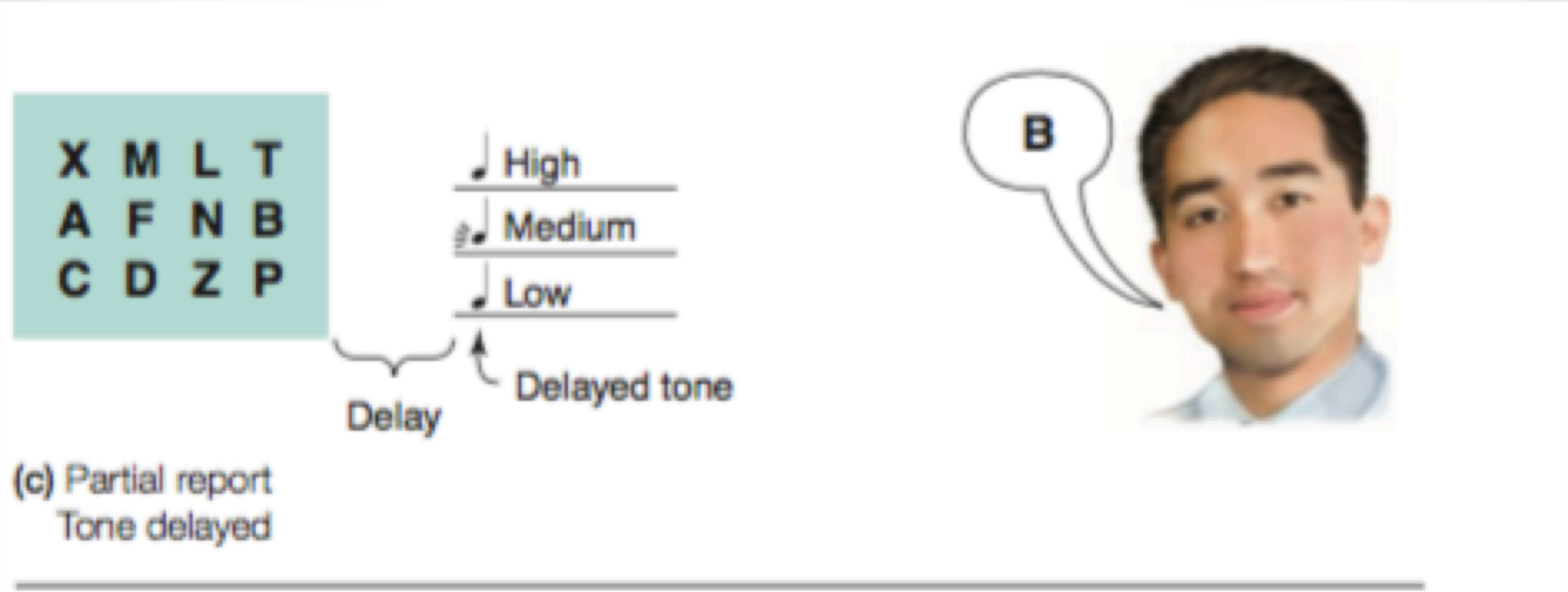


Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. (Fig. 5.5, p. 120)

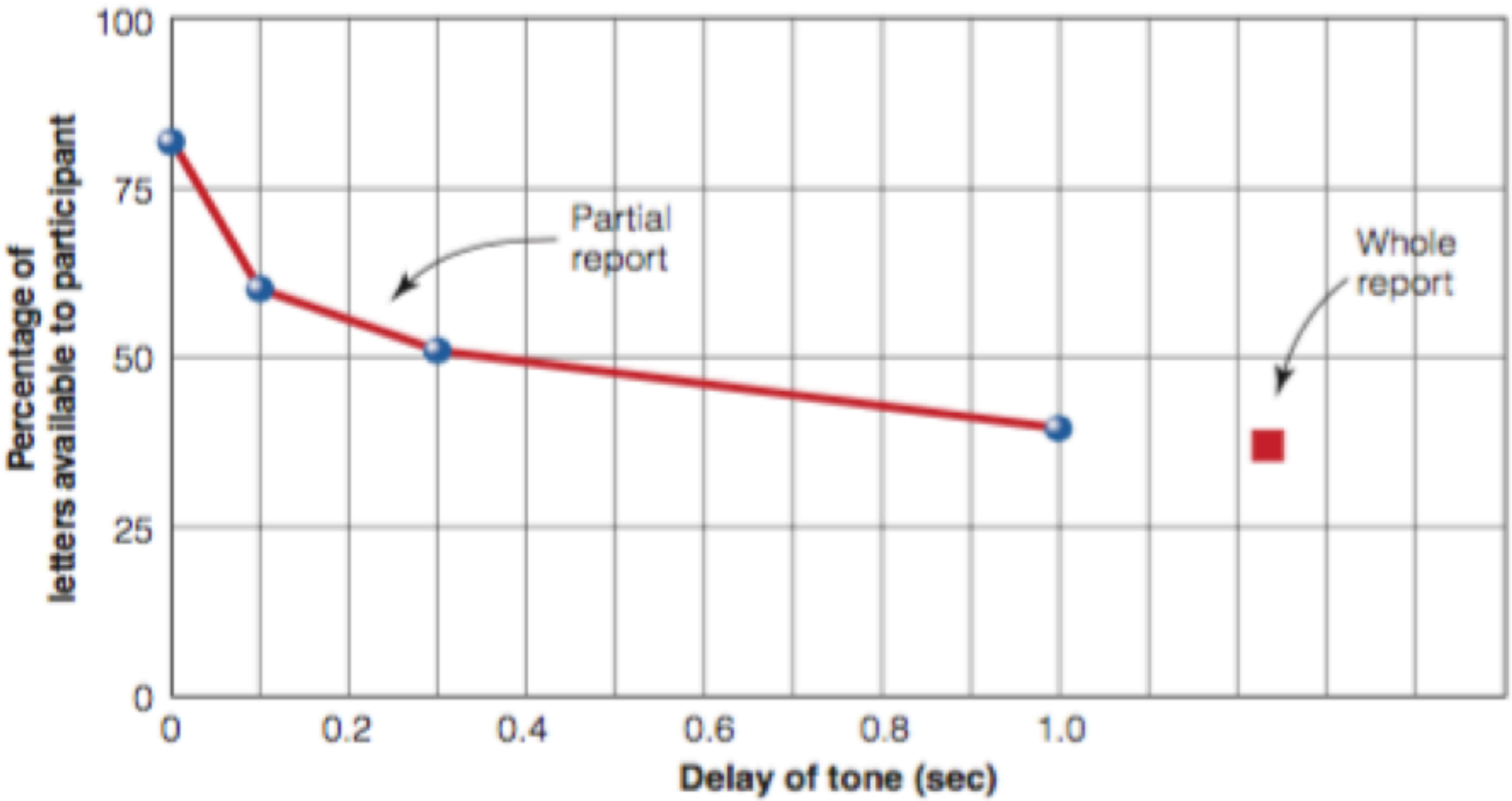


FIGURE 5.6 Results of Sperling's (1960) partial report experiments. The decrease in performance is due to the rapid decay of iconic memory (sensory memory in the modal model).

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. (Fig. 5.6, p. 122)

- Sperling concluded from these results that a short - lived sensory memory registers all or most of the information that hits our visual receptors, but that this information decays within less than a second.

- This brief sensory memory for visual stimuli is called the **iconic memory** and corresponds to the sensory memory stage of Atkinson & Shiffrin's model.

- Other research using auditory stimuli, has shown that sounds also persist in the mind. This persistence of sound, which is called **echoic memory**, lasts for a few seconds after presentation of the original stimulus (Darwin et al., 1972).

- The sensory memory can register huge amounts of information, but it retains this information for only seconds or fractions of a second.

- Many cognitive psychologists believe that the sensory store is important for :

    - collecting information to be processed
    - holding the information briefly while initial processing is going on &
    - filling in the blanks when the stimulation is intermittent.

- Sperling's experiment is important not only because it reveals the capacity of sensory memory (large) & its duration (brief), but also because it provides yet another demonstration of how clever experimentation can reveal extremely rapid cognitive processes that we are usually unaware of.

To Sum Up

References

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Course Title:

Basic Cognitive Processes

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Lecture 30: Memory - II

Short - term Memory

- **Short - term memory (STM)** is the system involved in storing small amounts of information for a brief period of time (Baddeley et al., 2009).

- Duration of Short - Term Memory
  - Brown (1958), and Peterson & Peterson (1959) used the method of recall to determine the duration of STM.
  - In their experiments, participants were given a task similar to one here:

I will say some letters and then a number. Your task will be to remember the letters. When you hear the number, repeat it and begin counting backwards by 3s from that number. For example, if I say ABC 309, then you say 309, 306, 303, and so on, until I say "Recall." When I say "Recall," stop counting immediately and say the three letters you heard just before the number.

Excerpt from: Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. Publishing

Start with the letters and number in trial 1 below. It is important that the person count out loud because this prevents the person from rehearsing the letters. Once the person starts counting, time 20 seconds, and say "recall." Note how accurately the person recalled the three letters and continue to the next trial, noting the person's accuracy for each trial.

Trial 1:	F Z L	45
Trial 2:	B H M	87
Trial 3:	X C G	98
Trial 4:	Y N F	37
Trial 5:	M J T	54
Trial 6:	Q B S	73
Trial 7:	K D P	66
Trial 8:	R X M	44
Trial 9:	B Y N	68
Trial 10:	N T L	39

Excerpt from: Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 3rd Ed. (p. 124).

- Peterson & Peterson also did a similar experiment in which they varied the time between when they said the number and when the participant began recalling the letters.
- Peterson & Peterson found that their participants were able to remember about 80% of the letters after counting for 3 seconds but could remember an average of only 12% of the three letter groups after counting for 18 seconds.
- They interpreted this result as demonstrating that participants forgot the letters because of **decay**; i.e. their memory decayed because of the passage of time after hearing the letters.

- However, when Keppel & Underwood (1962) looked more closely at the results, they found that if they considered the participant's performance on just the first trial, there was little *fall - off* between the 3 second & the 18 second delay.

- Why would memory worsen after a few trials?

  - Keppel & Underwood suggested that the drop - off in memory was due not to decay of the memory trace, Peterson & Peterson had proposed, but due to **proactive interference -** interference that occurs when information that was learned previously interferes with learning new information.

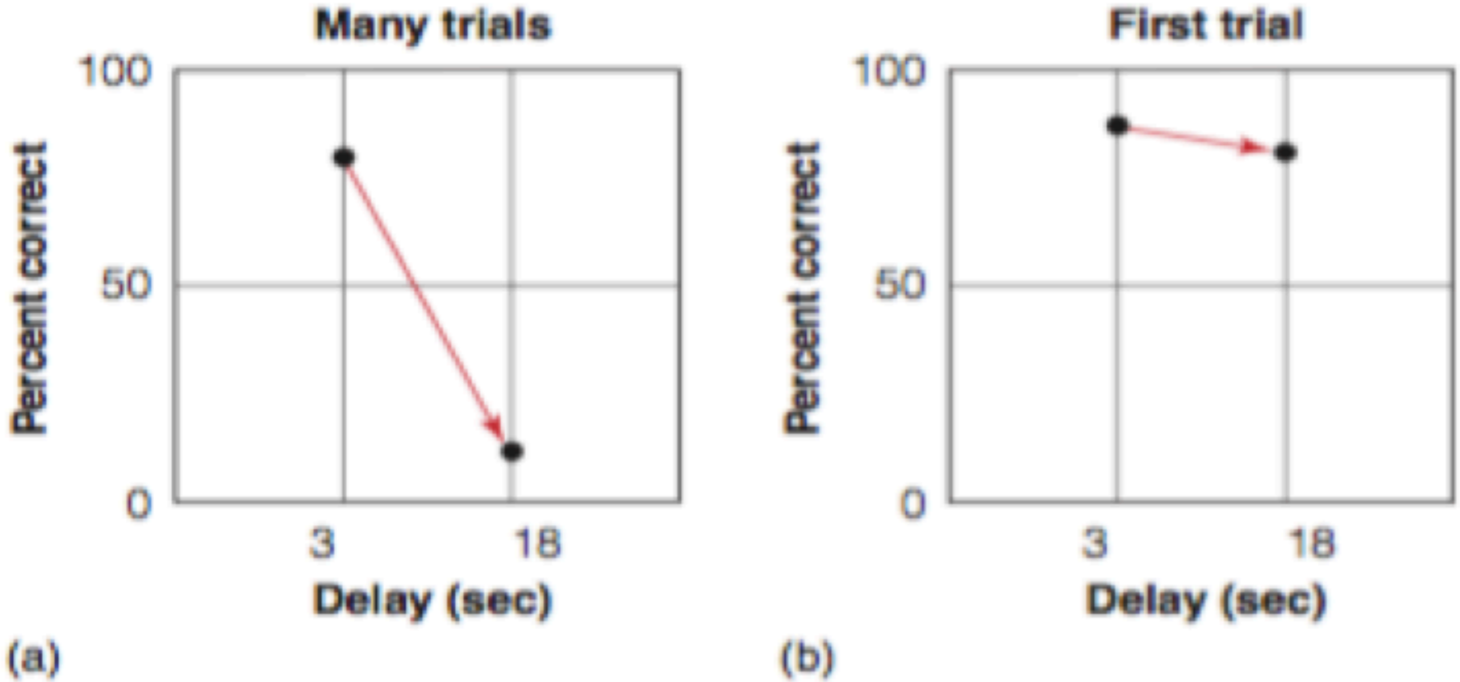

FIGURE 5.7 Results of Peterson and Peterson's (1959) duration of STM experiment. (a) The result originally presented by Peterson and Peterson, showing a large drop in memory for letters with a delay of 18 seconds between presentation and test. These data are based on the average performance over many trials. (b) Analysis of Peterson and Peterson's results by Keppel and Underwood, showing little decrease in performance if only the first trial is included.

Image: Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 3rd Ed. (Fig. 5.7, p. 125).

- Keppel & Underwood proposed that proactive interference is what caused the decrease in memory observed in the later trials of Peterson & peterson's experiment. Thus recalling the early letters in the list created interference that made it more difficult to remember the later letters in the list.

- Another illustration of *proactive interference* is when you try to remember new phone numbers of people who have just changed their number.

- **Capacity of Short - term memory:** there are certainly capacity limits on short - term memory as well. the estimates range between 4 - 9 items.

DEMONSTRATION Digit Span

Using an index card or piece of paper, cover all of the numbers below. Move the card down to uncover the first string of numbers. Read the numbers, cover them up, and then write them down in the correct order. Then move the card to the next string, and repeat this procedure until you begin making errors. The longest string you are able to reproduce without error is your digit span.

2 1 4 9
3 9 6 7 8
6 4 9 7 8 4
7 3 8 2 0 1 5
8 4 2 6 4 1 3 2
4 8 2 3 9 2 8 0 7
5 8 5 2 9 8 4 6 3 7

If you succeeded in remembering the longest string of digits, you have a digit span of 10 or perhaps more. The typical span is between 5 and 8 digits.

Image: Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 3rd Ed. (p. 125).

- According to the measurements of digit span, the average capacity of STM is about 5 - 9 items, i.e. about the length of a phone number.
- This idea was initially proposed by George Miller (1956) in a famous paper titled, “The Magical Number Seven, Plus or Minues Two”.
- More recent measures of STM capacity have set the capacity at about 4 items (Cowan, 2001). This conclusion was based on the results of experiments like the one by Luck & Vogel (1997), which measured the capacity of STM by flashing two arrays of coloured squares separated by a brief delay.

- The participant’s task was to indicate whether the second array was the same or different from the first array.
- On trials in which the second row was different, the colour of one square was changed

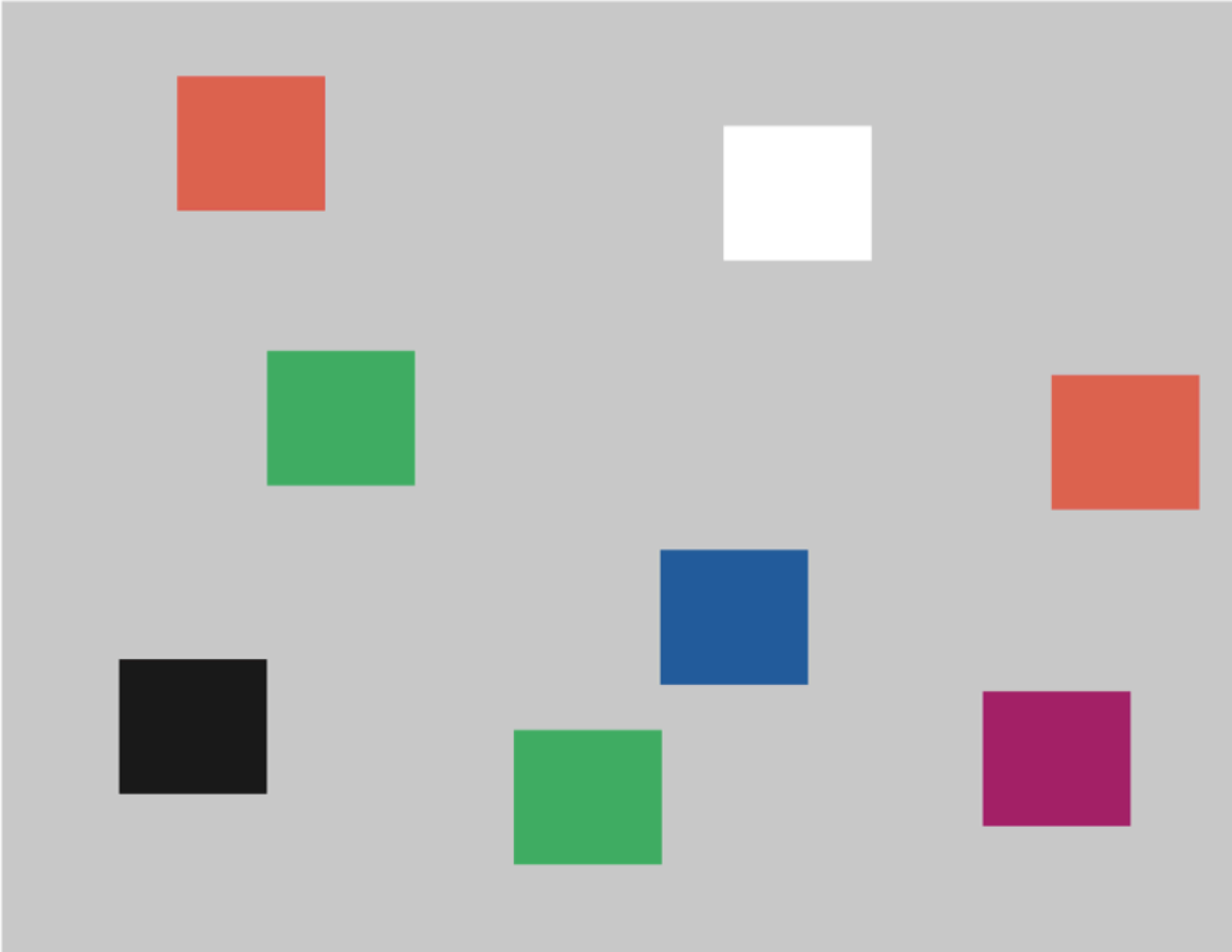

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Image: Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing.* 3rd Ed. (Fig. 5.8, p. 126).

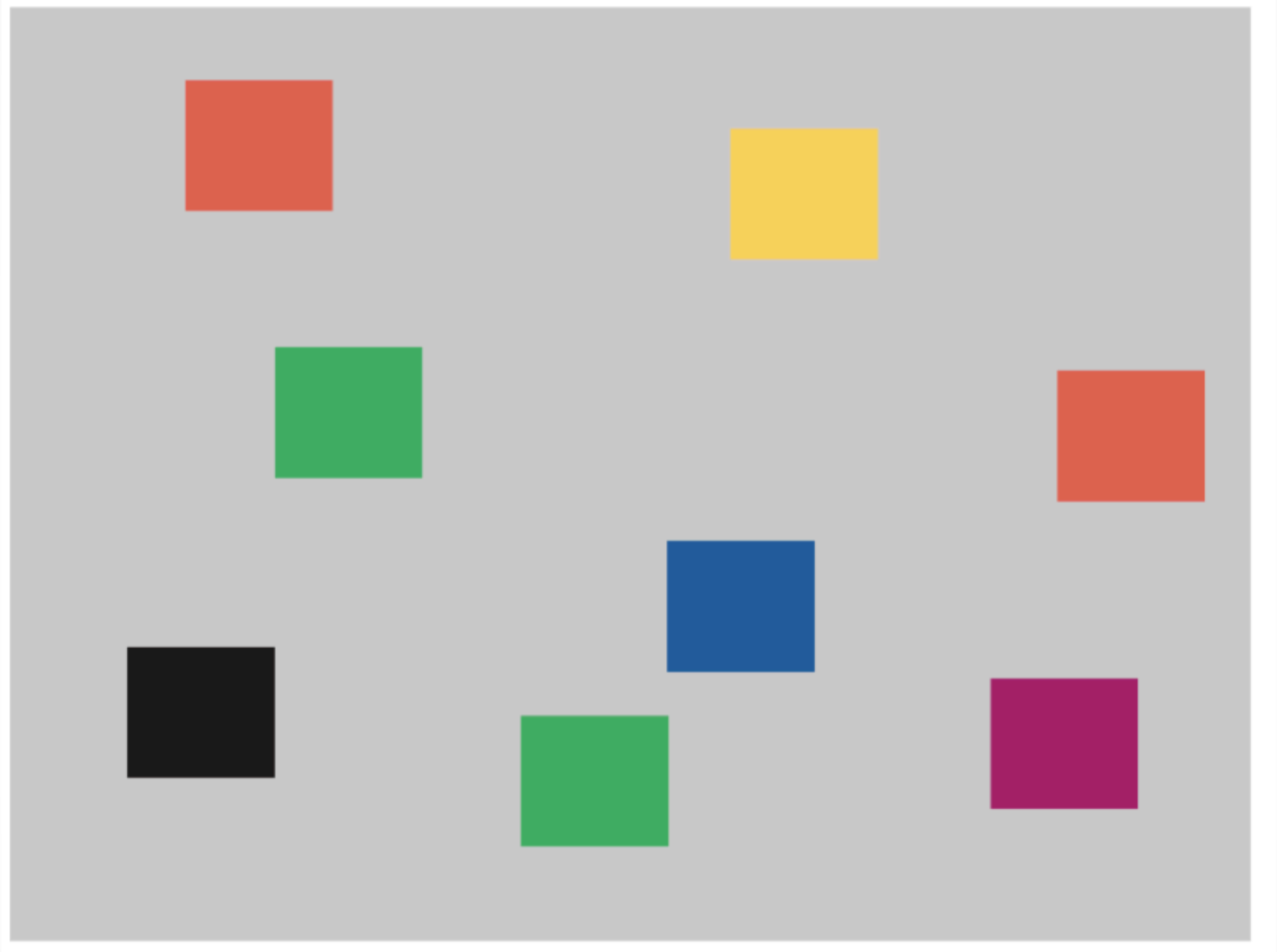


Image: Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing.* 3rd Ed. (Fig. 5.8, p. 126).

- The result of this experiment shows that performance was almost perfect when there were 1 to 3 squares in the arrays, but that performance began decreasing when there were more than 4 squares.

- Luck & Vogel (1997) concluded from this result that participants were able to retain about 4 items in their short - term memory.

- Other experiments, using verbal materials, have come to the same conclusion (Cowan, 2001).

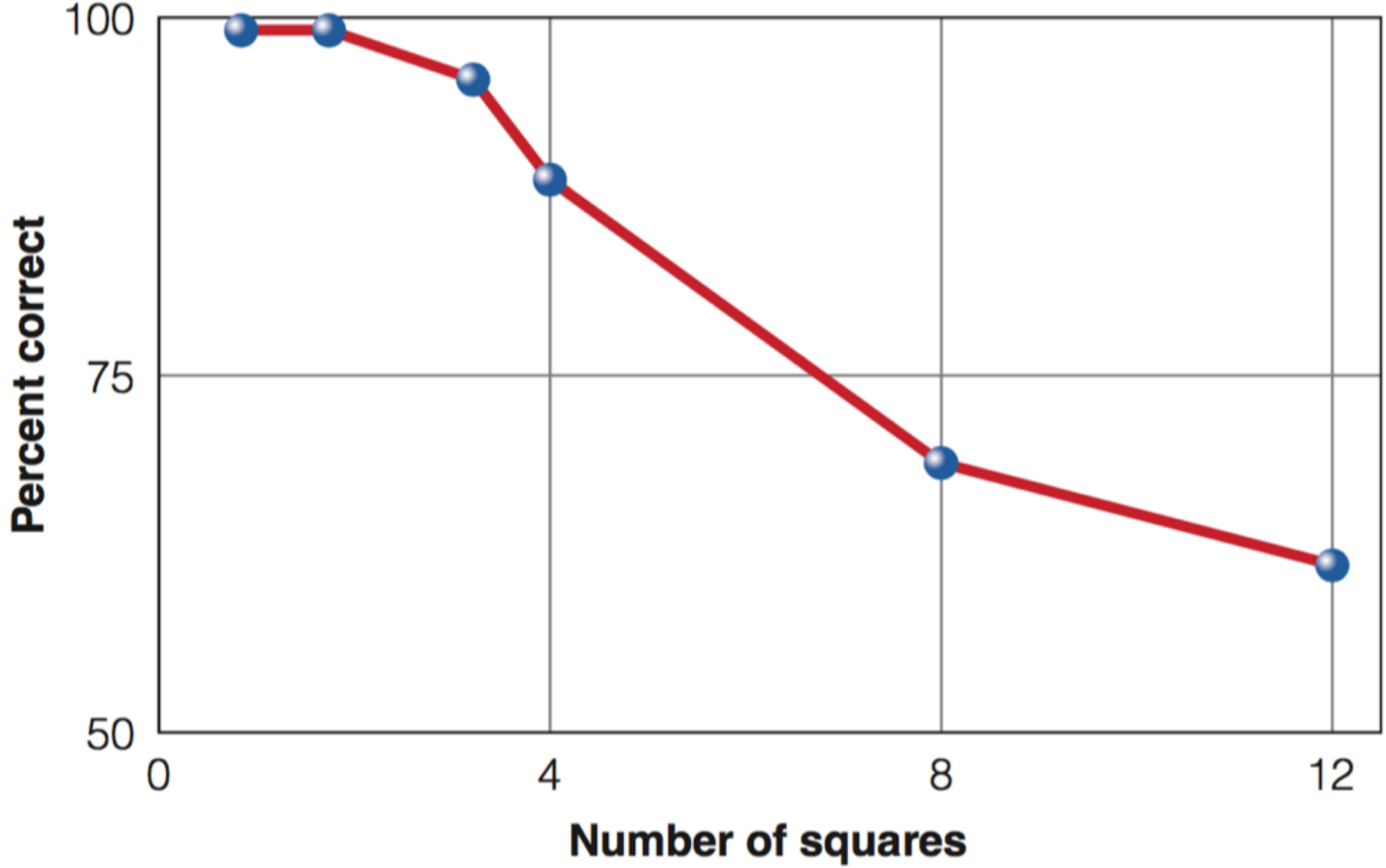


Image: Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 3rd Ed. (Fig. 5.8, p. 126).

- But 4 seems too less, or even 5 or 9, isn't it?
- How do we store much more information that just these numbers?

- **Chunking**: Miller (1956) introduced the concept of chunking to describe the fact that small units (like words) can be combined to larger meaningful units, like phrases, or even larger units like sentences, paragraphs or stories. E.g. if I ask you to learn these words:
- *monkey, child, wildly, zoo, jumped, city, ringtail, young*.
- or these pairs: *ringtail monkey, jumped wildly, young child, city zoo.*
- or these sentence: *The ringtail monkey jumped wildly for the young child at the city zoo.*

- A **chunk** has been defined as a collection of elements that are strongly associated with one another but are weakly associated with elements in other chunks (Cowan, 2001). e.g. ringtail monkey vs ringtail child.

- Thus, chunking in terms of meaning increases our ability to hold information in the STM.

- A similar demonstration is here:

BCIFNCCASICB

CIAFBINBCCBS

- Ericsson & colleagues (1980) demonstrated an effect of chunking by showing how a college student with average memory ability was able to achieve amazing feats of memory.

- Their participant, S.F. had a typical memory span of 7 digits, after extensive training (230 one -hour sessions), he was able to repeat sequences of up to 79 digits without error.

- How?

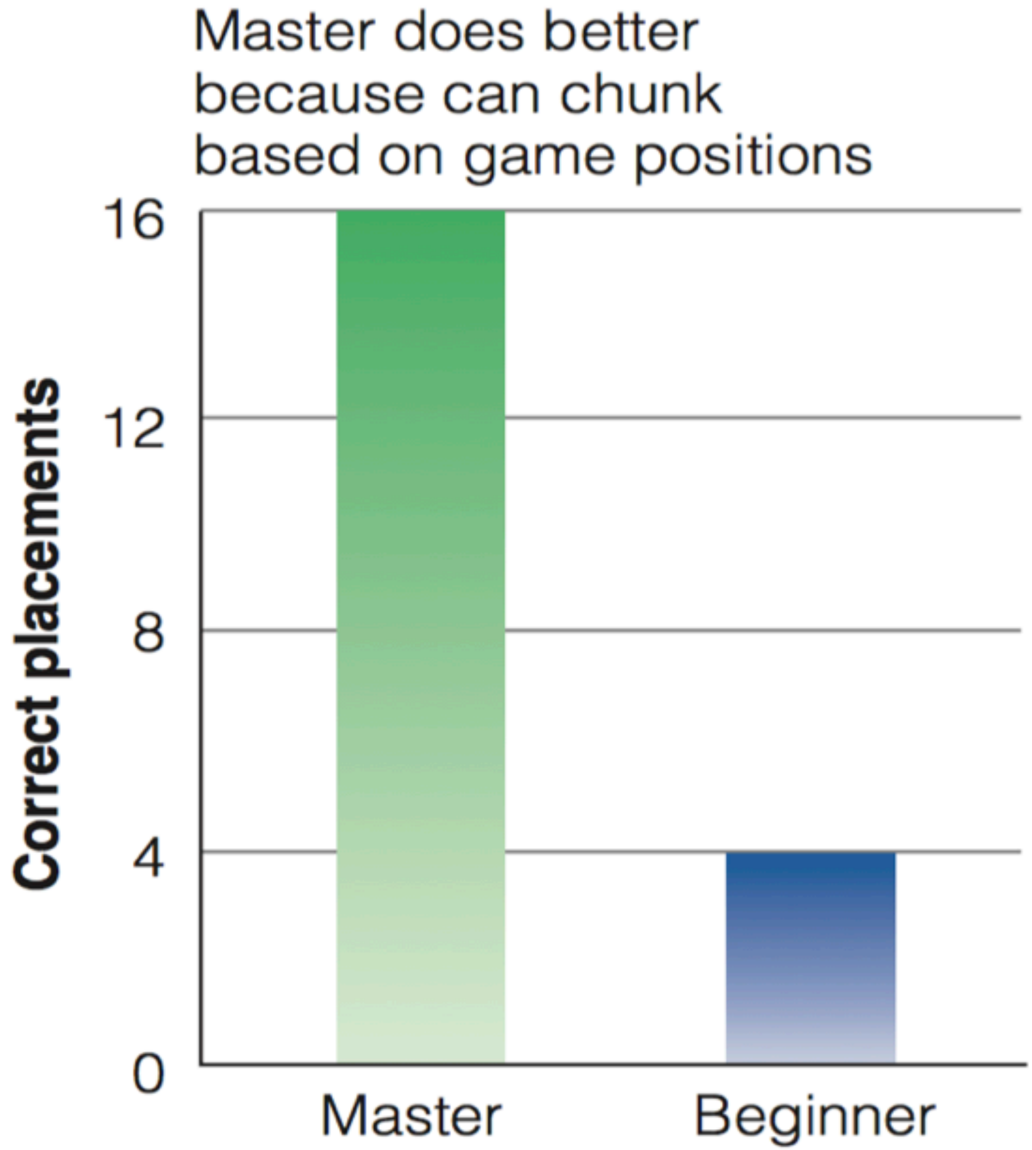
  - S.F. used chunking to recode the digits into larger units that formed meaningful sequences. e.g. 3492, became 2 minutes and 49 point 2 seconds; near world record mile time.

- another similar example is based on the interaction between the STM & the LTM; provided by an experiment done by Chase & Simon (1973), wherein they showed chess players arrangements of chess pieces taken from actual games; for 5 seconds.

- the chess players were then asked to reproduce the positions they had seen.

- Chase & Simon compared the performance of a chess master who had played or studied chess for more than 10,000 hours to the performance of a beginner who had less than 100 hours of experience.

- the results show that the chess master placed 16 pieces out of 24 correctly on his first try, compared to just 4/24 for the beginner. Also, the master required only 4 trials to reproduce all of the positions exactly, whereas the beginner could not do the same even after 7 trials.



(a) Actual game positions

Image: Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 3rd Ed. (Fig. 5.9, p. 127).

- So, does the master have better STM than the beginners?
- Chase & Simon answered this question by testing the ability of masters & beginners to remember random arrangements of the chess pieces.
- When the pieces were arranged randomly, the familiar patterns were destroyed, and the chess master’s advantage vanished.

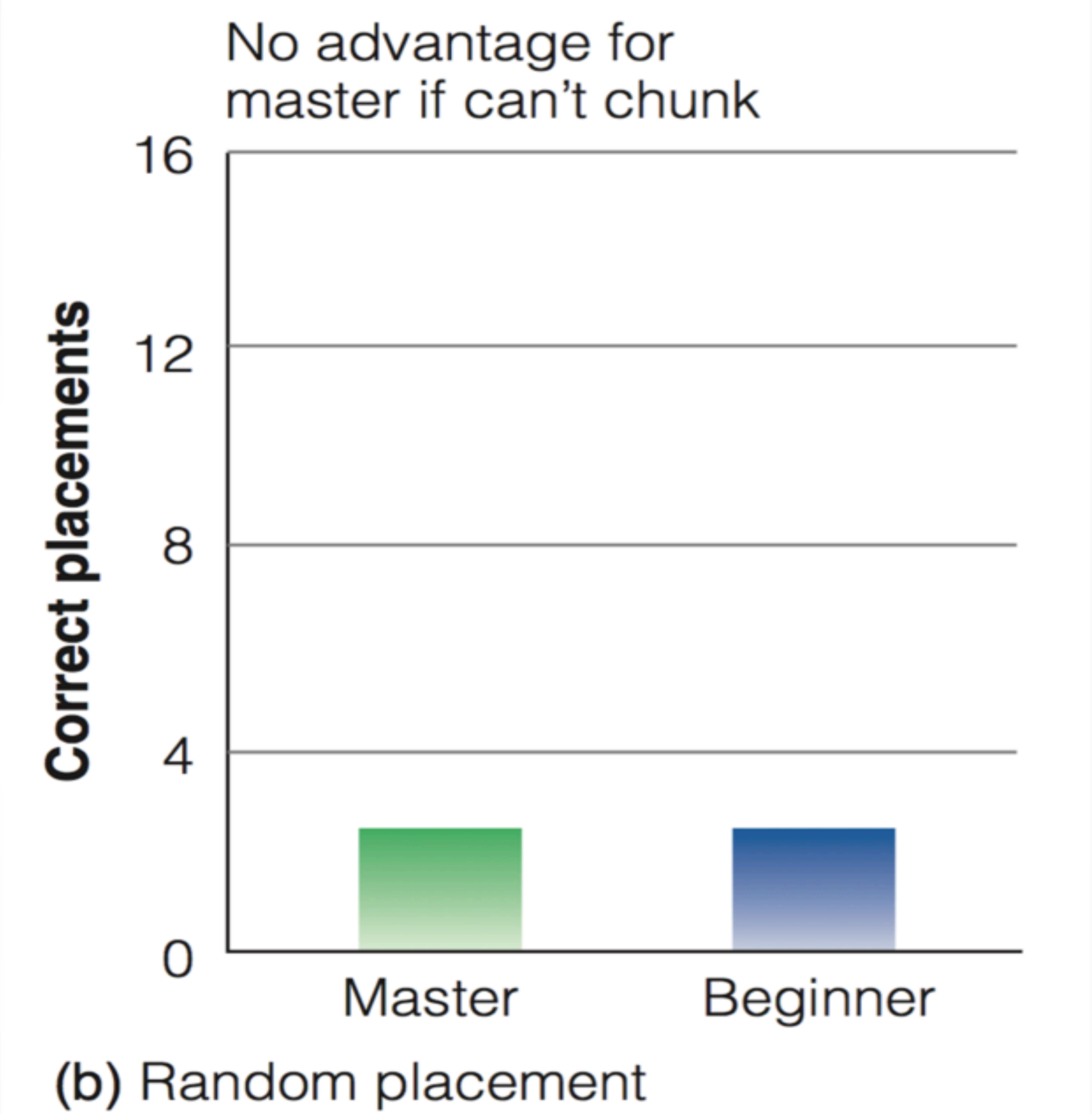


Image: Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 3rd Ed. (Fig. 5.9, p. 127).

- How is information coded in Short - term Memory?

- **Coding** refers to the way information is represented.

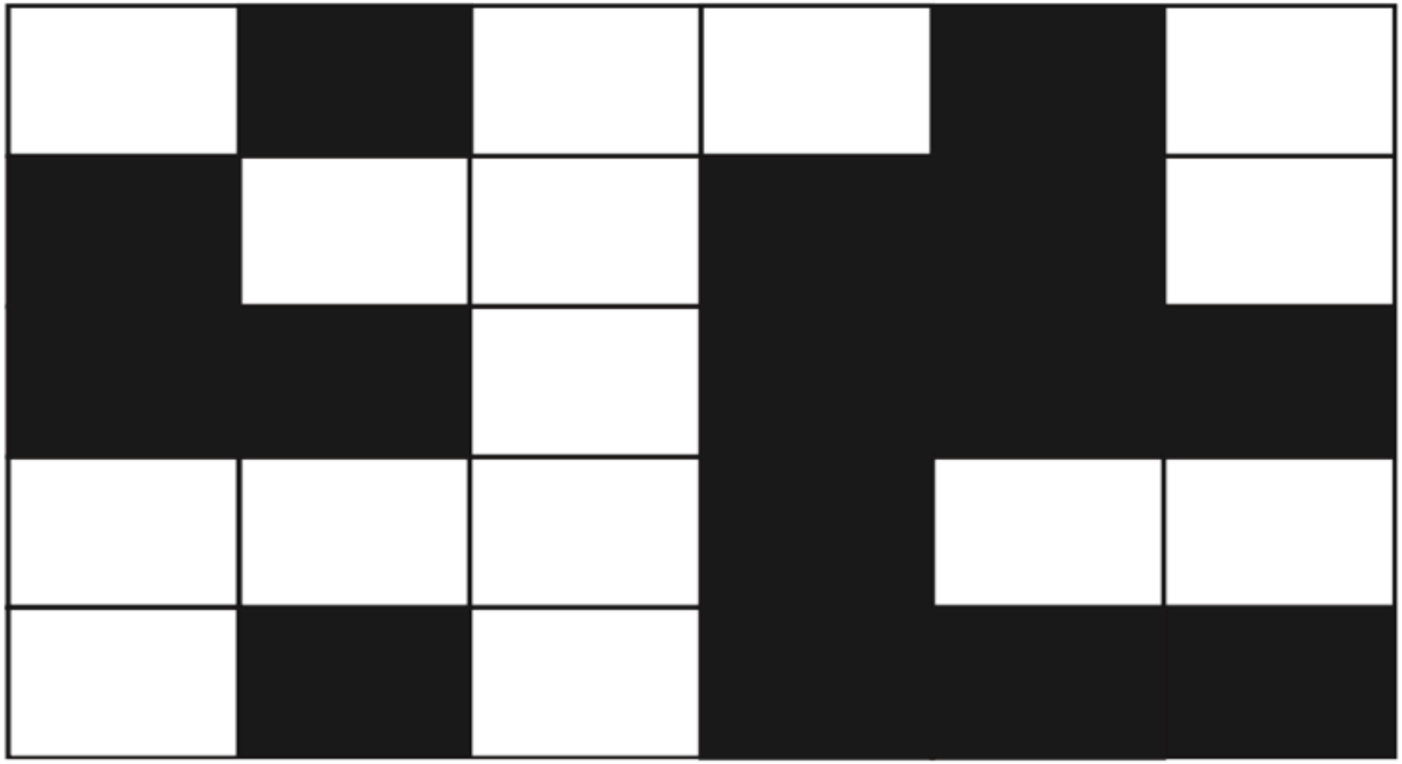
- determining how a stimulus is represented by the firing of neurons is a **physiological approach to coding**.
- we can also take a **mental approach to coding** by asking how a stimulus or an experience is represented in the mind.

- There could be a variety of ways in which one can code information.
- **Auditory Coding** involves representing items in the STM based in their sound.
  - For e.g. in Conrad (1964)'s experiment, participants saw a number of target letters which flashed briefly on a screen and were told to write down the letters in order they were presented.
  - Conrad found that when participants made errors, they were most likely to misidentify the target letter as another letter that **sounded like** the target. e.g. "F" was often misidentified as "S" or "X".

- Conrad concluded that the code for STM ia auditory, rather than visual.

- **Visual Coding** involves representing items visually, as would occur when remembering the details of a floor plan or the layout of streets on a map (Kroll, 1970). This use of visual codes in STM was demonstrated in an experiment by Sergio Della Sala and coworkers (1999), in which participants were presented with a task like:

- Della Sala found that participants were able to complete patterns consisting of an average of 9 shaded squares before making mistakes.



● **FIGURE 5.10** Test pattern for visual recall test. After looking at this for 3 seconds, turn the page.

Image: Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 3rd Ed. (Fig. 5.10, p. 128).

FIGURE 5.13 Answer matrix for the visual recall test. Put a check in each square that was darkened in the pattern you just looked at.

Image: Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 3rd Ed. (Fig. 5.13, p. 130).

- **Semantic Coding** is representing items in terms of their meaning. An example of semantic coding in STM is provided in an experiment by Wickens et al., (1976).

- On each trial, participants were presented with words related to either a fruit or profession.

- Participants in each group listened to three words for e.g. banana, peach, apple & then counted backwards for 15 seconds and then attempted to recall all the three words. They did this for a total of 4 trials, with different words presented on each trial.

- The basic idea behind this experiment was to create **proactive interference**, by presenting words in a series of trials from the same category.

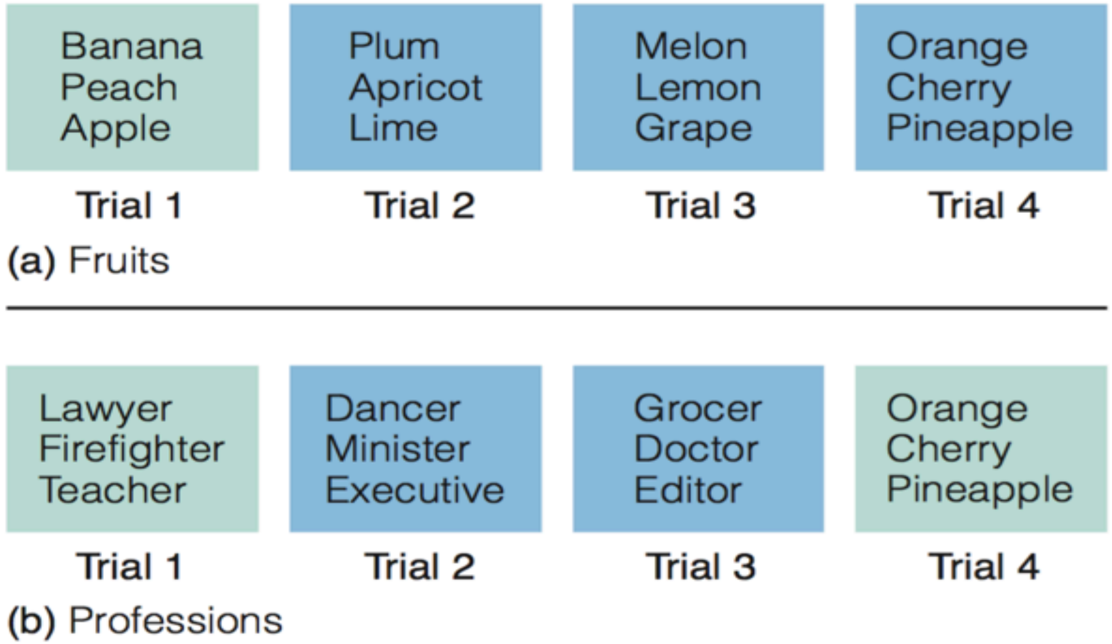


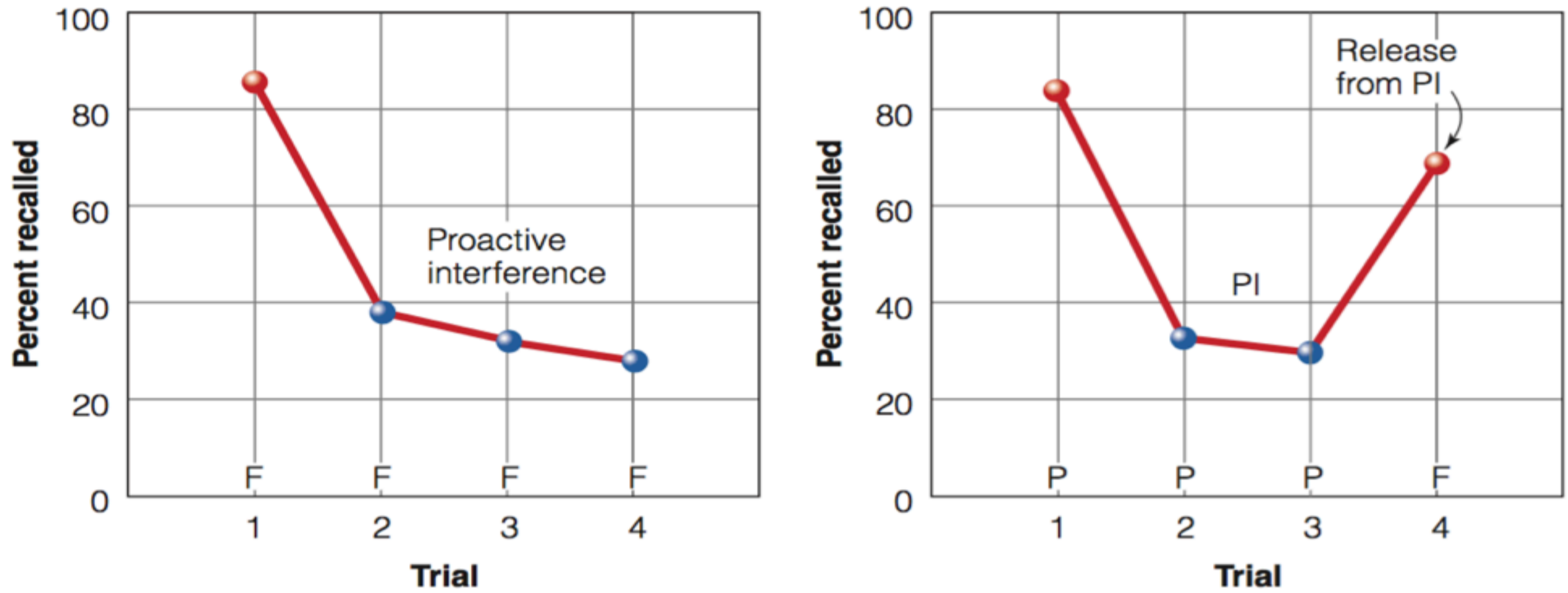
FIGURE 5.11 Stimuli for the Wickens et al. (1976) experiment. Participants in the fruit group are presented with the names of three fruits on each trial. Participants in the professions group are presented with the names of three professions on trials 1, 2, and 3, and with the names of three fruits on trial 4. Proactive interference based on meaning could occur on trials indicated by the blue rectangles. (Source: Based on D. D. Wickens, R. E. Dalezman, & F. T. Eggemeier, "Multiple Encoding of Word Attributes in Memory," *Memory & Cognition, 4*, 307–310, 1976.)

Image: Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 3rd Ed. (Fig. 5.11, p. 129).

- Results:
    - For the fruits group, one the first trial the average percent recalled was 86%, but performance dropped on trials 2, 3,& 4 as additions names of fruits were presented.
    - The blue data points indicate the presence of proactive interference.
    - Evidence, that this interference can be attributed to the meanings the words is provided by the results of the professions drop.

- As with fruits, performance is high on trial 1 & then drops on trials 2 & 3.

- But on trial 4, the names of fruits are presented; & because these are from a different category, proactive interference is reduced & there is an increase in performance; this is called the **release from proactive interference.**



(a) Fruit group (b) Professions group

FIGURE 5.12 Results of Wickens et al.'s (1976) proactive inhibition experiment. (a) Fruit group, showing reduced performance on trials 2, 3, and 4 caused at least partially by proactive interference (indicated by blue points). (b) Professions group, showing reduced performance on trials 2 and 3 but improved performance on trial 4. The increase in performance on trial 4 represents a release from proactive interference caused by the change of category from professions to fruits. (Source: Based on D. D. Wickens, R. E. Dalezman, & F. T. Eggemeier, "Multiple Encoding of Word Attributes in Memory," *Memory & Cognition*, 4, 307–310, 1976.)

Image: Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 3rd Ed. (Fig. 5.12, p. 130).

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- Goldstein (2010) Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 3rd Ed

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Course Title:

Basic Cognitive Processes

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Lecture 31: Memory - III

Working Memory

- Alan Baddeley reasoned that short - term memory processes must be dynamic and also consider of a number of components that can function separately.
- Acc. to this idea, the digit span task would be handled by one component while comprehending the paragraph would be handled by another component.

- The model Baddeley proposed was first described in a paper with Graham Hitch (Baddeley & Hitch, 1974) and, was later modified to explain new findings.

- In this model, the short - term memory component of memory is called *Working Memory*.

- ***Working Memory*** is defined as a limited capacity system for temporary storage & manipulation of information for complex tasks such as comprehension, learning and reasoning.

- From this definition we can see that working memory differs from short term memory in two ways:

  - STM is concerned mainly with *storing information* for a brief period of time, whereas working memory is concerned with the *manipulation of information* that occurs during complex cognition.

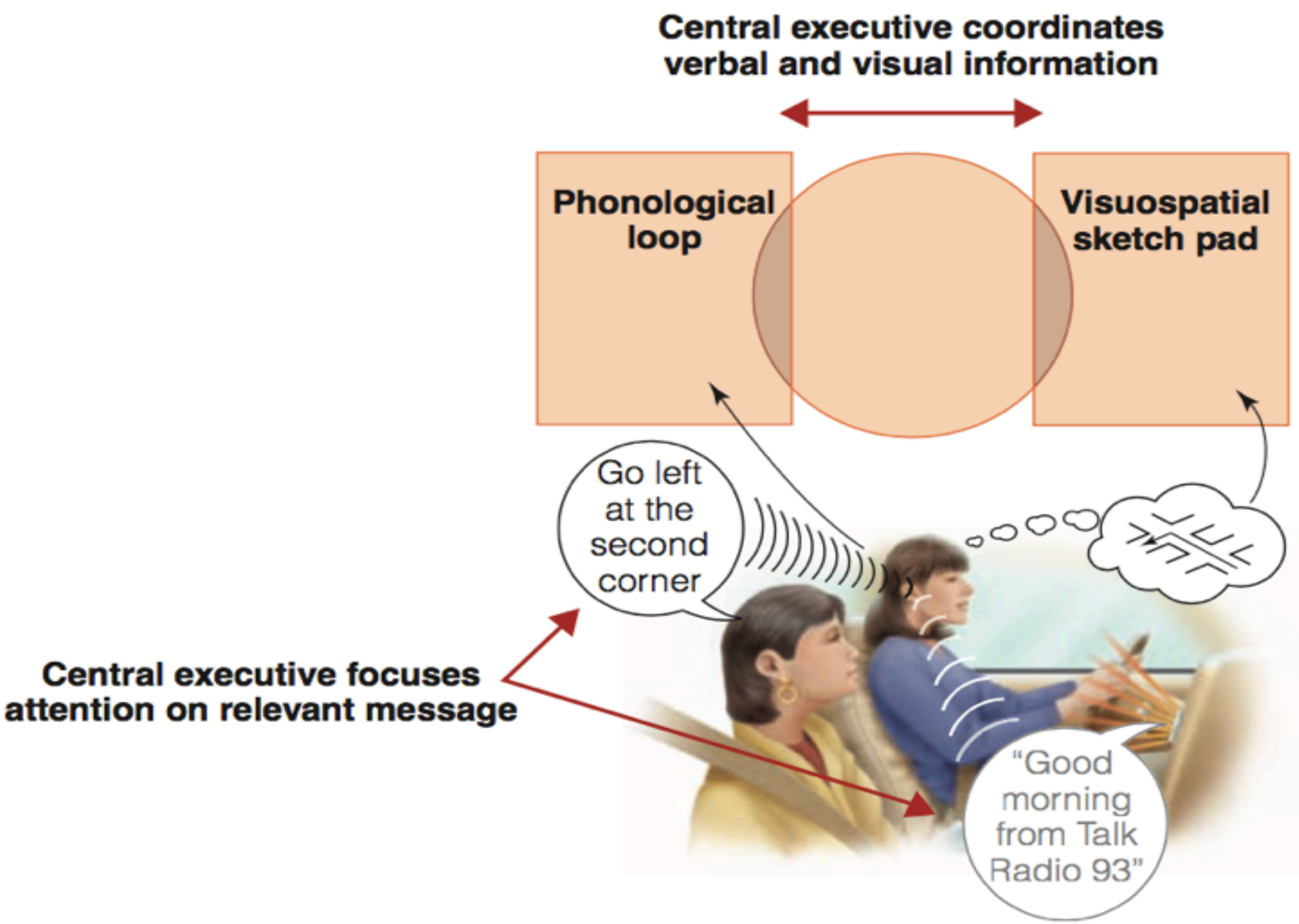
  - STM consists of a single component, whereas working memory consists of a *number of components*.

- Working memory accomplishes the manipulation of information through the action of three components: ***the phonological loop, the visuospatial sketch pad, & the central executive***.

- The **phonological loop** consists of two components: the phonological store, which has a limited capacity and holds information for only a few seconds; & the articulatory rehearsal process, which is responsible for rehearsal that can keep items in the phonological store from decaying. The phonological loop holds verbal and auditory information.

- The **visuospatial sketchpad** holds visual & spatial information.

- The **central executive** is where the major work of working mmemory occurs. The central executive pulls information from long - term memory and coordinates the activity of the phonological loop & visuospatial sketch pad by focusing on specific parts of a task and switching attention from one part to another.
    - One of the main tasks of the central executive is to decide on how to divide attention between tasks.



● **FIGURE 5.15** Tasks processed by the phonological loop (hearing directions; listening to the radio) and visuospatial sketch pad (visualizing the route) being coordinated by the central executive. The central executive also helps the person ignore the messages from the radio, so attention can be focused on hearing the directions.

Image: Goldstein (2010).Cognitive Psychology: Connecting Mind, research & Everyday Experience. *Wadsworth Publishing*. (Fig. 5.15, p. 132).

- **The Phonological Loop**
    - the *phonological similarity effect* is the confusion of letters or words that sound similar. remember Conrad's experiment.
    - the *word length effect* occurs when memory for lists of words is better for short words than for long words (Baddeley et al., 1984).

- *articulatory suppression* one way that the operation of the phonological loop has been studied is by determining what happens when its operation is disrupted. This occurs when a person is prevented from rehearsing items to be remembered by repeating an irrelevant sound, such as “the the the..” (Baddeley, 2000). the repetition of an irrelevant sound results in a phenomenon called **articulatory suppression** which reduces memory because speaking interferes with rehearsal.

- Baddeley & colleagues (1984) found that repeating “the the the..” not only reduces the ability to remember a list of words, but also eliminates the word length effect.

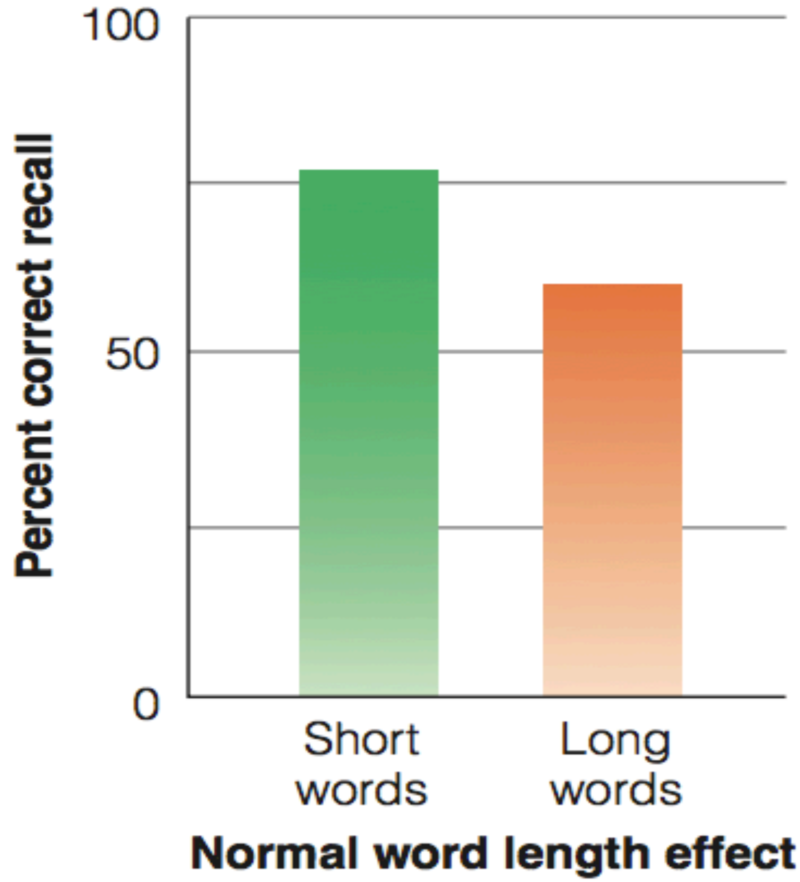


FIGURE 5.16 How word length affects memory, showing that recall is better for short words (Baddeley et al., 1984).

Image: Goldstein (2010).Cognitive Psychology: Connecting Mind, research & Everyday Experience. *Wadsworth Publishing*. (Fig. 5.16, p. 133).

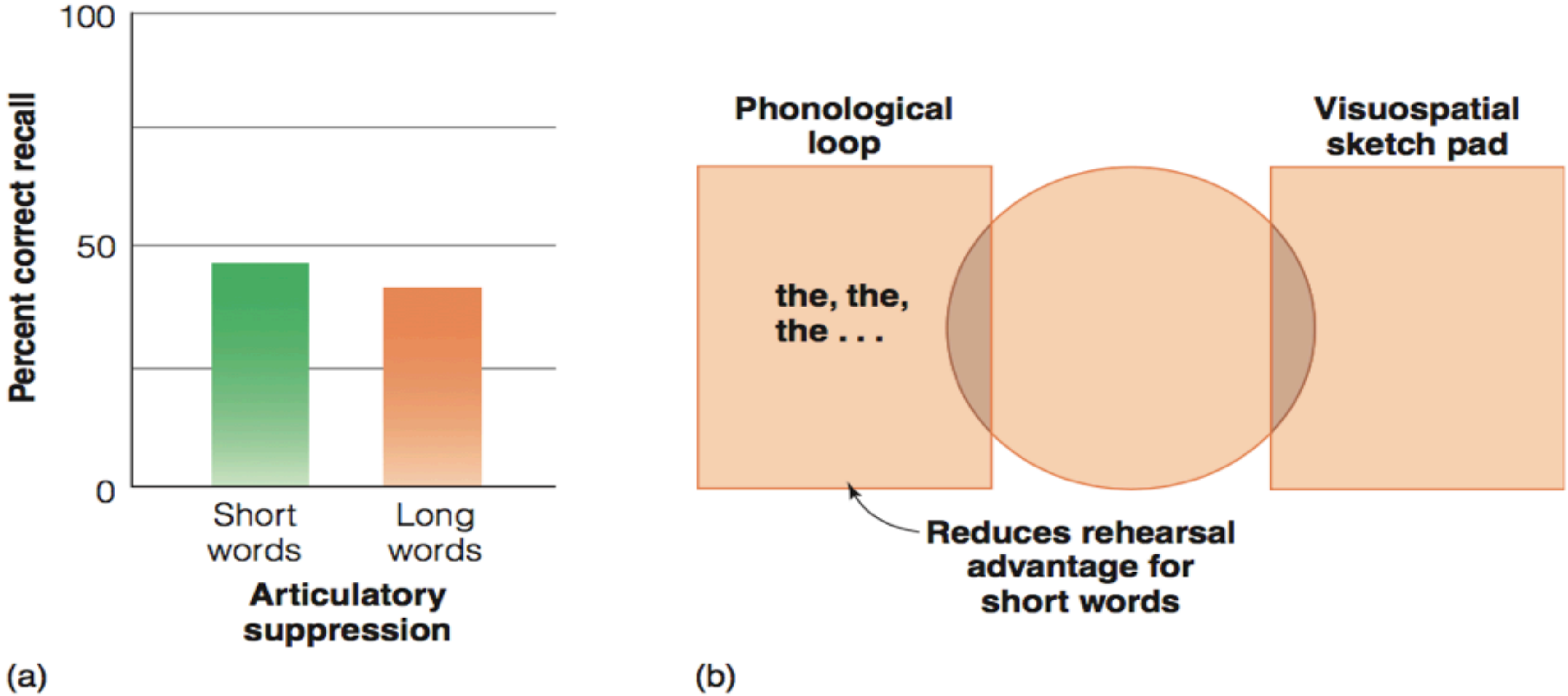


FIGURE 5.17 (a) Saying "the, the, the . . ." abolishes the word length effect, so there is little difference in performance for short words and long words (Baddeley et al., 1984). Saying "the, the, the . . ." causes this effect by reducing rehearsal in the phonological loop.

Articulatory suppression occurs when remembering the second list becomes harder because repeating "the, the, the . . ." overloads the phonological loop.

- Image: Goldstein (2010).Cognitive Psychology: Connecting Mind, research & Everyday Experience. *Wadsworth Publishing*. (Fig. 5.17, p. 134).

- **The Visuospatial Sketchpad:** handles visual & spatial information & is therefor involved in the process of visual imagery - the creation of visual images in the mind in the absence of a physical visual stimulus. The following demonstration illustrates an early visual imagery experiment by Shepard & Metzler (1971).

- When Shepard & Metzler measured participants' reaction time to decide whether pairs of objects were same or different, they obtained the relationship for objects (…figure) that were same or different. From this function it can be seen that when two shapes were separated by an orientation difference of 40 degrees, it took 2 seconds to decide that a pair was the same; but for a difference of 140 degrees, it took 4 seconds.

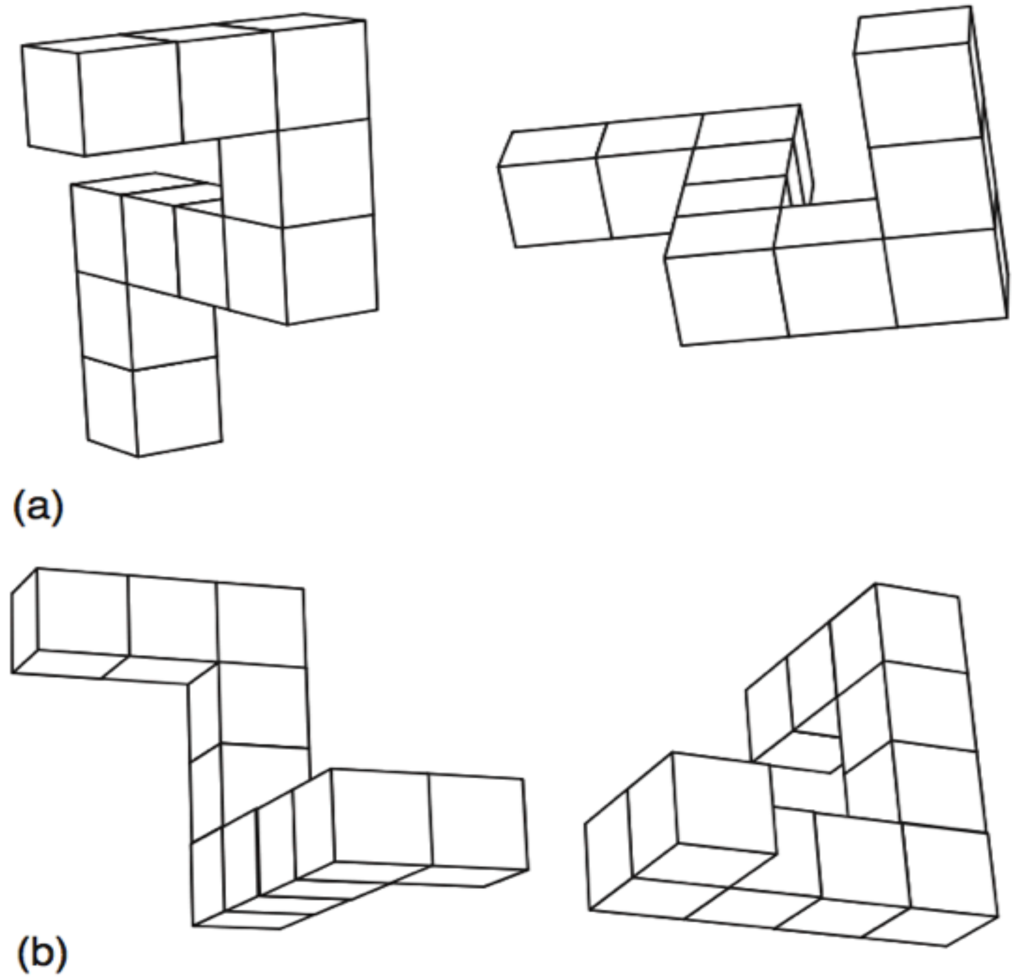


FIGURE 5.18 Stimuli for the "Comparing Objects" demonstration. (Source: R. N. Shepard & J. Metzler, "Mental Rotation of Three-Dimensional Objects," *Science, 171*, Figures 1a&b, 701–703. Copyright © 1971 American Association for the Advancement of Science. Reproduced with permission.)

- Image: Goldstein (2010).Cognitive Psychology: Connecting Mind, research & Everyday Experience. *Wadsworth Publishing*. (Fig. 5.18, p. 134).

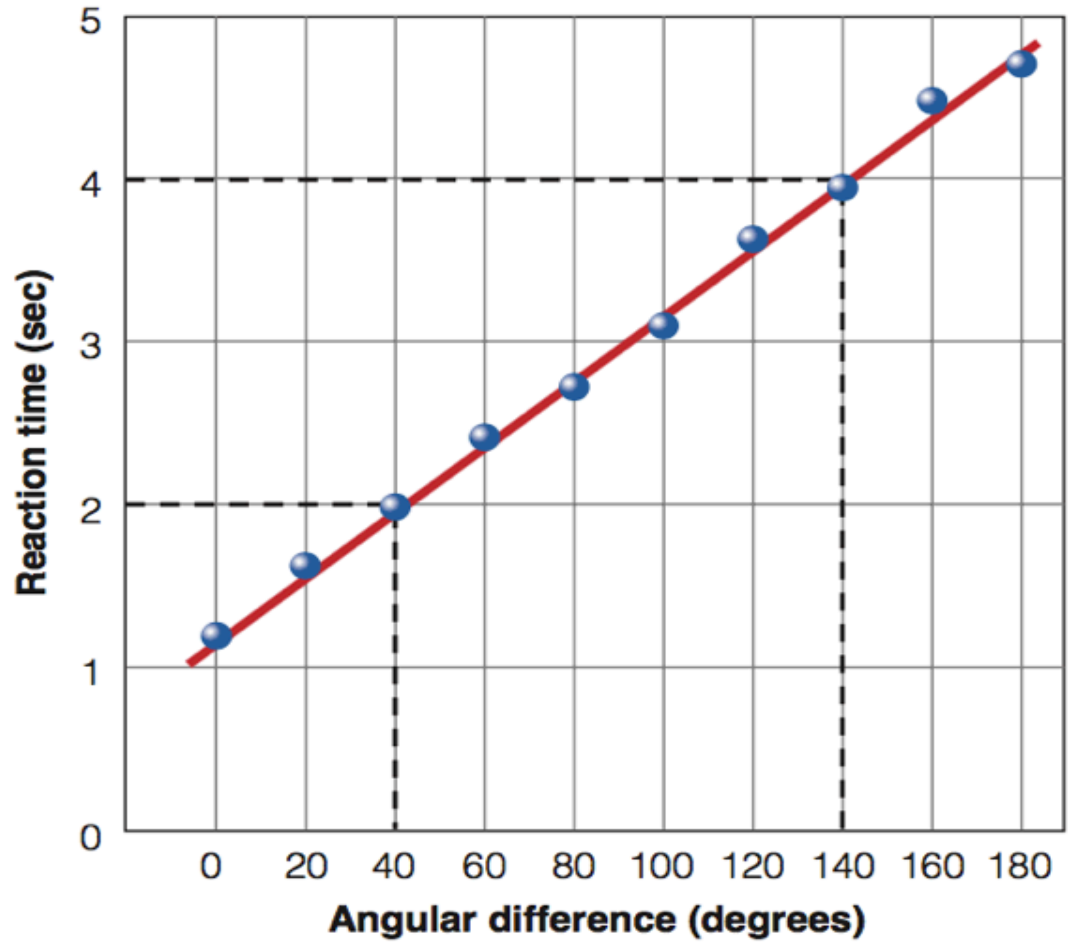


FIGURE 5.19 Results of Shepard and Metzler's (1971) mental rotation experiment. (Source: R. N. Shepard & J. Metzler, "Mental Rotation of Three-Dimensional Objects," *Science, 171*, Figure 2a, 701–703. Copyright © 1971 American Association for the Advancement of Science. Reproduced with permission.)

- Image: Goldstein (2010).Cognitive Psychology: Connecting Mind, research & Everyday Experience. *Wadsworth Publishing*. (Fig. 5.19, p. 135).

- Based on these findings, Shepard & Metzler concluded that participants were solving the problem by rotating the image of one of the objects in their mind, a phenomenon called **mental rotation.**

- Lee Brooks (1968) did some experiment in which he demonstrated how interference can affect the operation of the visuospatial sketch pad.

DEMONSTRATION Holding a Spatial Stimulus in the Mind

Task 1: Visualize the *F* in ● Figure 5.20. Then cover the F and while visualizing it in your mind, start at the upper left corner (the one marked with the *) and, moving around the outline of the F in a clockwise direction in your mind, point to "Out" in ● Figure 5.21 for an outside corner (like the one marked with the *), and "In" for an inside corner (like the one marked with the ●). Move your response down one level in Figure 5.21 for each new corner.

Image: Goldstein (2010).Cognitive Psychology: Connecting Mind, research & Everyday Experience. *Wadsworth Publishing*. (Demo, p. 135).

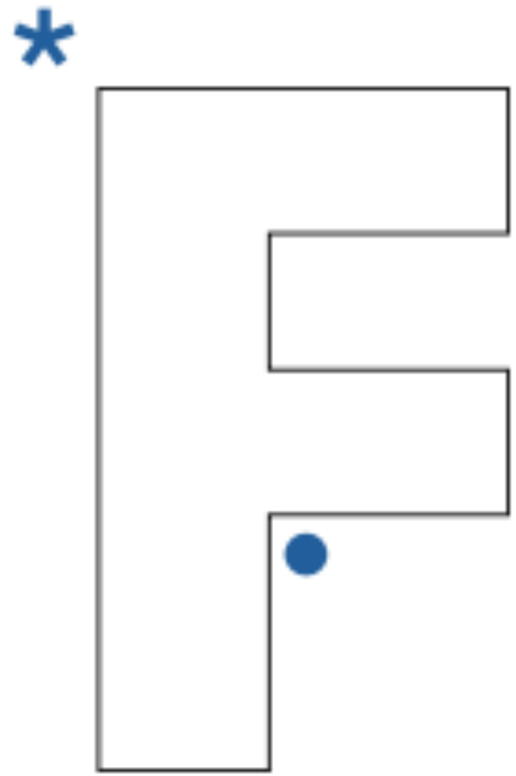


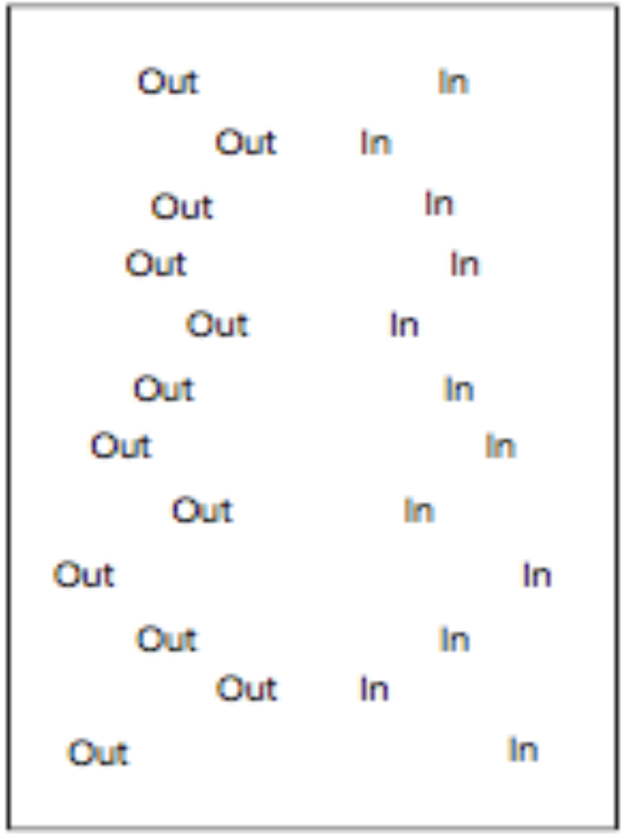
FIGURE 5.20 *F* stimulus for "Holding a Spatial Stimulus in the Mind" demonstration. (From Brooks, 1968.) The * indicates an outside corner, and the • indicates an inside corner.

Image: Goldstein (2010).Cognitive Psychology: Connecting Mind, research & Everyday Experience. *Wadsworth Publishing*. (Fig. 5.20, p. 135).

Task 2: Visualize the F again, but this time, as you move around the outline of the F in a clockwise direction in your mind, say “Out” if the corner is an outside corner or “In” if it is an inside corner.

Which was easier, *pointing* to “Out” or “In” or *saying* “Out” or “In”?

Image: Goldstein (2010).Cognitive Psychology: Connecting Mind, research & Everyday Experience. *Wadsworth Publishing*. (Demo, p. 135).



● **FIGURE 5.21** Response matrix for the "Holding a Spatial Stimulus in the Mind" demonstration. (From Brooks, 1968.)

Image: Goldstein (2010).Cognitive Psychology: Connecting Mind, research & Everyday Experience. *Wadsworth Publishing*. (Fig. 5.21, p. 135).

- Most people find that the pointing task is more difficult. The reason is that holding the image of the letter and pointing are both visuospatial tasks, so the visuospatial sketchpad becomes overloaded.

- In contrast, saying “out” or “in” is an articulatory task that is handled by the phonological loop, so speaking did not interfere with visualising the F.

- **The Central Executive** is the component that makes working memory "working" because it is the control centre of the working memory system. It's mission is not to store information, but to coordinate how information is used by the phonological loop & visuospatial sketchpad (Baddeley, 1996).

- Baddeley describes the central executive as the *attention controller.* It determines how attention is focused on a specific task, how it is divided between two tasks & how it is switched between tasks.

- The central executive is therefore essential in situations as for e.g. when the person is attempting to simultaneously drive & use a cell phone. In this example, the executive would be controlg a phonological loop process (talking on the phone) & a sketchpad process (visualising landmarks & the layout of the streets; navigating the car).

- One of the ways the central executive has been studied is by assessing the behaviour of patients with brain damage. As we see, the frontal lobe plays a central role in working memory; therefore that patients with frontal lobe damage have problems controlling their attention. e.g. a typical example is **perseveration** i.e. repeatedly performing the same behaviour even if it is not achieving the desired goal.

- Consider for example, a problem that can be easily solved by following a rule, “Pick up the red object.” A person with frontal lobe damage might be responding correctly on each trial as long as the rule stays the same. However, when the rule is changed, (“ Now pick the blue object.”), the person continues following the old rule even when feedback that his or her action is incorrect is given.

- Another example of how the central executive controls attention is provided by situations in which a person is supposed t focus attention on “relevant” stimuli and ignore other, “irrelevant stimuli”.

- Some people are better at focussing attention than others.

- **The Episodic Buffer:** There are also some results that the model cannot explain. One of those things is that working memory can hold more than would be expected based on just the phonological loop or the visuospatial sketchpad. for e.g. people can remember long sentences consisting of as many as 15 - 20 words. The ability to do this is related to chunking, in which meaningful units are grouped together.

- Baddeley decided it was necessary to propose an additional component of working memory to address these abilities.

- This new component, i.e. **the episodic buffer** can store more information (thereby providing extra capacity) & is connected to LTM (thereby making interchange between working memory & LTM possible).

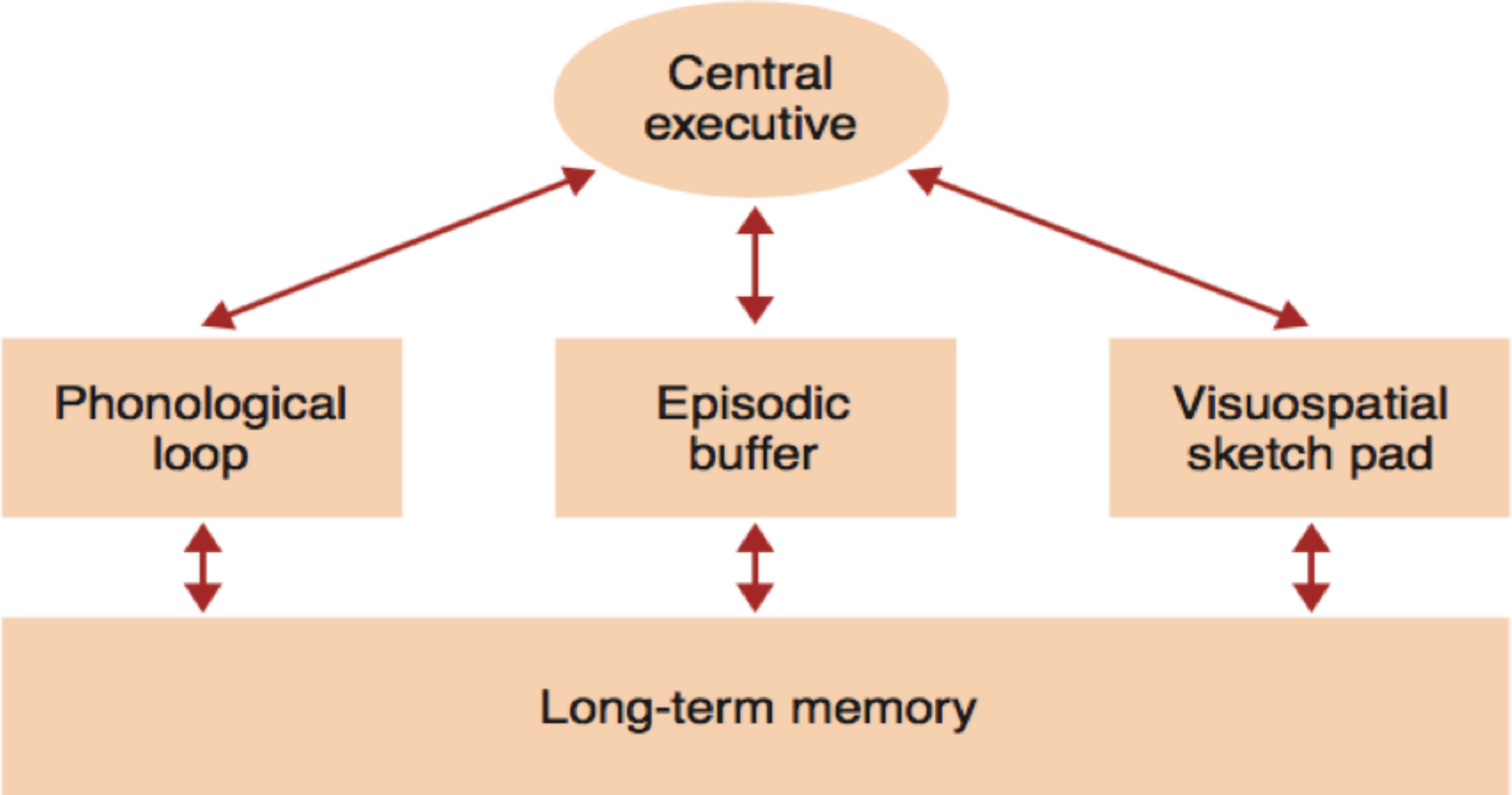


FIGURE 5.22 Baddeley's revised working memory model, which contains the original three components plus the episodic buffer.

Image: Goldstein (2010).Cognitive Psychology: Connecting Mind, research & Everyday Experience. *Wadsworth Publishing*. (Fig. 5.22, p. 137).

- Note that this model also shows that VSP & PL as connected to the LTM.

- The proposal of the episodic buffer represents another step in the evolution of Baddeley’s model, which has been stimulating research on working memory for more than 30 years since it was first proposed.

- The exact functioning of the episodic buffer, seems a little vague as it is very much a work in progress.

Working Memory & the Brain

- There are few methods that have been used to determine the connection between cognitive functioning & the brain:
  - analysis of behaviour after brain damage (lesion studies)
  - recording from single neurons (single cell recording)
  - recording electrical signals (EEG)
  - measuring brain activity (fMRI)

- the delayed response task: early research on the frontal lobe & memory was carried out in monkeys using the delayed response task, which required a monkey to hold information in working memory during a delay period (Goldman - Rakic, 1992).

- The monkey sees a food reward in one of two food wells; both wells are then covered, a screen is lowered, and then there a is a delay before which the screen is raised again.

- When the screen is raised, the monkey must remember which well had the food to uncover the well & then take the food well to obtain a reward.
- Monkeys can be trained to accomplish this task.

FIGURE 5.24 The delayed-response task being administered to a monkey.

Image: Goldstein (2010).Cognitive Psychology: Connecting Mind, research & Everyday Experience. *Wadsworth Publishing*. (Fig. 5.24, p. 138).

- However, when their prefrontal cortex is removed, their performance drops to the level of chance & they are correct only about 50% of the time.

- This result supports the idea that the PF is important for golding information for brief periods of time.

- **Brain activation in humans:**
  - The conclusion that many brain areas are involved in working memory has been confirmed by research using imaging techniques such as PET and fMRI to measure brain activity in humans. these studies show that as a person carries out a working memory task, activity occurs in the prefrontal cortex (Courtney et al., 1998).
  - The figure shows that other than areas in the frontal lobe; areas in the parietal lobe & the cerebellum are involved in working memory.

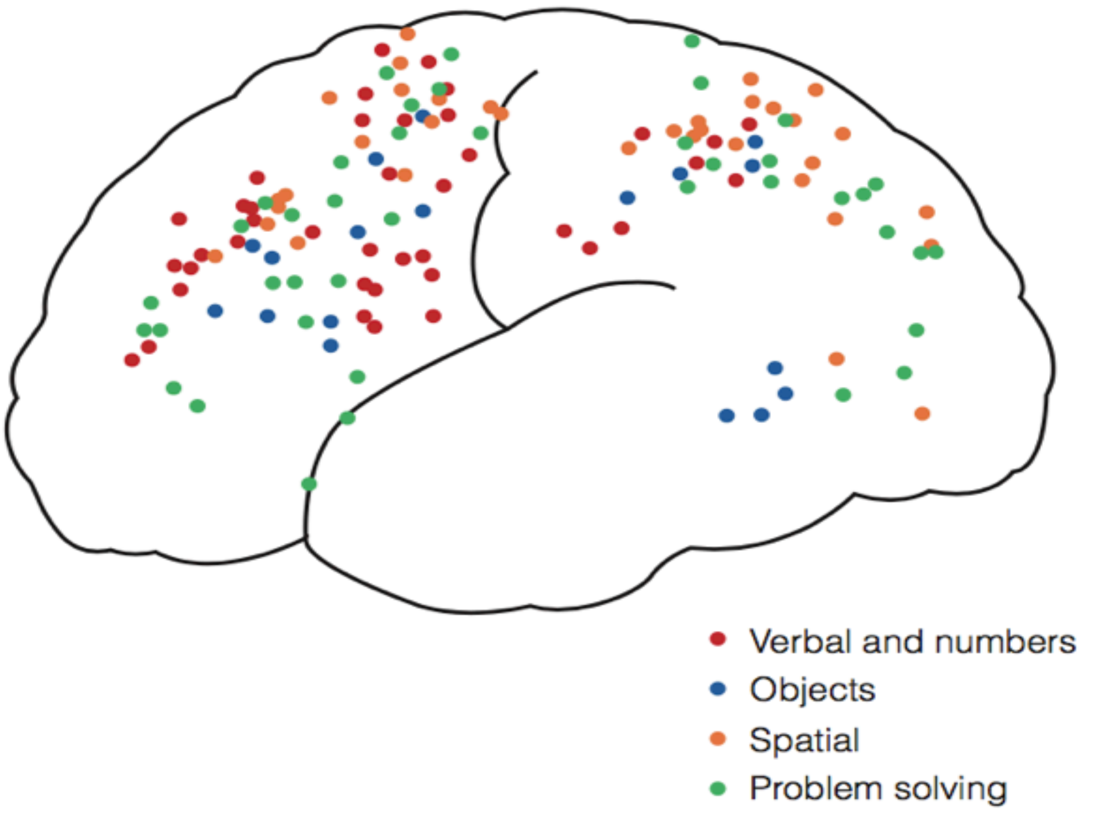


FIGURE 5.26 Some of the areas in the cortex that have been shown by brain imaging research to be involved in working memory. The colored dots represent the results of more than 60 experiments that tested working memory for words and numbers (red), objects (blue), spatial location (orange), and problem solving (green). (Source: R. Cabeza & L. Nyberg, "Imaging Cognition II: An Empirical Review of 275 PET and fMRI Studies," *Journal of Cognitive Neuroscience, 12*, 1–47, 2000.)

Image: Goldstein (2010).Cognitive Psychology: Connecting Mind, research & Everyday Experience. *Wadsworth Publishing*. (Fig. 5.26, p. 140).

- Vogel & cowokers (2005) did an experiment on the allocation of attention by measuring a component of the event related potential (ERP) in humans, recorded during a working memory task.

- The response they measured was related to encoding items in working memory, so a larger ERP response indicated that more space was used in working memory.

- Vogel & colleagues separated participants into two groups based on their performance on a test of working memory.
    - Participants in the high WM capacity group were able to hold a umber of items in the working memory; participants in the low WM capacity group were able to hold fewer items in the working memory.

- Bothe groups viewed the stimuli as shown in figure (); they first saw a cue indicating whether to direct their attention to the red rectangles on the left side or the red rectangles on the right rectangles on the right side of the displays that followed.

- they then saw a memory display for 1/10th of a second, followed by a brief blank screen & then a test display.

- On some trials, two red rectangles were presented on the left & right sides of the display, as shown in fig (); on the other trials two red rectangles & two blue rectangles were presented.

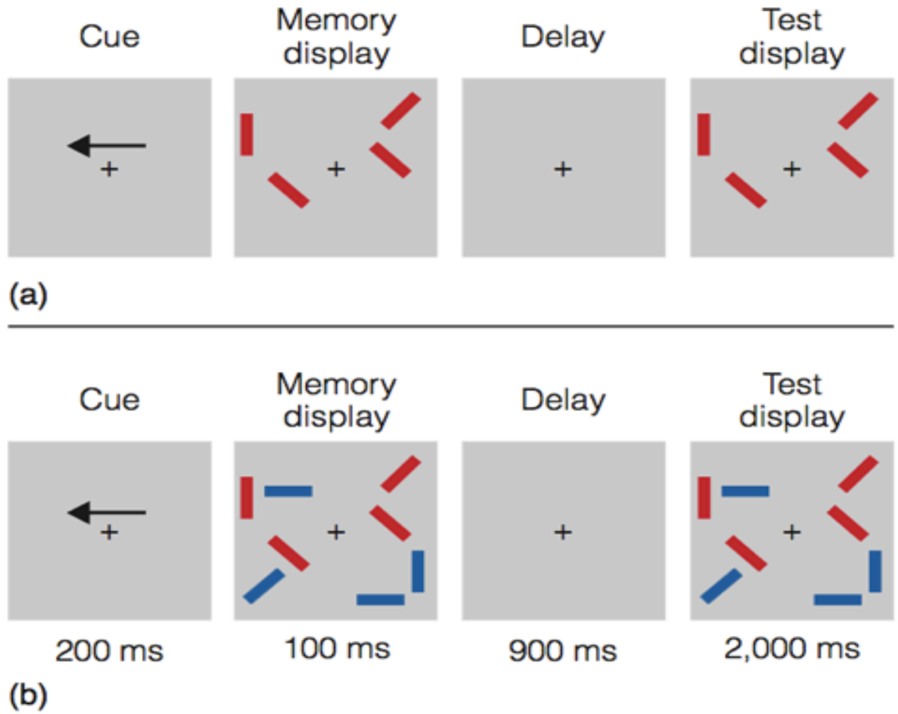


FIGURE 5.27 Sequence for the Vogel et. al (2005) task. The arrow in this example tells the participant to pay attention to the left side of the memory and test displays. The task is to indicate if the red rectangles on the attended side are the same or different in the two displays. (a) Display with two red rectangles on each side of the display. (b) Display with two blue rectangles added to each side. The participant is told to ignore the blue rectangles. (Source: Based on E. K. Vogel, A. W. McCollough, & M. G. Machizawa, "Neural Measures Reveal Individual Differences in Controlling Access to Working Memory," *Nature* 438, 500–503, 2005.)

Image: Goldstein (2010).Cognitive Psychology: Connecting Mind, research & Everyday Experience. *Wadsworth Publishing*. (Fig. 5.27, p. 140).

- The participant’s task was to respond to the test display by indicating whether the orientations of the red rectangles in the cued side of the test display was the same or different from the orientations of the red rectangles on the cued side of the memory display.

- the results show the size of the ERP response for both groups.

  - the left pair of bars show that the ERP response when just red rectangles were presented was similar for both groups of participants; however the right pair of bars indicate that adding blue rectangles had little effect on the response of the high capacity group; but it caused an increase in the response of the low capacity group.

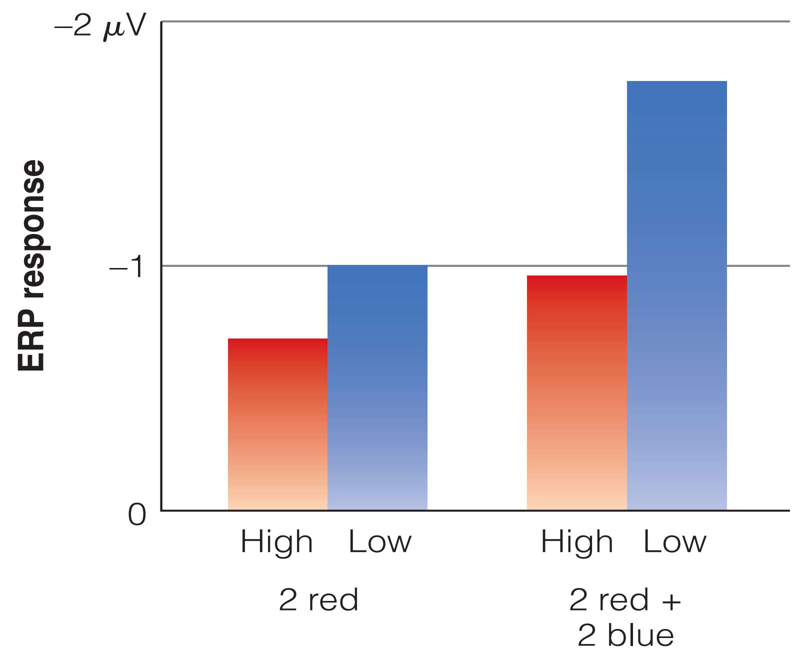


FIGURE 5.28 Results of the Vogel et al. (2005) experiment. The key finding is that performance is about the same for high- and low-capacity participants when only the red rectangles are present (left pair of bars), but although adding the two blue rectangles has little effect for the high-capacity participants, it causes an increase in the response for the low-capacity participants (right pair of bars). (Source: Based on E. K. Vogel, A. W. McCollough, & M. G. Machizawa, "Neural Measures Reveal Individual Differences in Controlling Access to Working Memory," *Nature 438,* 500–503, 2005.)

Image: Goldstein (2010).Cognitive Psychology: Connecting Mind, research & Everyday Experience. *Wadsworth Publishing*. (Fig. 5.28, p. 141).

- The fact that adding the two blue rectangles had little effect n the response of the high capacity group means that these participants were very efficient at ignoring the distracters, so the irrelevant blue stimuli did not take up any space in working memory. This means that the central executive was functioning well for these participants.

- The fact that adding the two blue rectangles caused a large increase in the response of the low capacity group means the these participants were not able to ignore the irrelevant blue stimuli, & the blue rectangles were therefore taking up space in working memory the central executive of these participants was not operating as efficiently as that of the high capacity group.

- Vogel & colleagues concluded that some people’s central executives are better at allocating attention than others.

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- Goldstein (2010).Cognitive Psychology: Connecting Mind, research & Everyday Experience. *Wadsworth Publishing*.

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Course Title:

Basic Cognitive Processes

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Lecture 33: Memory - V

Types of Long Term Memory

- The two main division of LTM are **explicit memory** & **implicit memory.**

- **Explicit Memory** consists of **episodic memory**, i.e. memory for personal experiences and **semantic memory** i.e. stored knowledge and memory for facts.

- **Implicit Memories** are memories that are used without awareness, so the contents of implicit memories cannot be reported (Smith & Grossman, 2008).

- Implicit Memories are of three types:
  - **Priming** - change in response to a stimulus caused by the previous presentation of the same or a similar stimulus. an example of priming would be finding it easier to recognise words that are familiar or that have been recently seen compared to words that have been rarely encountered.
  - **Procedural Memory**: is the memory for doing things. e.g. typing notes
  - **Classical Conditioning** is a form of learned memory.

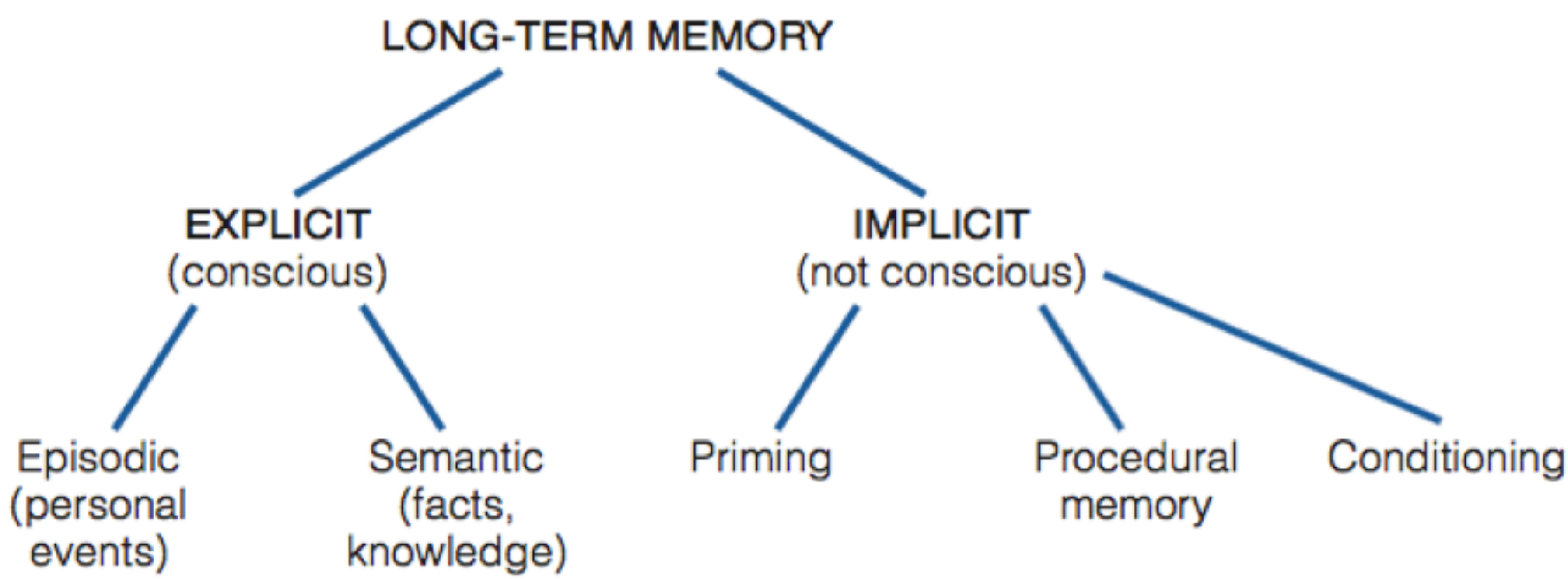


FIGURE 6.6 Long-term memory can be divided into explicit memory and implicit memory. We can also distinguish between two types of explicit memory, episodic and semantic. There are a number of different types of implicit memory. Three of the main types are priming, procedural memory, and conditioning.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, researh & Everyday Experience. *Wadsworth Publishing.* (Fig. 6.6, p. 156)

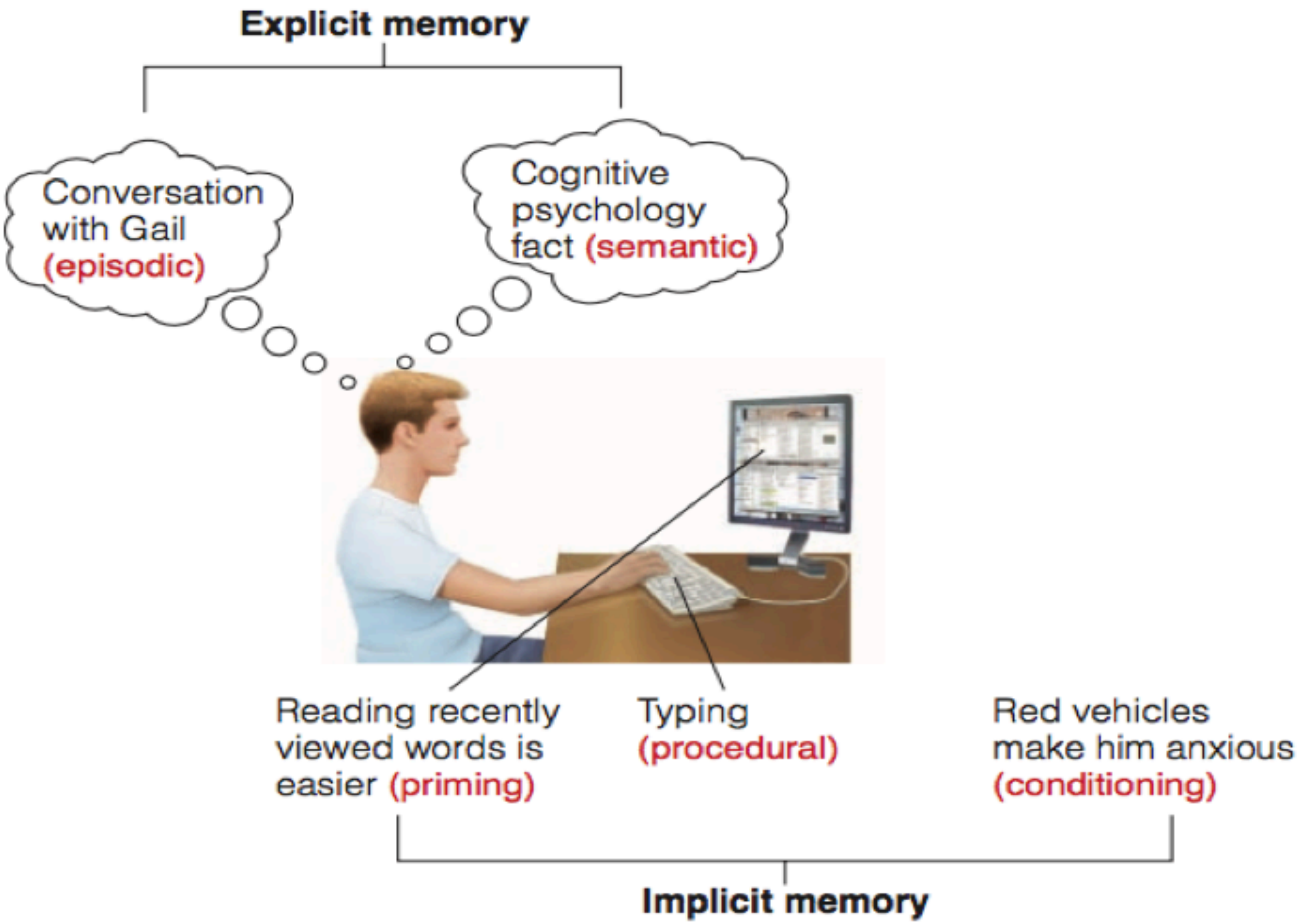


FIGURE 6.7 Cliff is experiencing two types of explicit memory (episodic and semantic), and his behavior is being influenced by three types of implicit memory (priming, procedural, and conditioning).

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, researh & Everyday Experience. *Wadsworth Publishing.* (Fig. 6.7, p. 157)

Episodic and Semantic Memory (Explicit)

- Acc. to Tulving, the defining property of the experience of episodic memory is that it involves **mental time travel** - the experience of traveling back in time to reconnect with events that happened in the past. For e.g. One can travel back on the evening in 2011 when India won the cricket world cup.

- Tulving describes this experience of mental time travel/ episodic memory as self - knowing or remembering.

- In contrast to the mental time travel property of episodic memory, the experience of semantic memory involves accessing knowledge about the world that does not have to be tied to remembering a personal experience.

- This knowledge can be of things like facts, vocabulary, numbers & concepts. When we experience, *semantic memory*, we are not traveling back in time to a specific event from our past, but we are accessing things that we 'know' about.

- **The Separation of Episodic & Semantic Memories**
  - **Neuropsychological Evidence**: We first consider the case of K.C., who at the age of 30 rode his motorcycle off a freeway exit ramp and suffered severe damage to his hippocampus and surrounding structures (Rosenbaum et al., 2005).
  - As a result of this injury, K.C. lost his episodic memory - he can no longer relive any of the events of his past.
  - However, he knows, that certain things happened which would correspond to semantic memory.

- He is aware of the fact that his brother died two years ago, but is not aware of the things related to his brother's death & those circumstances that he experienced then; like hearing of the situations of his brother's death etc.
- K.C. also remembers facts like where the eting utensils are located in the kitchen and the difference between a strike and a spare in bowling.
- Thus, K.C. has lost the episodic part of his memory, but his semantic memory is largely intact.

- An opposite case was that of an Italian woman who was in normal health until she suffered an attack of encephalitis at the age of 44 (De Renzi et al., 1987).
- The first signs of the problem were headaches ^ a fever, which were later followed by hallucinations lasting for upto 5 days.
- When she returned home after a 6 - week stay in the hospital, she had difficulty in recognising familiar people; she had trouble shopping because she could not remember the meaning of words on the shopping list or where things were in the store.

- She could no longer recognise famous people or recall facts such as the identity of Beethoven or the fact that Italy was involved in World War II. AA of these are semantic memories.

- Despite this severe impairment of memory for semantic information, she was still able to remember events in her life.

- She could remember what she had done during the day & things that had happened weeks or months before.

- Thus, although she had lost semantic memories, she was still able to form new episodic memories.

- These cases taken together, demonstrate a double dissociation between episodic memory and semantic memory, which supports that idea that memory for these two types of information probably involves different mechanisms.

TABLE 6.2 Dissociations of Episodic and Semantic Memory

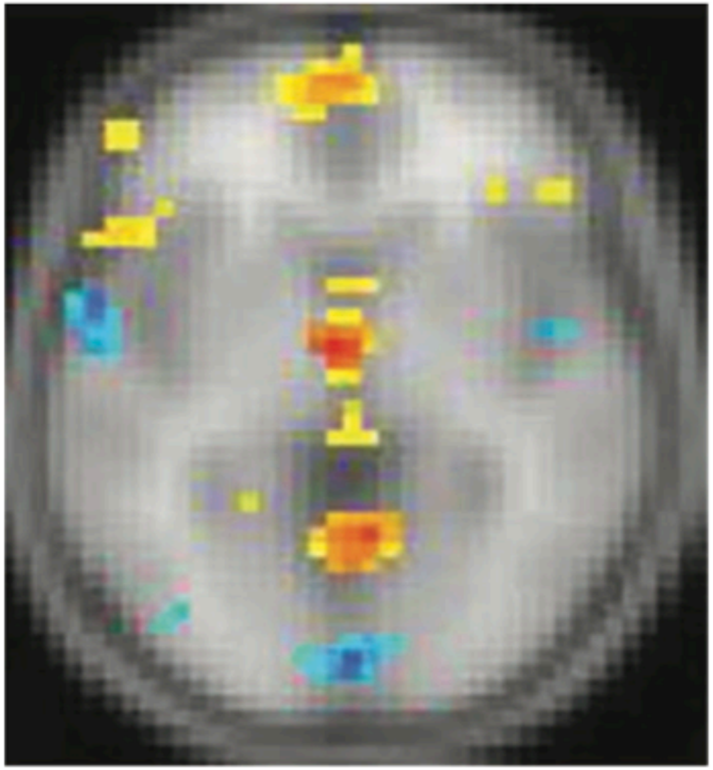
	Semantic	Episodic
K.C.	OK	Poor
Italian woman	Poor	OK

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, researh & Everyday Experience. *Wadsworth Publishing.* (Table 6.2, p. 159)

- **Brain Imaging Evidence:** Evidence for separate mechanisms has also been provided by the results of brain imaging experiments.

- Levine et al., (2004) had participants keep diaries on audiotape describing every day personal events (example: “It was the last night our Salsa dance class…”) & facts drawn from their semantic knowledge (“By 1947, there were 5,000 Japanese Canadian living in Toronto.”).

- When the participants later listened to these audiotaped descriptions while in an MRI scanner, the recordings of everyday events elicited detailed episodic autobiographical memories (people’s own experiences); while the other recordings simply reminded people of facts.



● **FIGURE 6.8** Brain showing areas activated by episodic and semantic memories. The yellow areas represent brain regions associated with episodic memories; the blue areas are regions associated with semantic memories. (Source: B. Levine et al., "The Functional Neuroanatomy of Episodic and Semantic Autobiographical Remembering: A Prospective Functional MRI Study," *Journal of Cognitive Neuroscience, 16,* 1633–1646, 2004 , MIT Press Journals.)

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, researh & Everyday Experience. *Wadsworth Publishing.* (Fig. 6.8, p. 159)

- The results of the experiment indicated that while there is overlap between activation caused by episodic and semantic memories, there are major differences.

- Other research has also found differences between the ares activated by episodic and semantic memory (Cabeza & Nyberg, 2000).

- **Connections between episodic and semantic memories :** The distinction between episodic and semantic memories have been extremely useful for understanding memory mechanisms.

- Although episodic & semantic memories have been shown to be connected in a variety of ways.

- For e.g. when we are learning facts (potential semantic memories), we are usually simultaneously having a personal experience such as sitting in the class or studying in the library.

- **Episodic Memories Can Be Lost, Leaving Only Semantic Memories**: One can remember a lot of times important semantic information for example that the Parliament of India consists of the Lok Sabha & the Rajya Sabha in a Civics Class.
- Years later, one might still know these facts about the parliament but forget about the situations where you learned these facts.

- **Semantic Memory Can Be Enhanced If Associated With Episodic Memory:** For example: If knowledge about the facts associated with high school graduation has personal significance, it will be remembered better.

- Westmacott & Moscovitch (2003) showed that participants have better recall for names of public figures, such as actors, singers & politicians, whom they associate with personal experiences.

- **Semantic Memory Can Influence Our Experience by Influencing Attention:** For example: Abhishek & Aditi are watching a game of cricket.

- Later, Aditi remembers the details of the play, for example the Batsman X was caught on square leg while playing a pull shot to a spinner. However, Abhishek does not remember this information, he just remembers that the batsman got out.

- Aditi could recall better because she was the member of the college girls cricket team while Abhishek hs never been fond of cricket much.

Priming, Procedural Memory & Conditioning

- **Priming:** occurs when the presentation of one stimulus (the priming stimulus) changes the response to a subsequent test stimulus (the test stimulus), either positively or negatively, which causes an increase in speed or accuracy of the response to the test stimulus or decrease in the speed or accuracy of the response.

- One type of positive priming, **repetition priming,** occurs when the test stimulus is the same oas or resembles the priming stimulus. For example: seeing the word *bird* may cause you to respond more quickly to another representation of the word *bird* than to a word you had not seen.

- ***Conceptual Priming*** occurs when the enhancement caused by the priming stimulus is based on the meaning of the stimulus. For example, presentation of th word *furniture* might cause you to respond faster to a later presentation of the word chair.

- Many experiments have been done in which researchers have demonstrated implicit memory using techniques. An example is provided by an experiment by Peter Graf & coworkers (1985), who tested three groups of participants: 1) eight amnesia patients with Korsakoff's syndrome and two patients another form of amnesia 2) patients without amnesia who were under treatment for alcoholism and 3) patients without amnesia who had no history of alcholism.

- Graf & coworkers presented list of words to their participants and asked them to rate each word on a scale of 1 to 5 based on how much they liked each word (1 = like extremely; 5 = dislike extremely).

- This caused participants to focus on rating the words rather than on committing the words to memory.

- Immediately after rating the words in the lists, participants were tested in one of two ways: (1) a test of explicit memory, in which there were asked to recall the words they had seen & (2) a test of implicit memory, in which they were presented with 3 - letter fragments and were asked to add a few letters to create the first word that came to their mind.

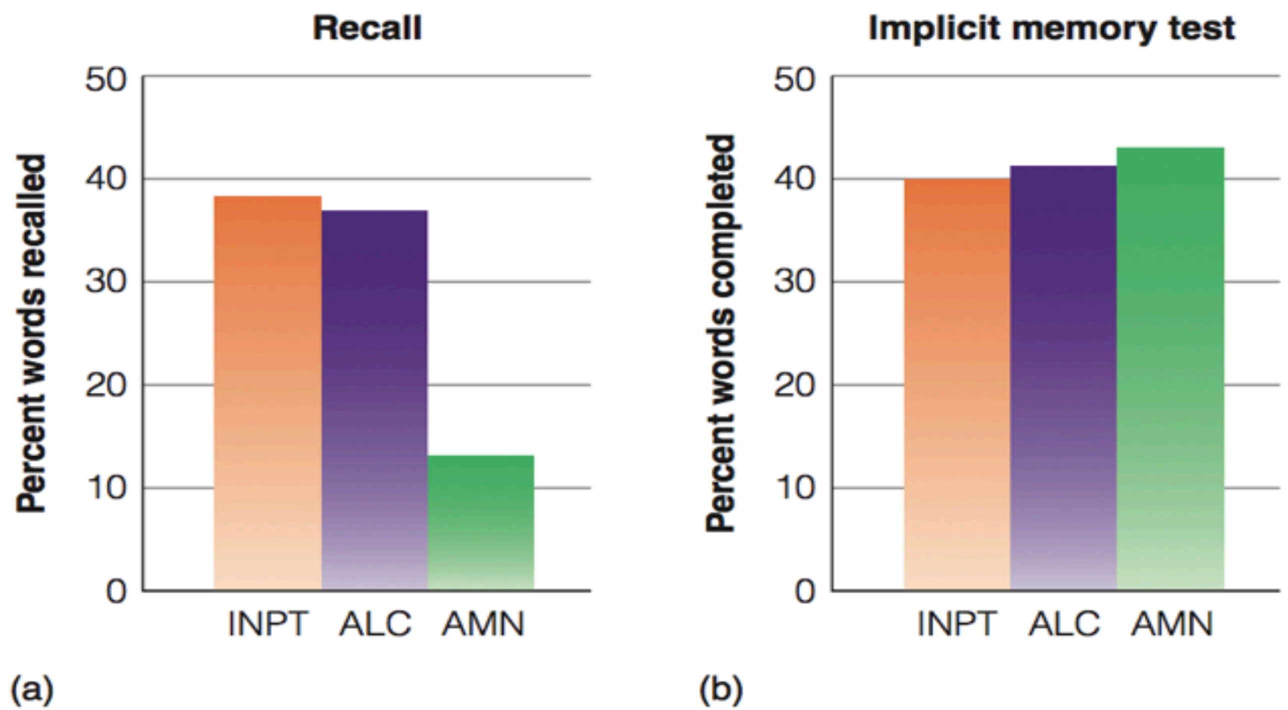


FIGURE 6.10 Results of the Graf et al. (1985) experiment. (a) The results of the recall test indicate that the amnesic patients (AMN) did poorly on the test compared to the medical inpatients (INPT) and the alcoholic controls (ALC). (b) The results of the implicit memory test, in which the task was to complete three-letter word stems, shows that the amnesic patients performed as well as the other patients. (Source: P. Graf, A. P. Shimamura, & L. R. Squire, "Priming Across Modalities and Priming Across Category Levels: Extending the Domain of Preserved Function in Amnesia," *Journal of Experimental Psychology: Learning, Memory, and Cognition, 11*, 386–396, 1985.)

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, researh & Everyday Experience. *Wadsworth Publishing.* (Fig. 6.10, p. 162)

- The results of the recall experiment showed that the amnesia patients had poor recall compared to the two control groups.

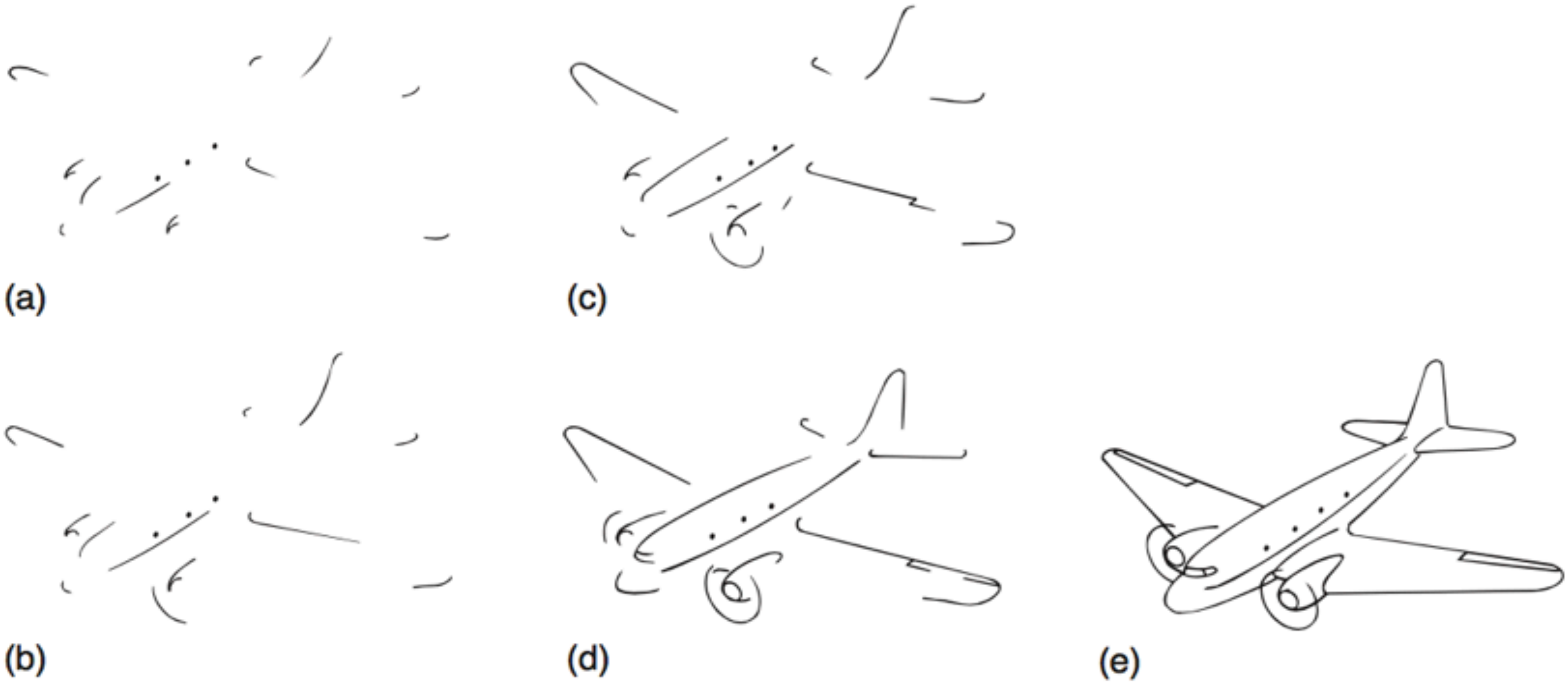
- This poor recall confirms the poor explicit memory associated with their amnesia.

- But the result of the implicit memory test, tells a different story: these results indicate the percentage of primed words that were created in the word completion test; demonstrates that the amnesia patient performed just as well as the controls.

- This shows that priming can occur even when there is little explicit memory for words.

- Another example, of repetition priming in a person with brain damage was presented in an experiment by Warrington & Weiskrantz (1968), who tested 5 patients with Korsakoff's syndrome.

- The researchers presented incomplete pictures, such as the ones in Fig 6.11 and the participants's task was to identify the picture.



● **FIGURE 6.11** Incomplete pictures developed by Gollin (1960) that were used by Warrington and Weiskrantz (1968) to study implicit memory in patients with amnesia.
(Source: E. K. Warrington & L. Weiskrantz, "New Method of Testing Long-Term Retention With Special Reference to Amnesic Patients," *Nature, London, 217,* March 9, 1968, 972–974, Figure 1. Copyright © 1968 Nature Publishing Group. Republished with permission.)

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, researh & Everyday Experience. *Wadsworth Publishing.* (Fig. 6.11, p. 163)

- The results shown in Fig 6.12 indicate that by the third day of testing these participants made fewer errors before identifying the pictures than they did at the beginning of training, even though they had no memory for any of previous day’s training.

- The improvement of performance represents an effect of implicit memory because the patients learned from experience even though they could not remember having the experience.

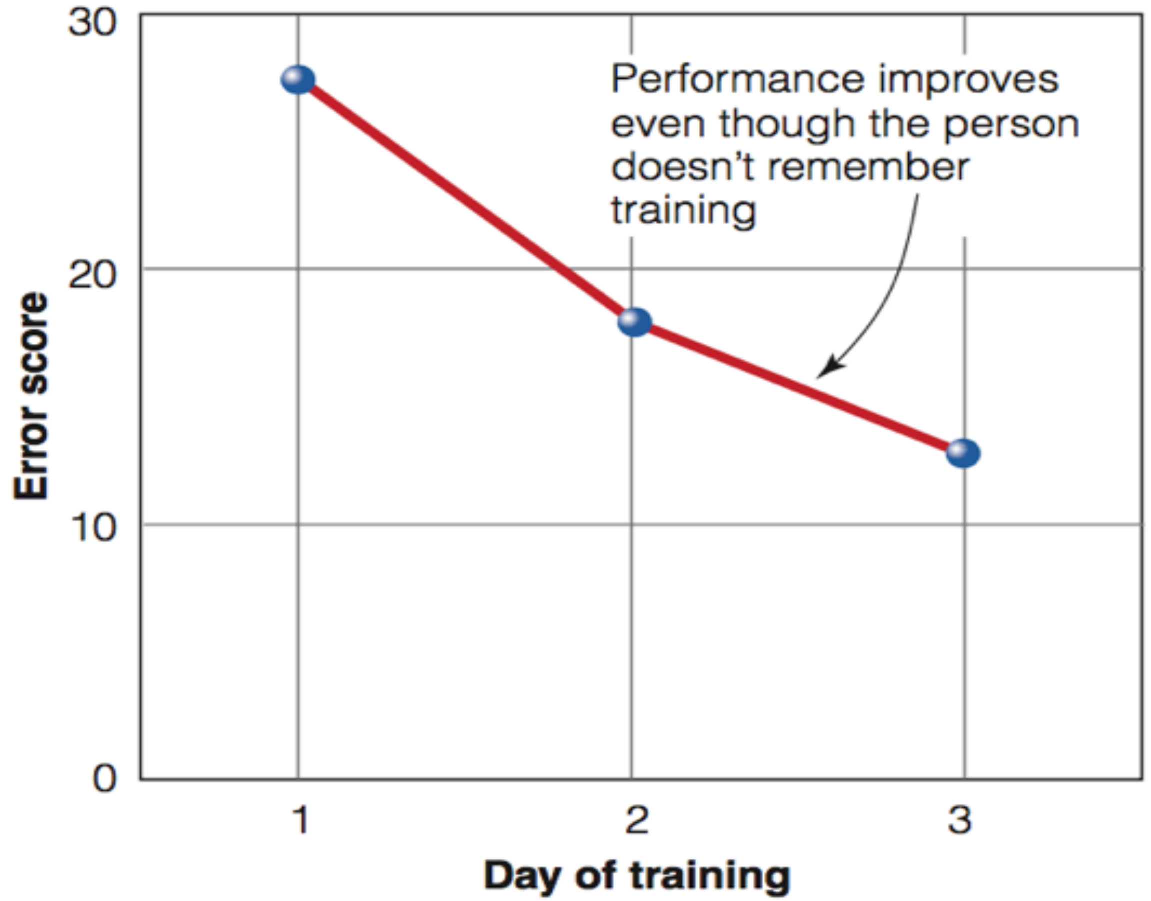


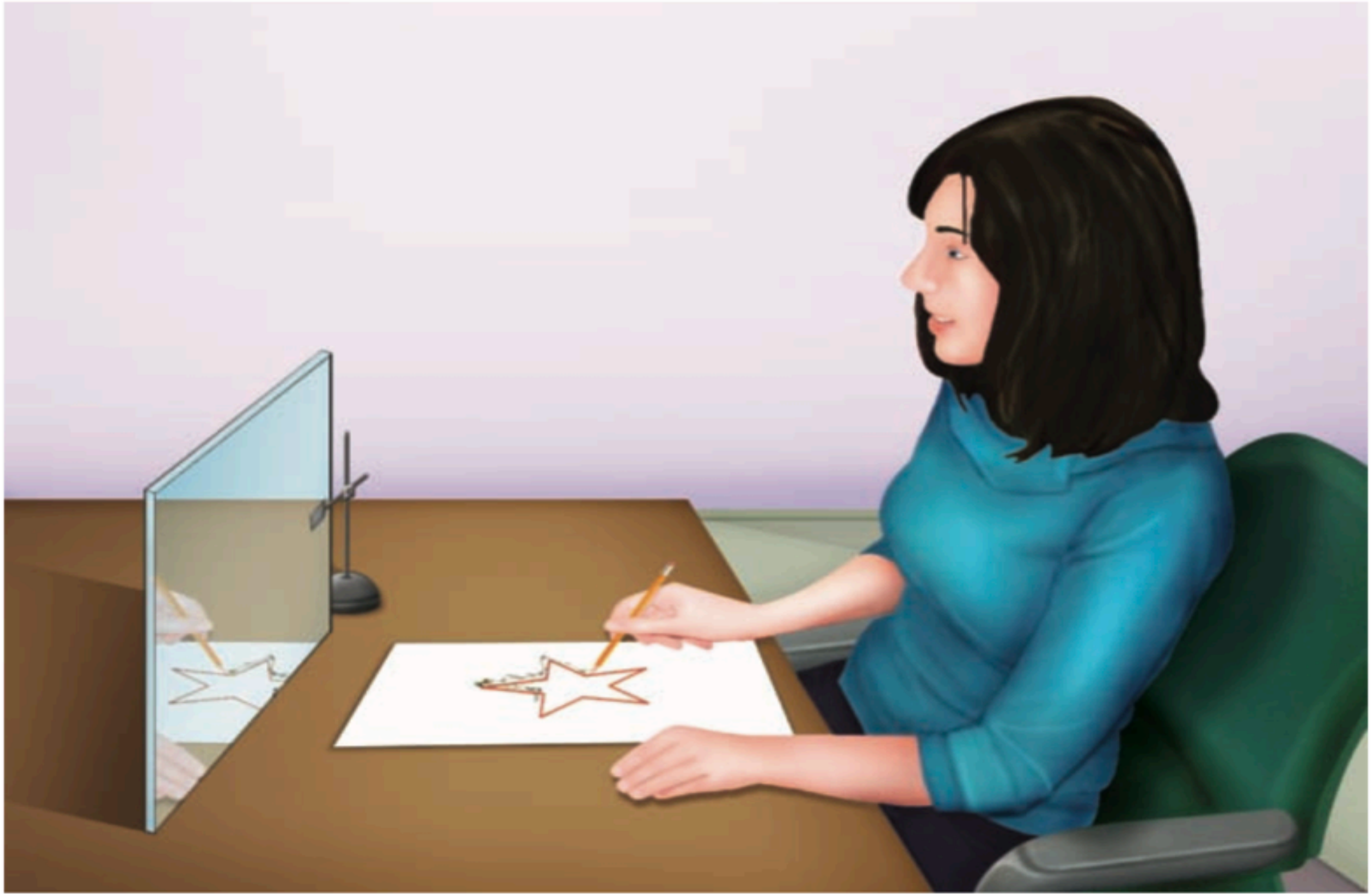
FIGURE 6.12 **Results of Warrington and Weiskrantz's (1968) experiment.** (Source: Based on E. K. Warrington & L. Weiskrantz, "New Method of Testing Long-Term Retention With Special Reference to Amnesic Patients," *Nature, 217*, 972–974, March 9, 1968.)

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, researh & Everyday Experience. *Wadsworth Publishing.* (Fig. 6.12, p. 163)

- **Procedural Memory**: Also called *skill memory* because it is memory for doing things that usually require action.

- The implicit nature of procedural memory has been demonstrated in amnesia patients who can master a skill without remembering any of the practice that led to this mastery. For example: H.M. practiced a task called *mirror drawing,* which involves copying a picture that is seen in mirror.

- After days of practice H.M. became quite good at mirror drawing, though each time he did it, he thought he was practicing for the first time.



● **FIGURE 6.13** Mirror drawing. The task is to trace the outline of the star while looking at its image in the mirror.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, researh & Everyday Experience. *Wadsworth Publishing.* (Fig. 6.12, p. 163)

- Other amnesia patients, as well also demonstrated no loss of procedural memory.
  - Jimmy G. could still tie his shoes.
  - Clive Wearing could still play piano.
  - K.C. , the middle – aged Italian woman, who had lost his episodic memory, now learned how to sort books in the library

- That Amnesic people can still retain skills learned in the past & even learn new skills, led to an approach of rehabilitating patients with amnesia by teaching them new tasks, that they can easily master, even though they cannot learn the episode of training (Bolognani et al., 2000; Clare & Jones, 2008).

- One can also understand the nature of implicit memory by examining their own experiences.
- For example: Do you remember how your learn to ride a cycle? Or to maintain balance while on the bike?

- **Classical Conditioning** occurs when the followingtwo kinds of stimuli are paired.
  - (a) a neutral stimulus that intially does not result in a response and
  - (b) a conditioning stimulus that results in a response.
- An example could be:
  - food > salivating response.
  - food + bell > salivating response.
  - bell > salivating response.

- Conditioning is evolutionary useful as it allows organisms to develop expectations that helps them prepare for contingencies (both good & bad).

References

- Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*

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Course Title:

Basic Cognitive Processes

By: Dr. Ark Verma,
Assistant Professor of Psychology,
Department of Humanities & Social Sciences,
IIT Kanpur

Lecture 34: Memory - VI

Long Term Memory Encoding & Retrieval

Making Memories?

- How do you make a memory?

STUDENT #1: The main technique I use to study is to make up a story in my mind, basically a fake memory, the type a person would use to create an effective lie, in order to remember material. An example of this strategy is how I studied for our first cognitive psych exam this semester. “Jo changed his name to Hermann Helmholtz today. Jo has always been an odd one. He always infers things are there that aren’t. Like the time he liked that girl Amygdala. Speaking of Amygdala, she was an emotional girl.” When I tell this story to myself I create an image, much like a memory to associate with what I am trying to remember. That way when I take the test an entire sequence of events is recalled so that I am better able to remember the information. (Elizabeth Eowyn Waibel, University of Wisconsin)

Excerpt: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. (p.172)

STUDENT #2: I like to go to class early and study in the classroom. To remember, I need to take notes from the book as I read. For certain harder classes, I remember better if I do this before class. Then during class I just add to my previous notes. This lets me listen more during class instead of being busy writing.... I like to start conversations with my parents or friends about what I've learned in class. They have usually learned something about it too, and remind me of details I may have forgotten. (Kristin Eddinger, Florida Atlantic University)

Excerpt: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. (p.172)

STUDENT #3: A technique I've used has been to find someone unsuspecting, perhaps a friend or family member, and teach them what I've learnt. I did this to a mate about 5 years ago, taught him about the structure of the tooth. To this day he remembers it and always reminds me of the time I jumped him with this "random" information! (Brigitte Dunbar, Massey University, Auckland, New Zealand)

Excerpt: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. (p.172)

STUDENT #4: My tactic is to go through my textbook (and lecture notes) and to create a sort of "tabbed" set of notes, where sub-concepts are tabbed underneath larger concepts. This follows the organization of textbooks to a degree … so I get something like Declarative Memory–Episodic–About events in our lives–Semantic–About facts.… After reading a few paragraphs, I write down what I learned, but first I have to figure out the major and minor points. But the most important part about this is it acts as a way to test myself. I can just throw a piece of paper over my notes and slowly move it down the page, and I try to recall what is "inside" a certain heading (and explain it to myself), and then I go down it line by line to check (if I missed a sub-heading, I try to recall what's under it, if anything). (Taylor Murphy, University of Alberta)

Excerpt: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. (p.172)

STUDENT #5: I read each chapter, take notes (sometimes word for word, or by short-hand) on my computer where I can organize them in a way that makes sense to me. Finally, I make note cards and study these. (Natalie Tyler, Georgia State University)

Excerpt: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. (p.172)

Rehearsal

- Getting information into memory needs rehearsal - i.e. the process of repeating information over & over.

- *maintenance rehearsal*: plainly repeating information to remember without analysing it for meaning or possible connections is called maintenance rehearsal.

- *elaborative rehearsal*: the more effective way of transferring information into LTM, involves thinking about the meaning of an item or attempting to connect the new information with prior knowledge.

- **Levels of Processing Theory:** Craik & Lockhart proposed the idea of *levels of processing* in 1972; according to which memory depends on how information is encoded, with "deeper" processing resulting in better encoding & retrieval than "shallow" processing.

- The basics: Acc. to the levels of processing approach, depth of processing is determined by the nature of the task during encoding.

DEMONSTRATION Remembering Lists

Part 1. Cover the list below and then uncover each word one by one. Your task is to count the number of vowels in each word and then go right on to the next one. Once you get to the end of the list, cover it and follow the instructions at the end of the list.

chair
mathematics
elephant
lamp
car
elevator
thoughtful
cactus

Instructions: Count backward by 3s from 100. When you get to 76, write down the words you remember. Do that now.

Excerpt: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. (Demo., p.174)

Part 2. Cover the list below and uncover each word one by one as you did in the previous part. This time, visualize how useful the item might be if you were stranded on an uninhabited island. When you get to the end of the list, follow the instructions.

umbrella
exercise
forgiveness
rock
hamburger
sunlight
coffee
bottle

Instructions: Count backward by 3s from 99. When you reach 75, write down the words you remember. Do that now.

Excerpt: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. (Demo, p.174)

- You would have noticed that the second process results in better memory.

- Craik & Lockhart's levels - of - processing theory states that memory depends on the depth of processing that an item receives.

- Shallow Processing involves little attention to meaning. Shallow processing occurs when attention is focused on physical features, such as whether a word is printed in lowercase or capital letters, or the number of vowels in a word etc.

- Deep Processing involves close attention, focusing on an item's meaning and relating it to something else (that you already know).

METHOD Varying Depth of Processing

The procedure for the Craik and Tulving experiment is diagrammed in ● Figure 7.1a. A question was presented, followed by a word, and then the participant responded. Shallow processing was achieved by asking questions about the word's physical characteristics; deeper processing was achieved by asking about the word's sound; and the deepest processing was achieved by a task that involved the word's meaning. The following examples are similar to those used in Craik and Tulving's experiment.

1. Shallow processing: A question about physical features of the word
   Question: Is the word printed in capital letters?
   Word: *bird*
2. Deeper processing: A question about rhyming
   Question: Does the word rhyme with *train*?
   Word: *pain*
3. Deepest processing: A fill-in-the-blanks question
   Question: Does the word fit into the sentence "He saw a ____________ on the street"?
   Word: *car*

Excerpt: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing.* (Demo, p.175)

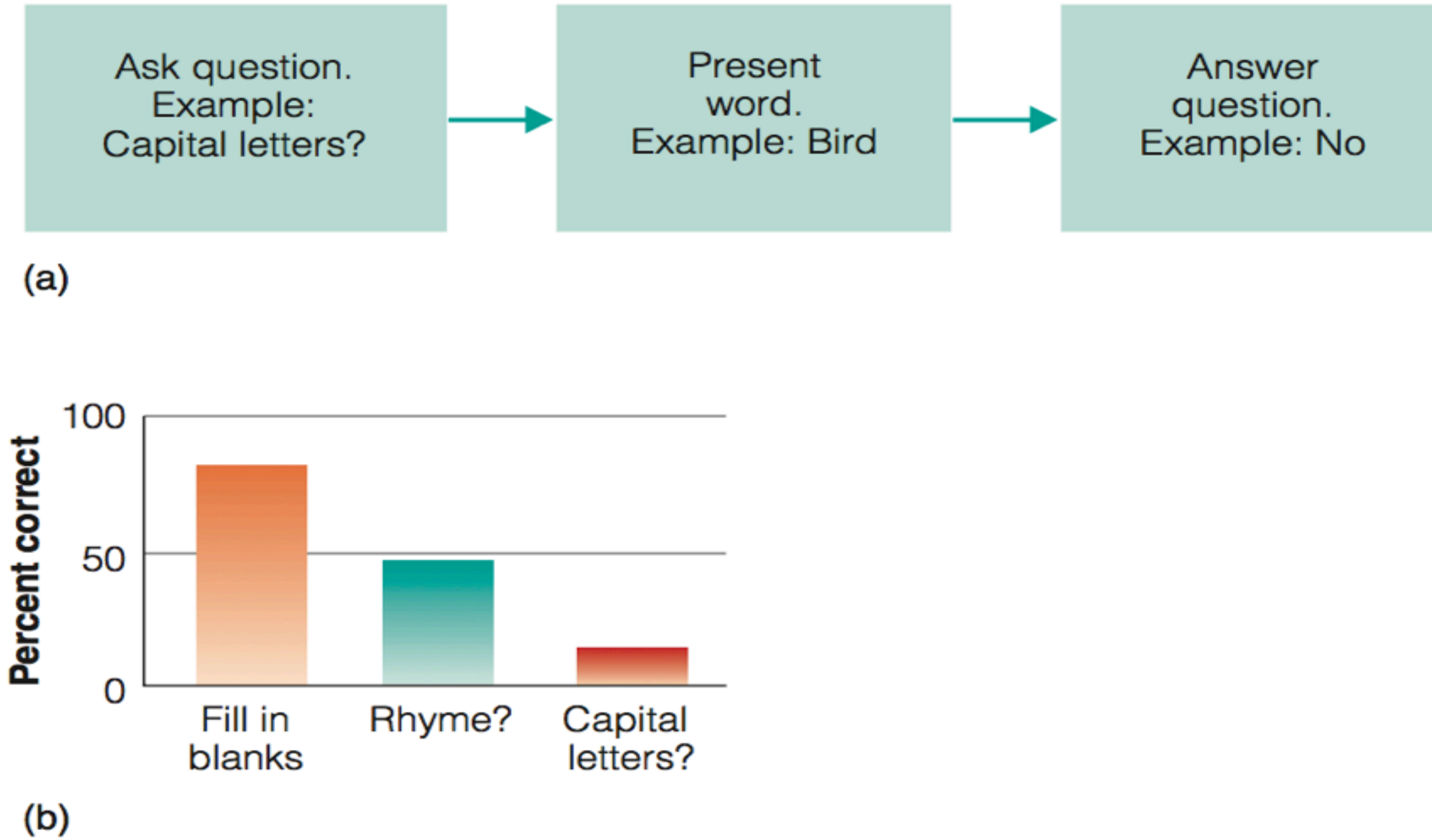
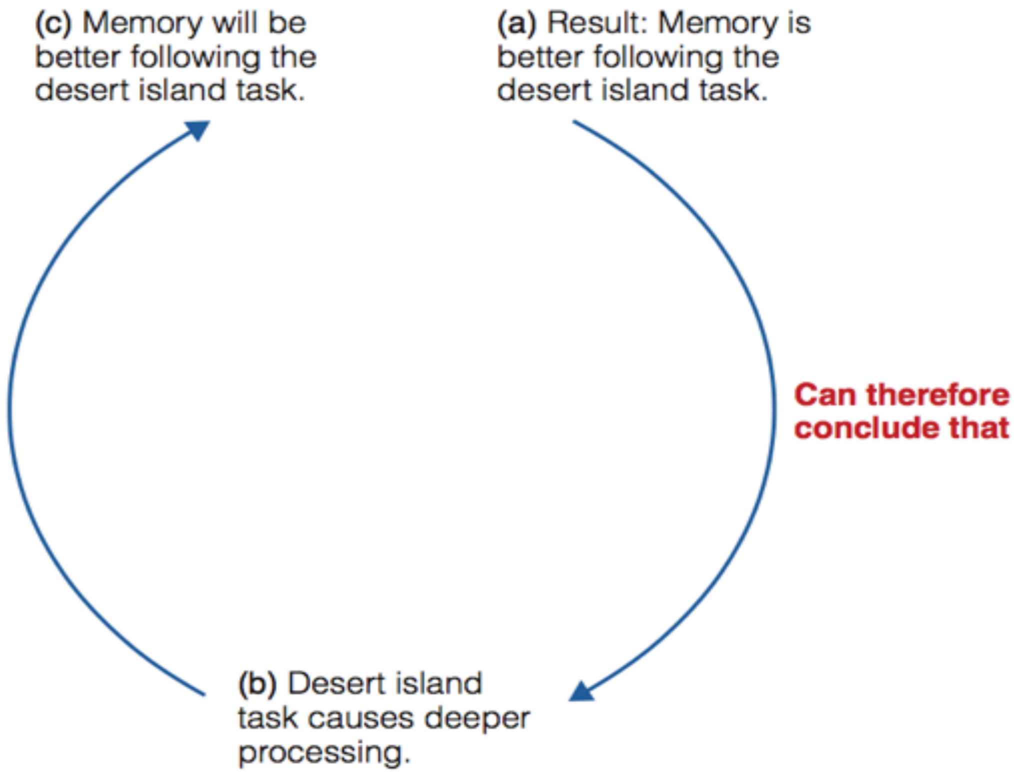


FIGURE 7.1 (a) Sequence of events in Craik and Tulving's (1975) experiment. (b) Results of this experiment. Deeper processing (fill-in-the-blanks question) is associated with better memory.

Excerpt: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. (Fig. 7.1, p.175)

- The difficulty: It's difficult to decide what leads to a particular depth of processing.



● **FIGURE 7.2** The circularity of defining depth of processing in terms of memory and then predicting that deeper processing will result in better memory. See text for details.

Excerpt: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. (Fig. 7.1, p.176)

Moving further: Encoding & Retrieval

- let us test how encoding influences retrieval, by varying types of encoding and how retrieval is affected.

- **Placing words in a complex sentence**: How to remember the word *chicken*?
    - 1. She cooked the chicken.
    - 2. The great bird swooped down and carried off the struggling chicken.
- Craik & Tulving (1975) found that memory for a word is much better when the word is presented in a complex sentence.
    - Apparently, most of the participants in Craik & Tulving's experiment found the giant bird sentence to be more memorable.

- **Forming Visual Images**: Bower & Winzenz (1970) decided to test whether using visual imagery - “images in the head” that connect words visually - can create connections that enhance memory.

- They used a procedure called paired - associate learning, in which a list of word pairs is presented. Later, the first word of each pair is [resented, and the participant’s task is to remember the word it was paired with.

- Bower & Winzenz presented a lis of 15 pairs of nouns, such as *boat-tree,* to participants for 5 seconds each.

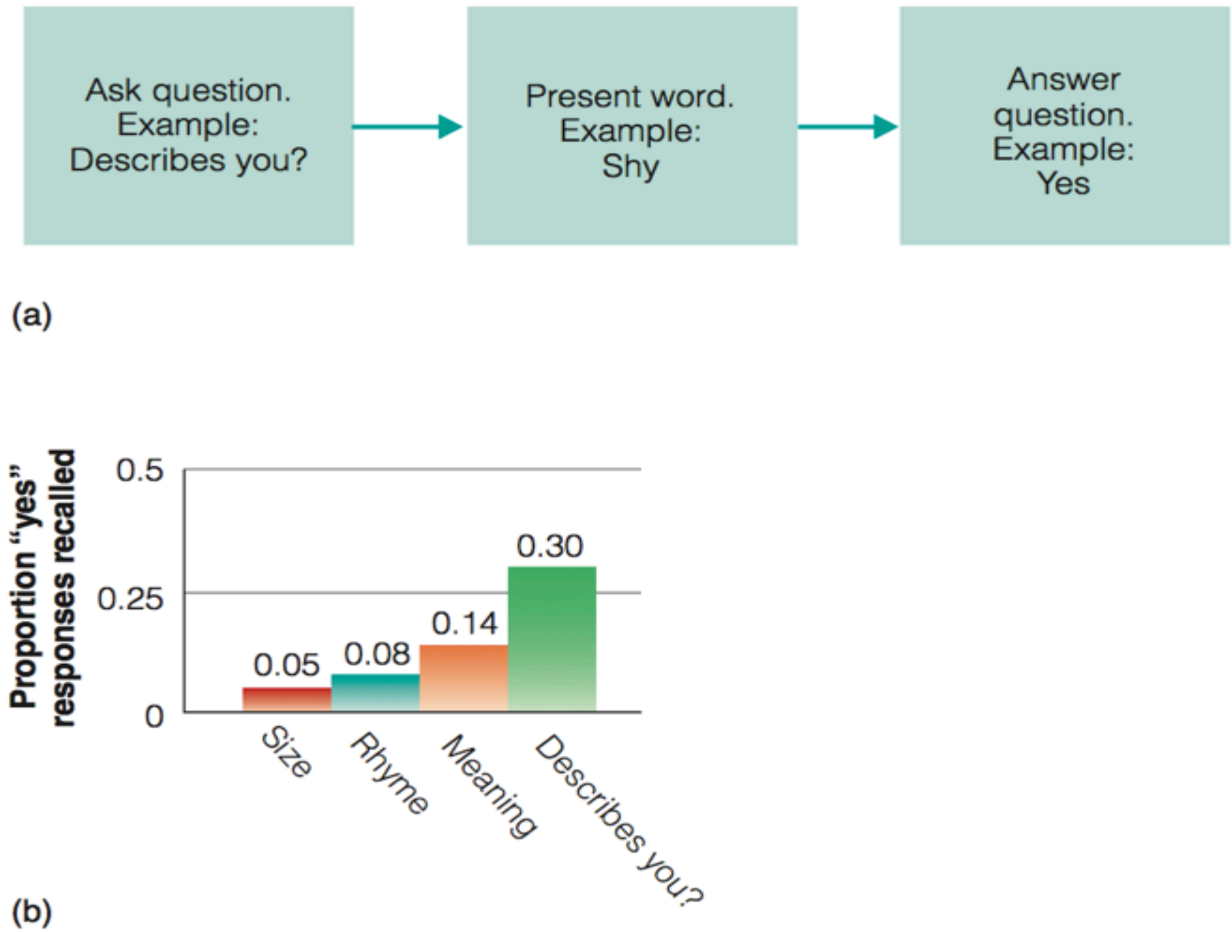
- One group was told to silent repeat the pairs as they were presented & another group was told to form a mental picture in which the two items were interacting.

- Which group remembered the words better?

- **Linking Words to Yourself**: An example of how ememory is improved by encoding is the *self - reference effect*, i.e. memory is better if you can relate the word/ information to be learned to yourself.

- Rogers & coworkers (1977) demonstrated this by using the same procedure Craik & Tulving had used in their depth - of - processing experiment.

- Here are examples of the four types of questions:
  - **1.** Physical characteristics of word “Printed in small case?
    Word: *happy*
  - **2.** Rhyming
    “Rhymes with *happy*?” Word: *snappy*
  - **3.** Meaning
    “Means the same as *happy*?” Word: *upbeat*
  - **4.** Self-reference “Describes you?” Word: *happy*



● **FIGURE 7.4** (a) Sequence of events in Rogers et al.'s (1979) self-reference experiment. This is the same as the design of Craik and Tulving's (1975) experiment shown in Figure 7.1, but some of the questions refer to the person being tested. (b) Results of the experiment. (Source: T. B. Rogers, N. A. Kuiper, & W. S. Kirker, "Self-Reference and the Encoding of Personal Information," *Journal of Personality and Social Psychology, 35*, 677–688, 1977.)

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. (Fig. 7.4, p.177)

- **Generating Information:** Generating material yourself, rather than passively receiving, enhances learning & attention.

- Slameka & Graf (1978) demonstrated this effect, called the *generation effect*, by having participants study a list of word pairs in two different ways:

- *Read* group: Read these pairs of related words.-> king - crown; horse - saddle; lamp - shade etc.

- *Generate* group: Fill in the blank with a word that is related to the first word. king - cr; horse -sa; lamp - sh etc.

- After either reading or generating the list of word pairs, they were presented with the first word in each pair and were told to indicate the word that went with it.

- **Organising Information**: The memory system also uses organisation to access information.

DEMONSTRATION Reading a List

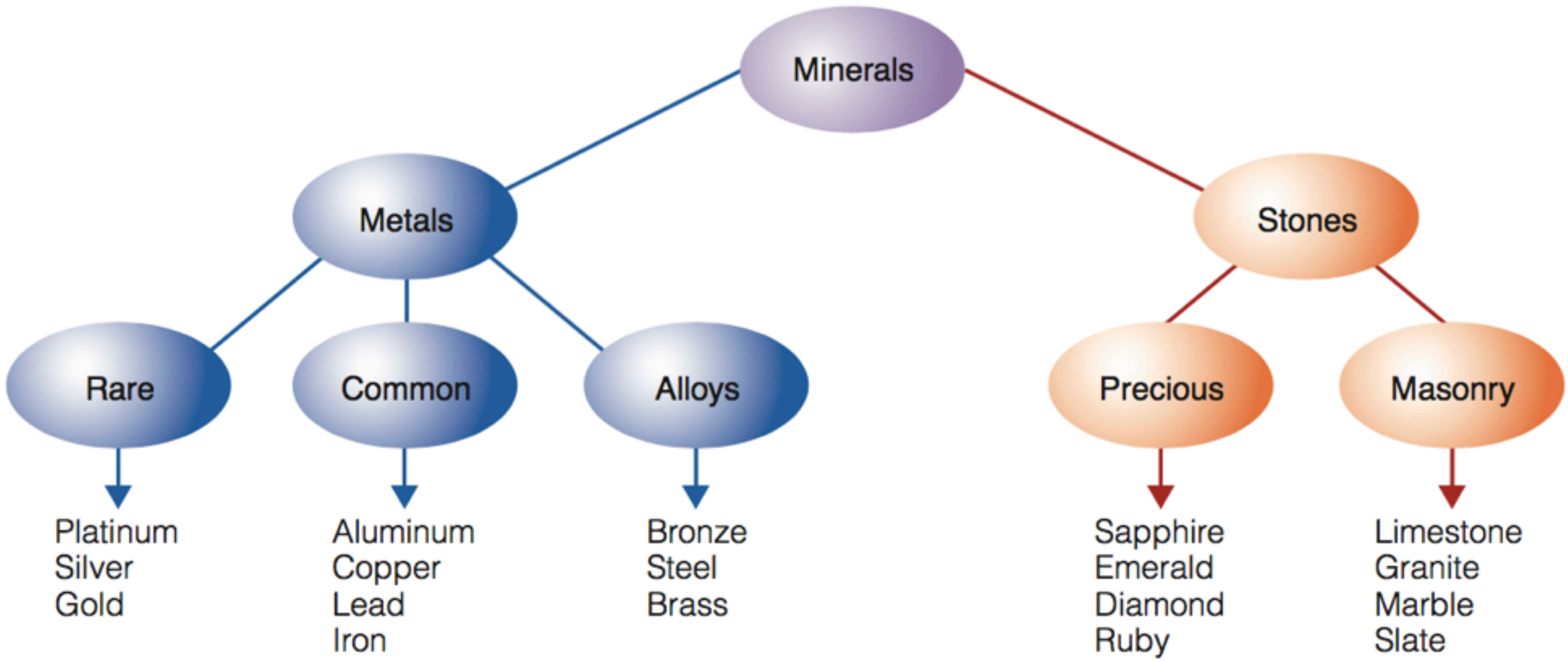
Get paper and pen ready. Read the following words, then cover them and write down as many as you can.

apple, desk, shoe, sofa, plum, chair, cherry, coat, lamp, pants, grape, hat, melon, table, gloves

STOP! Do the demonstration now, before reading further.

Excerpt: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. (Demo, p.178)

- The words are recalled better if they are grouped together.
- One reason is that remembering words by a category serves as retrieval cue for other words in that category.
- Bower & coworkers (1969) tested for memory of words which were presented in an organised manner from the beginning, during encoding. In from of an "organisational tree".



● **FIGURE 7.5** The "organizational tree" for minerals used in Bower et al.'s (1969) experiment on the effect of organization on memory. (Source: G. H. Bower et al., "Hierarchical Retrieval Schemes in Recall of Categorized Word Lists," *Journal of Verbal Learning and Verbal Behavior, 8,* Figure 1, 323–343. Copyright © 1969 Elsevier Ltd. Republished with permission.)

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. (Fig. 7.5, p.179)

- One group of participants studied four separate trees for mineral, animals, clothing, & transportation for 1 minute each and were then asked to recall as many words as they could from all four trees.

- In the recall test, participants tended to organise their responses in the same way as the trees were organised.

- Participants average an overall 73 words from all four trees.

- Another group of participants also saw four trees, but the words were randomised such that each tree contained a random assortment of minerals, animals, clothing and transportation.

- These participants were able to remember only 21 words from all four trees.

- Thus organising material to be remembered results in substantially better recall.

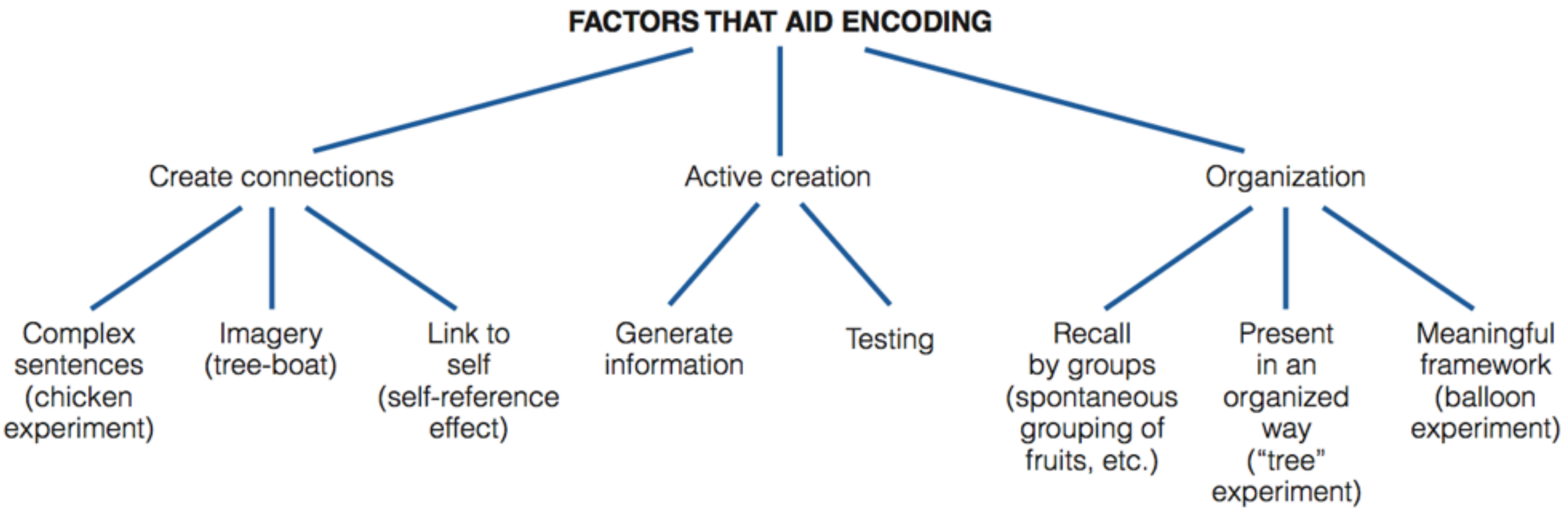


FIGURE 7.6 The organizational tree for some of the material about encoding presented in this section of the chapter.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. (Fig. 7.6, p.179)

- **Testing:** Recent research shows that being tested on the material being learnt results in better recall than rereading the material.

- Roediger & Karpicke (2006) demonstrated the advantages of testing.

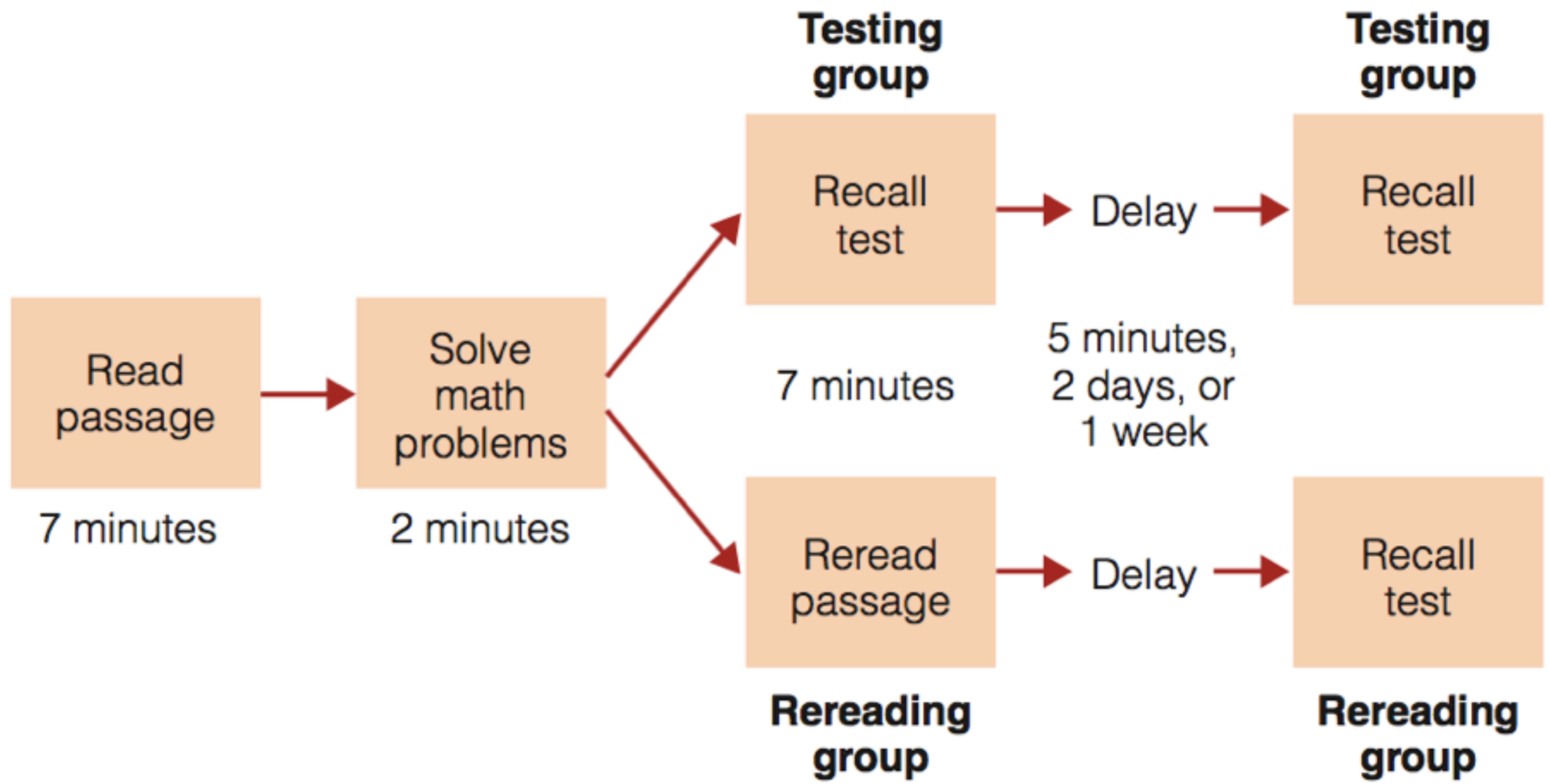


FIGURE 7.8 Design of the Roediger and Karpicke (2006) "testing effect" experiment.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. (Fig. 7.8, p.180)

- In the first phase of the experiment, college students read prose passages for 7 minutes followed by a 2 - minute break during which they solved math problems.
- Then one group took a 7 minute recall test in which they were asked to write down as much of the passage as they could remember, in no particular order.
- The other group were given 7 minutes to re-read the material.

- In the second phase of the experiment, which occurred after a delay of either 5 minutes, 2 days, or 1 week participants were given the recall test in which they wrote down what they remembered from the passage.
- The results show that there was little difference between the two groups after 5 minute delay; but the testing group was much better in performance after 2 day & 1 week delays. This is the **testing effect.**

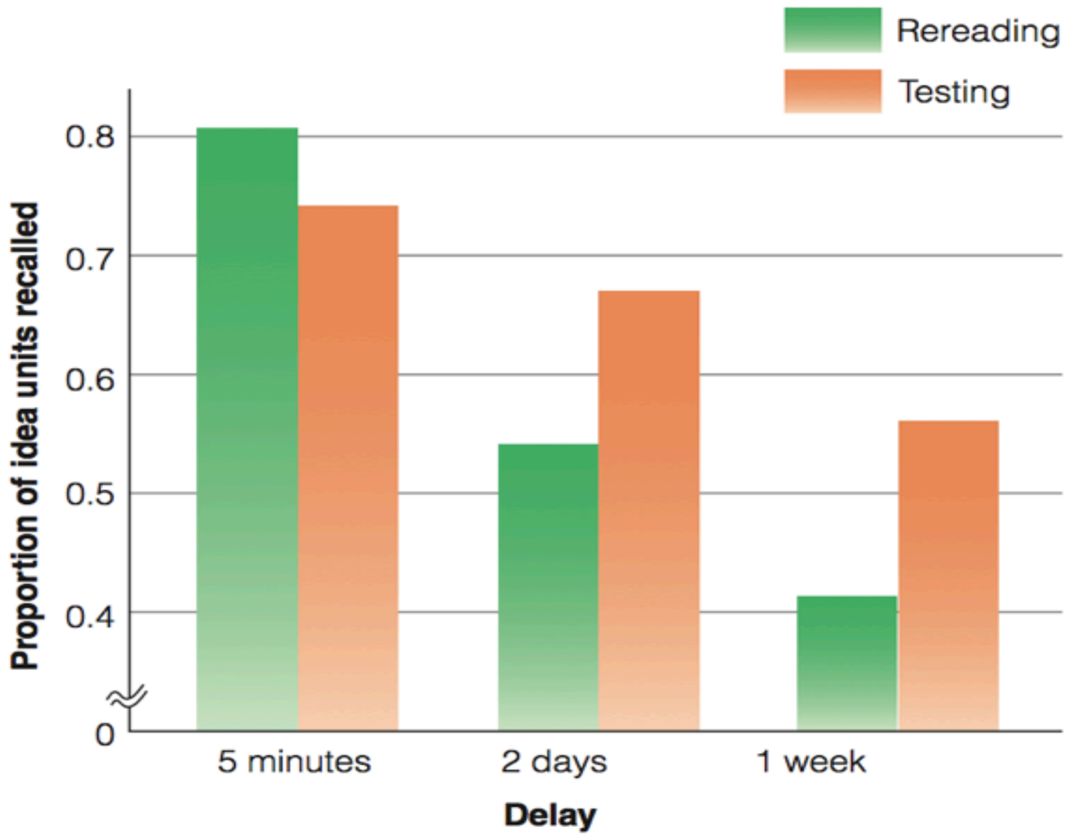


FIGURE 7.9 Results of the Roediger and Karpicke (2006) experiment. Note that at longer times after learning, the performance of the testing group is better than the performance of the rereading group. (Source: H. L. Roediger & J. D. Karpicke, "Test-Enhanced Learning: Taking Memory Tests Improves Long-Term Retention," *Psychological Science, 17*, 249–255, 2006. Reprinted by permission of John Wiley & Sons, Inc.)

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. (Fig. 7.9, p.181)

To Sum Up

TABLE 7.1 Encoding Procedures That Affect Retrieval

Condition	Experiment/Result
Word in complex sentence	Better memory for a word ("chicken") used in a complex sentence (more detailed description of the word)
Forming visual image	Pairs of words remembered better if images formed (compared to just reading word pairs)
Linking to self	Words associated with self are remembered better (self-reference effect)
Generating information	Memory better if second word of a word pair is generated by the person, compared to just being presented with the word (generation effect)
Organizing information	Studying information that is organized, as in a "tree," results in better memory; presenting information so organization is difficult ("balloon" story) results in poor memory
Testing	Testing following learning results in better memory than rereading material after learning (testing effect)

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing.* (Table 7.1, p.181)

References

- Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing. 4th ed.*

Indian Institute of Technology
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Course Title:

Basic Cognitive Processes

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Lecture 35: Memory - VII

Retrieval

- Retrieval Cues are words or other stimuli that help us remember information stored in our memory. For e.g. location.

When I was 8 years old, both of my grandparents passed away. Their house was sold, and that chapter of my life was closed. Since then I can remember general things about being there as a child, but not the details. One day I decided to go for a drive. I went to my grandparents' old house and I pulled around to the alley and parked. As I sat there and stared at the house, the most amazing thing happened. I experienced a vivid recollection. All of a sudden, I was 8 years old again. I could see myself in the backyard, learning to ride a bike for the first time. I could see the inside of the house. I remembered exactly what every detail looked like. I could even remember the distinct smell. So many times I tried to remember these things, but never so vividly did I remember such detail. (Angela Paidousis)

Excerpt: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (p. 182)

- Recall Methods:

  - Free recall: a participant is simply asked to recall stimuli. This stimuli could be words previously presented or events experienced earlier in the participant's life.

  - Cued Recall: the participant is presented with retrieval cues to aid in recall of the previously experienced stimuli. This cues are typically words or phrases.

  - For example: Tulving & Pearlstone (1966) did an experiment in which they presented participants with a list of words to rmremember; which were drawn from specific categories. The memory test used was either a free or a cued recall one.

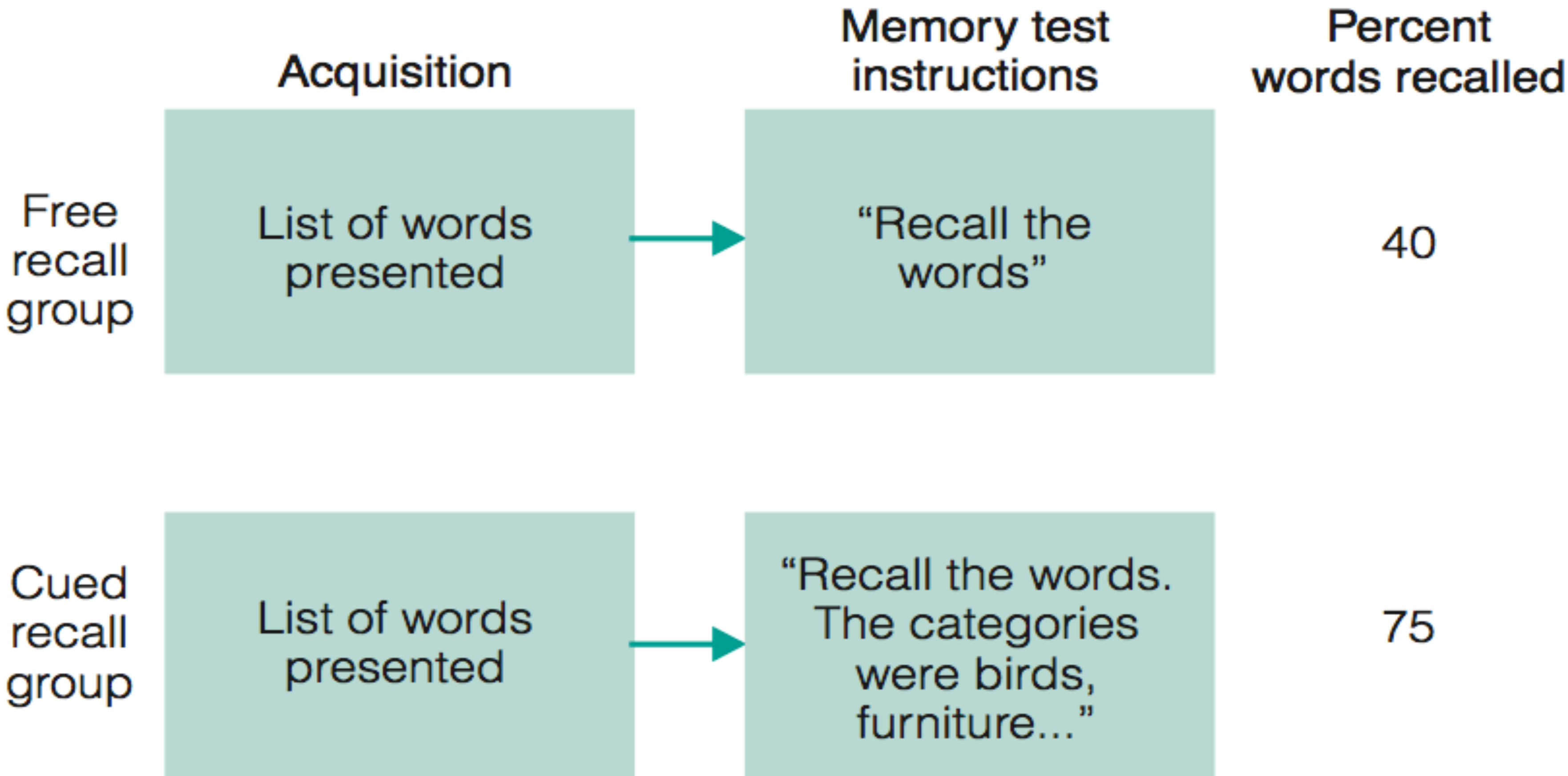


FIGURE 7.10 Design of the Tulving and Pearlstone (1966) experiment. The memory performance for each group is shown on the right.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (Fig. 7.10, p. 183)

- The results of Tulving & Pearlstone’s experiment demonstrated that retrieval cues aid memory. Participants in the free recall group recalled 40% of the words whereas those in the cued recall group could remember about 75% of the words.

- In another experiment, Mantyla (1986) presented ihis participats with a list of 600 nouns such as banana, freedom & tree.

- During learning, the participants were told to write down three words they associated with each noun. For example, for nbanan they could write yellow, punches & edible.

- When the participants took a surprise memory test, in which they were presented with the three words they had created & were asked to reproduce the original word, they were able to remember 90% of the 600 words.

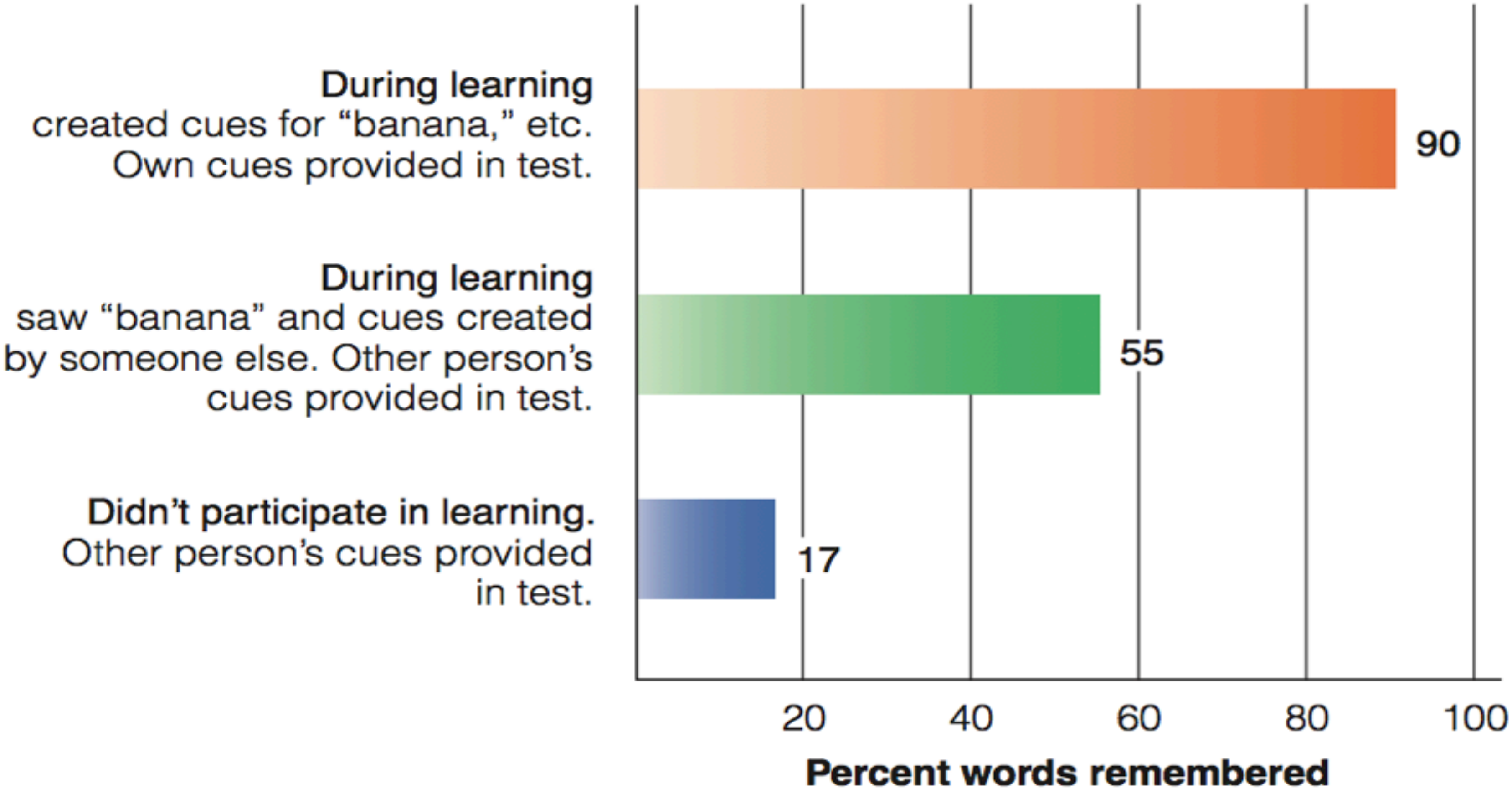


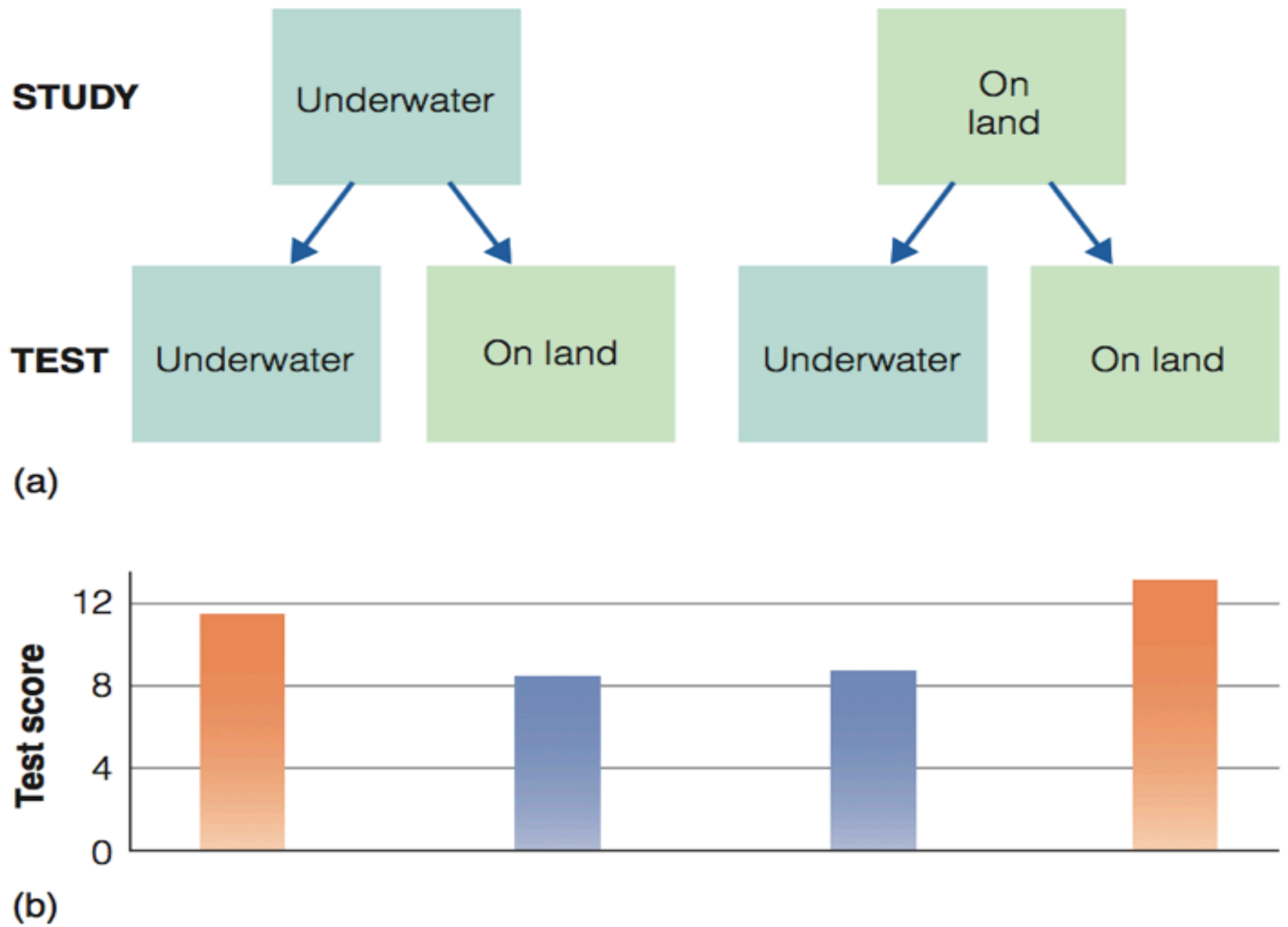
FIGURE 7.11 Mantyla's (1986) experiment. Memory was best when retrieval cues were created by the participant (top bar) and not as good when retrieval cues were created by someone else (middle bar). Participants guessed a small percentage of the words if they had not seen the words and saw only cues created by someone else (bottom bar).

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (Fig. 7.11, p. 183)

- **Matching Conditions of Encoding & Retrieval**

  - **Encoding Specifity**: The principle of ending specificity states that we encode information along with its context. For ex. Angela encoded many experiences within the context of her grandparent’s house; which were reinstated by returning to the house after which she remembered many of those experiences.

  - Godden & Baddeley (1975) conducted a “diving experiment”, where one group of participants put on diving equipment & studied a list of words underwater & another group studied them on land. They were later test for these, & the results showed that best recall occurred when encoding & retrieval occurred in the same condition.



● **FIGURE 7.12** (a) Design for Godden and Baddeley's (1975) "diving" experiment. (b) Results for each test condition are indicated by the bar directly under that condition. Orange bars indicate situations in which study and test conditions matched.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (Fig. 7.12, p. 184)

- **State - dependent learning:** learning that is associated with a particular internal state, such as mood or state of awareness.

- Acc. to this principle, memory will be better when a person's internal state during retrieval matches his or her internal state during encoding.

  - For example: Each & Metcalfe (1989) demonstrated that memory is better when a person's mood during retrieval matches his or her mood during encoding; by asking participants to think positive thoughts while listening to "merry"music or depressing thoughts while listening to "melancholic" music. Participants rated their mood as "very pleasant" or "very unpleasant".

- Once this occurred they were asked to study lists of words while in their positive or negative mood.

- After they study session ended, the participants were told to return in 2 days. Two days later, the participants returned & the same procedure was followed to induce the same mood.

- The results showed that they did better when their mood at recall matched their mood at encoding time.

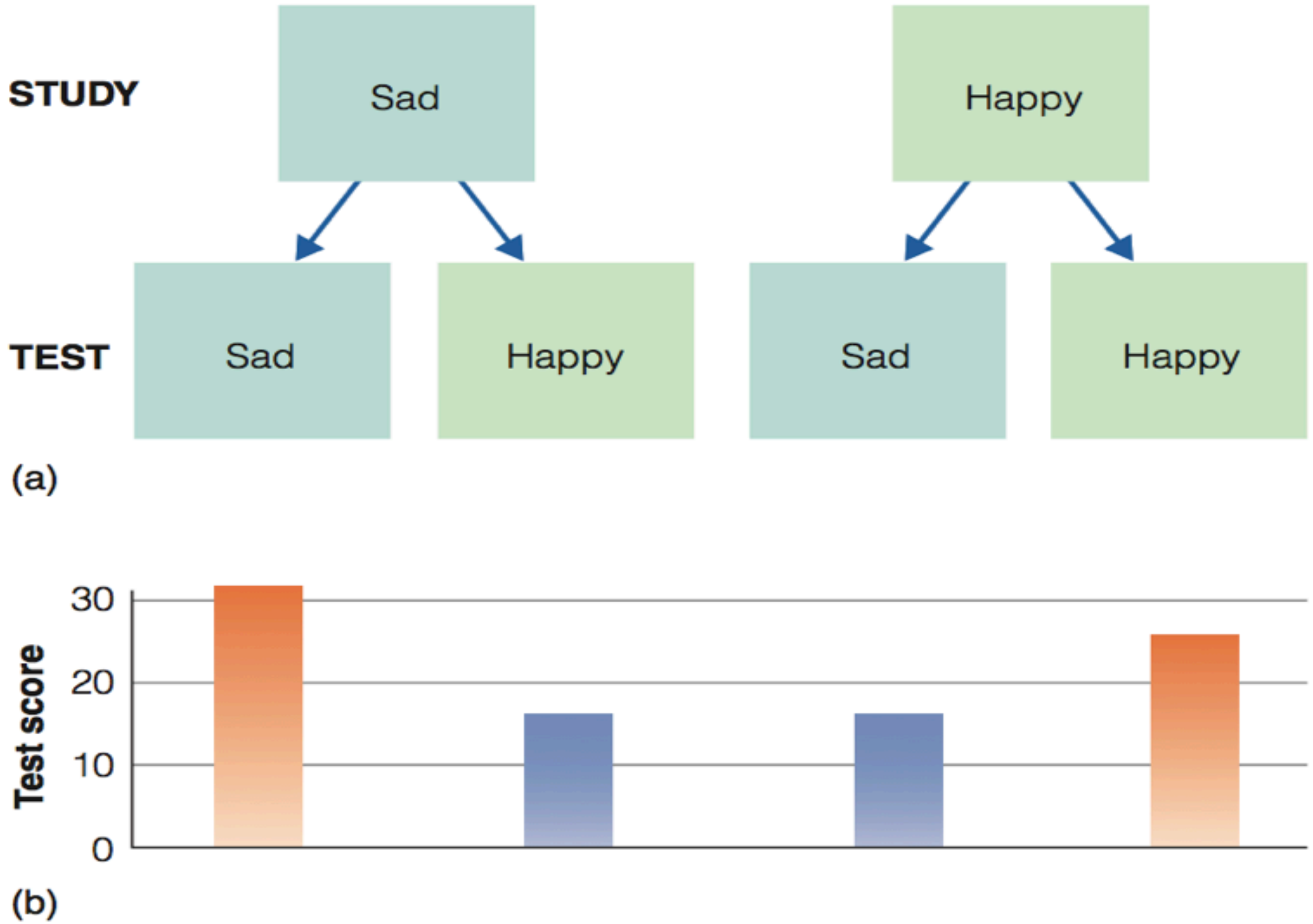


FIGURE 7.14 (a) Design for Eich and Metcalfe's (1989) "mood" experiment. (b) Results of the experiment.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (Fig. 7.14, p. 185)

- **Transfer Appropriate Processing:** The phenomenon of transfer - appropriate processing shows that memory performance is enhanced if the type of task at encoding matches the type of task at retrieval.

- A transfer - appropriate processing experiment varies the type task used for encoding & the task used for retrieval.

- Morris & coworkers (1977) did an experiment with two parts: The encoding part of the experiment had two conditions: 1) the meaning condition, in which the task focused on the meaning f the word & 2) the rhyming condition, in which the task focused on the sound of the word.

- Participants in both conditions heard a sentence with one word replaced by the word “blank”; 2 seconds later, they heard a target word.
- The task for the memory group was to answer “yes” or “no” based on the meaning of the sentence creating by replacing the “blank” with the “target” word.
- The task for the rhyming word was to answer “yes” or no” based ont= the rhyme created by replacing “blank” with the target word.

Examples From the Meaning Condition

1. Sentence: The *blank* had a silver engine.

   Target word: *train*

   Correct answer: "yes"

2. Sentence: The *blank* walked down the street.

   Target word: *building*

   Correct answer: "no"

Examples From the Rhyming Condition

1. Sentence: *Blank* rhymes with pain.

   Target word: *train*

   Correct answer: "yes"

2. Sentence: *Blank* rhymes with car.

   Target word: *Building*

   Correct answer: "no"

Excerpt: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (p. 186)

- In the retrieval part of the experiment, participants from both the groups were given a rhyming recognition test. For the test, participants were presented with 32 words that rhymed with one f the target words presented during encoding & 32 words that dd not rhyme.

- The rhyming words presented in this test were always different rom the target word presented earlier.

- The participants task was to indicate whether each word presented during retrieval rhymed with one of the targets they had heard during learning.

- The results showed that participants who were in the rhyming group during encoding remembered more words than participants who are in the meaning group.

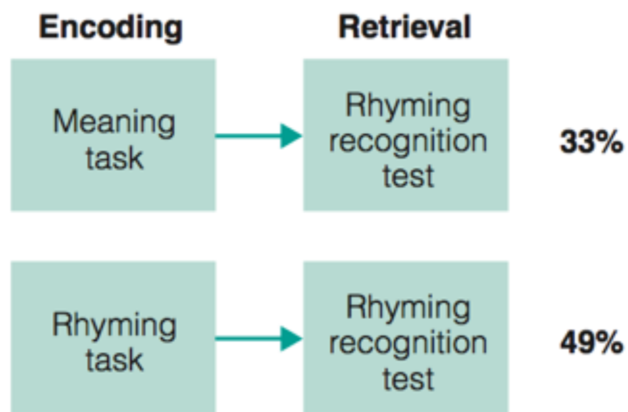


FIGURE 7.15 Design and results for the Morris et al. (1977) transfer-appropriate processing experiment. Participants who did a rhyming-based encoding task did better on the rhyming test than participants who did a meaning-based encoding task. This result would not be predicted by levels-of-processing theory, but is predicted by the principle that better retrieval occurs if the encoding and retrieval tasks are matched.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing.* 4th ed. (Fig. 7.15, p. 185)

Memory & The Brain

- Hebb (1948) introduced the idea that learning & memory are represented in the brain by physiological changes that take place at the synapse. Let's assume that a particular experience caused nerve impulses to travel down the axon of the neuron A onto neuron B.

- Hebb's idea was that this activity strengthens the synapse by causing structural changes, greater transmitter release & increased firing.

- Hebb also proposed that changes that occur in hundreds & thousands of synapses that are activated by a particular experience, provide a neural record of the experience.
- These proposals became the starting point for modern research. in memory & its physiology.

FIGURE 7.16 (a) What happens at a synapse as a stimulus is first presented. The record next to the electrode indicates the rate of firing recorded from the axon of neuron B. (b) As the stimulus is repeated, structural changes are beginning to occur. (c) After many repetitions, more complex connections have developed between the two neurons, which causes an increase in the firing rate, even though the stimulus is the same one that was presented in (a).

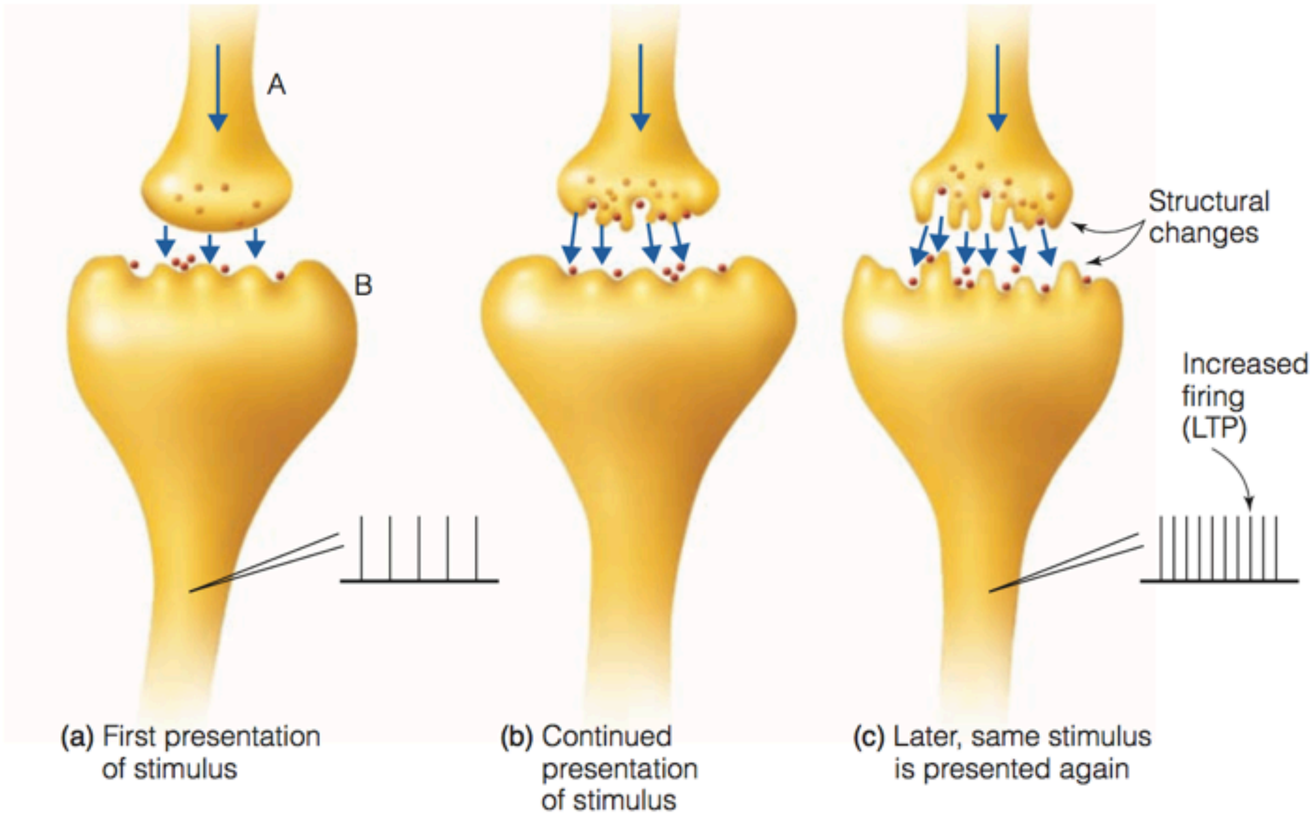


Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (Fig. 7.16, p. 190)

- One outcome of these changes at the synapse is called **long term potentiation** - enhanced firing of neurons after repeated stimulation.

- LTP is illustrated in the firing records in the figure shown earlier.

- However after repeated presentation, the neuron responds more rapidly to the same stimulus.

- LTP shows that repeated stimulation not only causes structural changes but also enhanced responding.

- Where does memory occur in the brain?
    - Memory does not occur in a specific place in the brain; it is distributed across a range of different areas.
    - the frontal cortex is important for memory while other areas for e.g. the medial temporal lobe can be said to be important for the LTM.

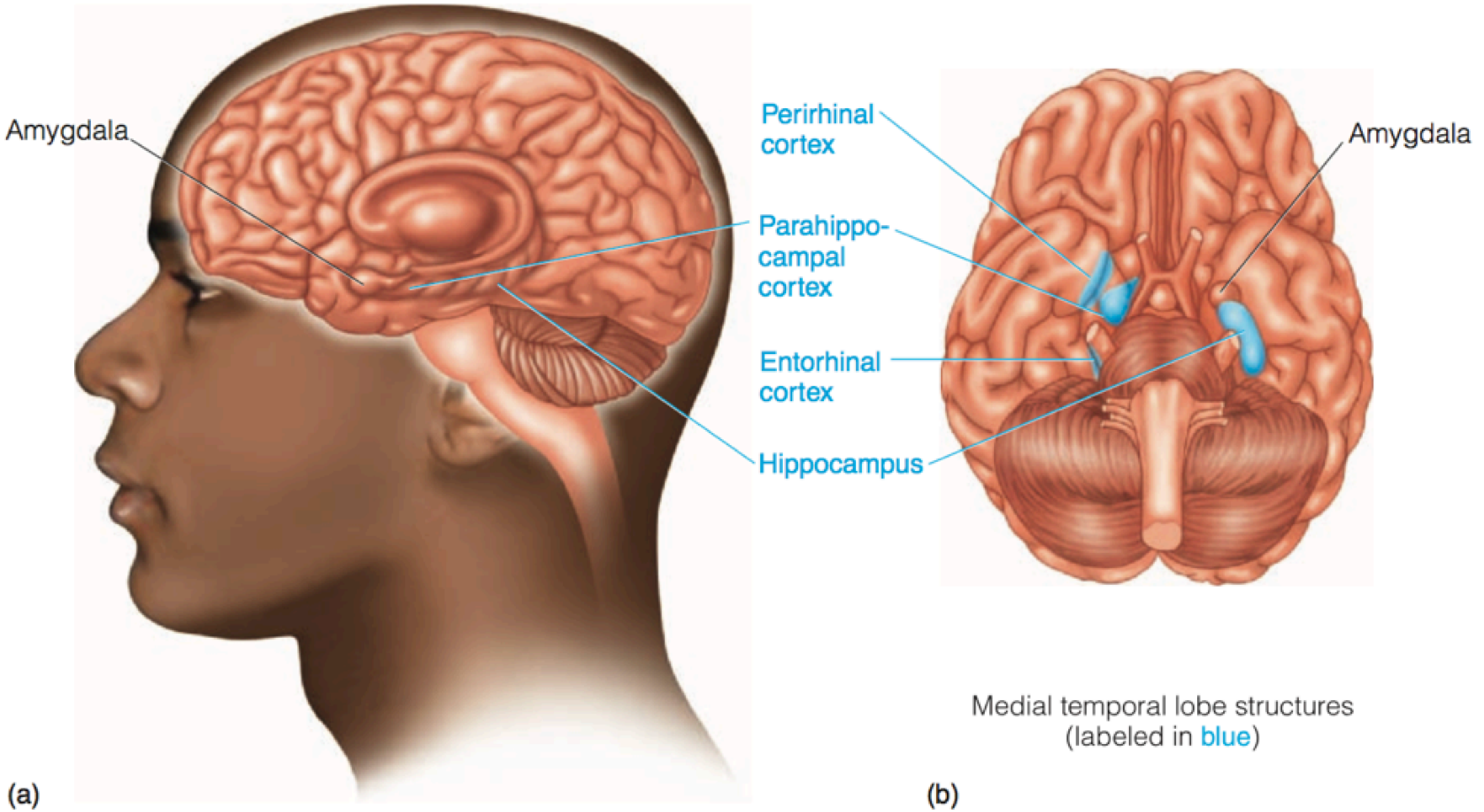


FIGURE 7.17 (a) Side view of the brain and (b) underside of the brain, showing the amygdala and structures in the medial temporal lobe (perirhinal cortex, parahippocampal cortex, entorhinal cortex, and hippocampus).

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (Fig. 7.17, p. 191)

- The medial temporal lobe houses the hippocampus. It also houses the perirhinal cortex.

- Davachi & coworkers (2003) designed a study to determine how these ares responded to the names of objects presented as a part of the memory experiment.

- Participants viewed a series of 200 words in a fMRI scanner & were instructed to create an image of a specific place that went with each words. for e.g. for *dirty* they could create a garbage dump.

- 20 hours later, the participants were presented with a recognition test in which they saw the same 200 words they had seen earlier, along with a new set of 200 words.

- During this part of the experiment, they were not in the scanner; their task was to indicate which of the words they had seen before, so a correct answer would be "old" when an old words was presented , and "new" when a new word was presented.
- Davachi found that participants remembered 54% of he old words & forgot the rest 46% words.
- The results indicate that activity in the perirhinal cortex was great for remembered words than for the forgotten words. This, in the perirhinal cortex, words that generated more activity during encoding were more likely to be familiar to the participants during the recognition test.
- This result confirms physiologically what we have seen behaviourally.

FIGURE 7.18 Design of Davachi's experiment. During encoding, participants in a scanner created images in their mind in response to words. During retrieval 20 hours later, the participants' task was to recognize the words they had seen.

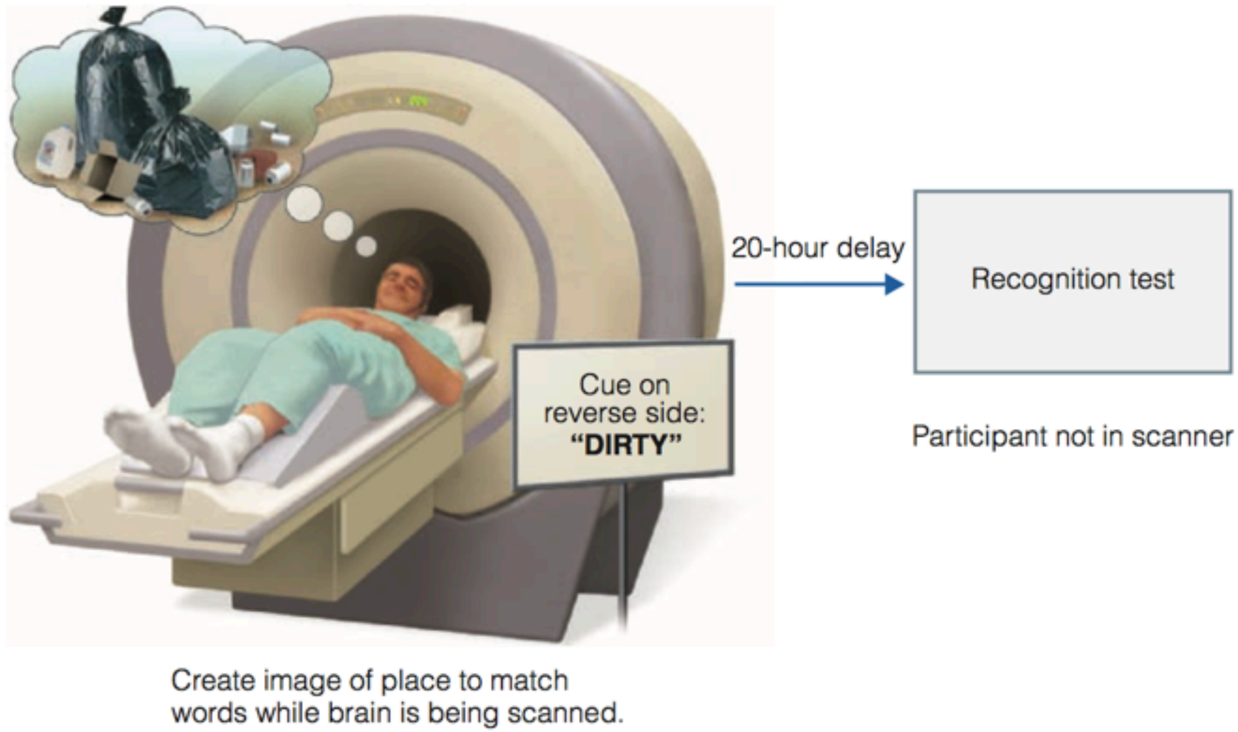
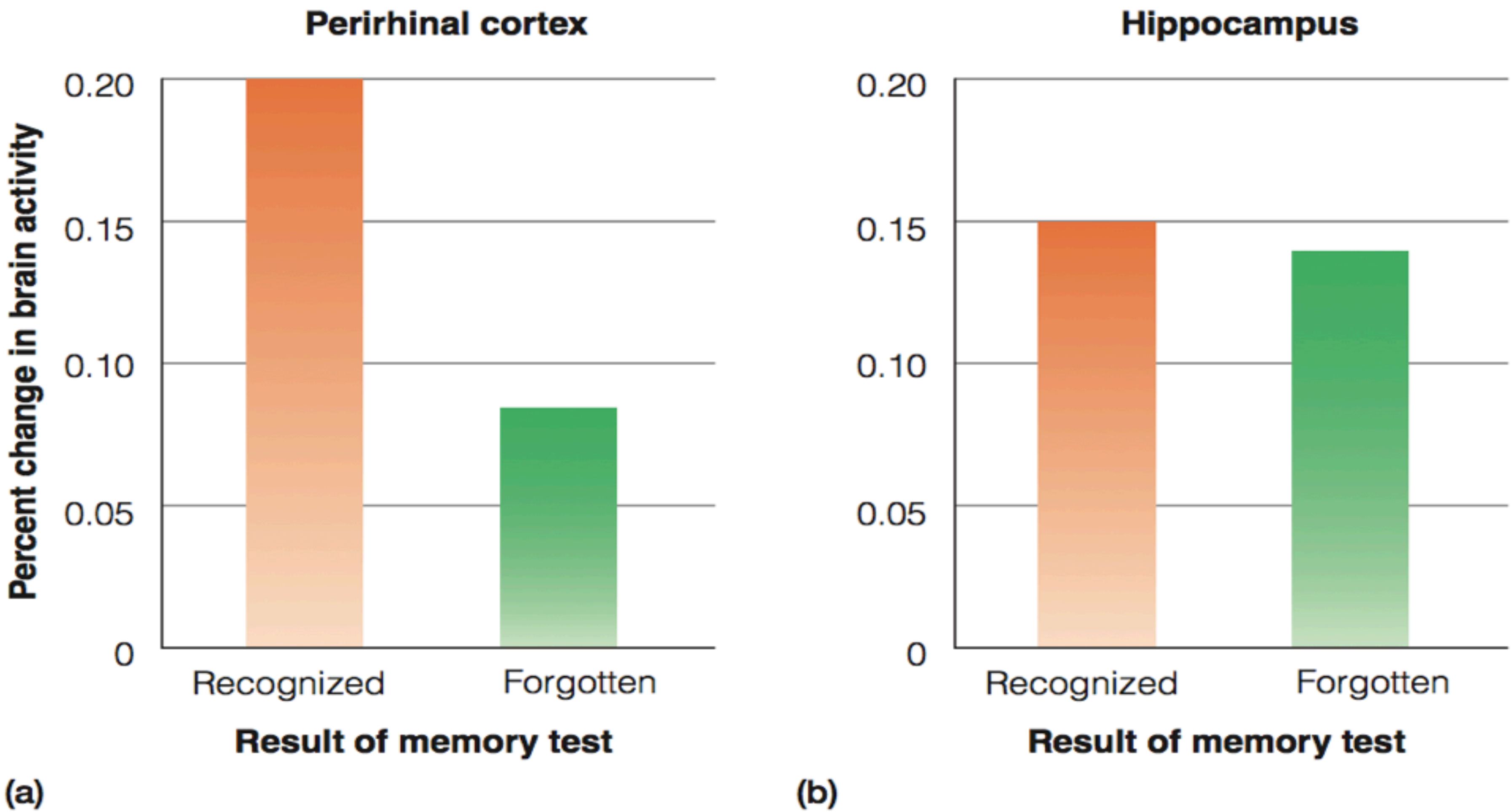


Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (Fig. 7.18, p. 192)



● **FIGURE 7.19** Results of Davachi's experiment. (a) Response in perirhinal cortex measured during encoding for items that were recognized and forgotten in the retrieval test. (b) Response of the hippocampus for recognized and forgotten items.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (Fig. 7.19, p. 193)

- Other structures in the MTL are also involved in memory for e.g. the parahippocampal area is important for remembering spatial information; & the entorhinal cortex is involved in recognition memory.

Memory Consolidation

- *consolidation* refers to the process that transforms the newly formed fragile memories to more stable & permanent state where they are more resistant to disruption or change (Frankland & Bontempi, 2005).

- This process involves a reorganisation in the nervous system, which occurs at two levels:

- *synaptic consolidation* which occurs at the synapse and happens rapidly over a period of minutes. e.g. the structural changes in the neurons.

- *systems consolidation* involves the gradual reorganisation of circuits within brain regions and takes place over a much longer time scale.

- Early research , inspired by Hebb's pioneering work on the role of the synapse in the memory focused on synaptic consolidation. More recent research has focused on the phenomenon of systems consolidation & the role of different brain areas. for e.g. the hippocampuss plays a central role in the *standard model of consolidation.*

- Two Theories:
  - **Standard Model of Consolidation:** The graded property of retrograde amnesia, in which amnesia is worse for experiences that occurred just before the brain injury, plus other evidence, led to the proposal of this model.
  - The model proposes that memory retrieval depends on the hippocampus during consolidation, but that one consolidation is complete, retrieval no longer depends on the hippocampus.

- Incoming information activates a number of areas in the cortex; activation is distributed across the cortex because memories typically involve many sensory & cognitive areas. This is because the memory for events & things may involve activity in a variety of areas (for e.g. those involved in processing different sights, sounds & smells).

- The hippocampus coordinates the activity of the different cortical areas, which at this point are not connected in the cortex.

- The major mechanism of consolidation is reactivation, a process during which the hippocampus replays the neural activity associated with a memory.

- During reactivation, activity occurs in the network connecting the hippocampus & the cortex.

- This activity results in the formation of connections between the cortical areas. This reactivation process occurs during sleep or during periods of relaxed wakefulness & can also be enhanced by conscious rehearsing of a memory.

- Eventually, the cortical connections become strong enough so that the different sites in the cortex become directly linked, and the hippocampus is no longer necessary.

- Thus, acc. to the standard model of consolidation, the hippocampus is strongly active when memories are first formed but become less active as memories are consolidated, until eventually only cortical activity is necessary to retrieve remote memories.

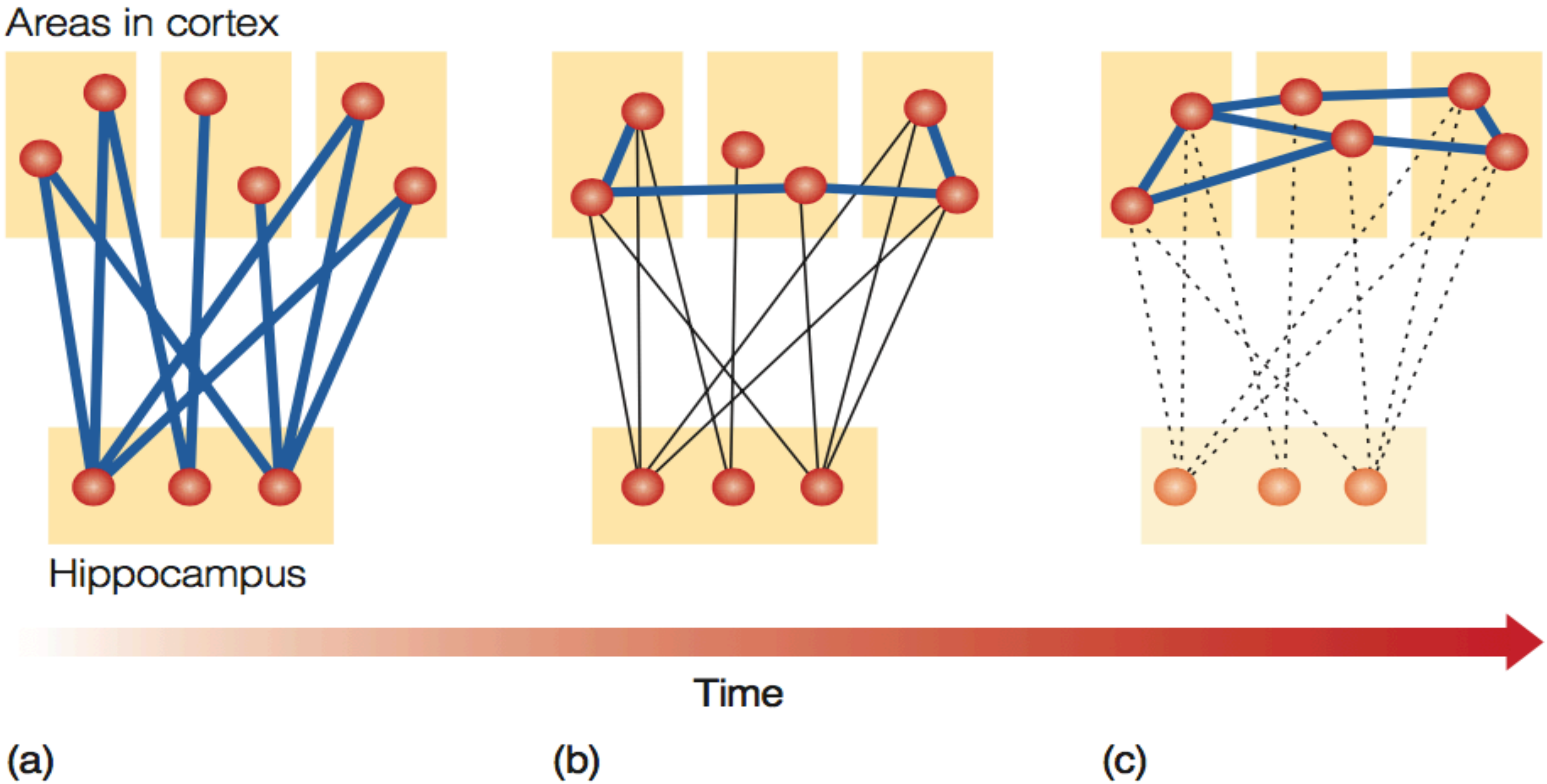


FIGURE 7.21 Sequence of events that occur in consolidation. Connections between the cortex and the hippocampus are initially strong but weaken as connections within the cortex are established. (Adapted from Frankland & Bontempi, 2005.)

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (Fig. 7.20, p. 194)

- **The multiple trace hypothesis:** Acc. to the multiple trace hypothesis, the hippocampus is involved in retrieval of remote memories, especially episodic memories (Nadel & Moskovitch, 1997).

- Evidence for this idea comes from experiments like one by Giboa & coworkers (2004) who elicited recent & remote episodic memories by showing participants photographs of themselves engaging in variouss activities that were taken at times ranging from recently to when they were 5 yrs old.

- The result of the experiment showed that the hippocampus was active during retrieval of both, recent & remote memories.

- The fact that there is evidence supporting both the standard & multiple trace hypothesis has led to a great deal of discussion among memory researchers regarding whether or not the hippcocampus is involved in remote memories (Jadhav & Frank, 2009).

- Reconsolidation: Nader & other researchers propose that after a memory is reactivated, it must undergo reconsolidation, which is similar to the consolidation that occurred after the initial learning but apparently occurs more rapidly (Dudai, 2006).

- One can say that memory becomes susceptible to being changed or disrupted everytime it is retrieved.

- Reconsolidation might provide an opportunity for reinforcing or updating memories.

- For example: an animal that returns to the location of a food source & finds that food has been moved to a new location nearby.

- Now returning to the original location has reactivated the original memory, new information updates the original memory about the change in location & the updated memory is now reconsolidated.

- In another experiment, Nader & colleagues (2000) used classical conditioning on a rat to create a fear response of "freezing" to a presentation of a tone, by pairing the tone with a shock.

- In each condition, the rat received a tone-shock pairing & is injected with *anisomycin*, an anti-biotic that inhibits its protein synthesis & so prevents changes at the synapse that are responsible for formation of new memories.

- An important aspect of the experiment was the timing of injection of anisomycin.

- In condition 1, the rat recieves the pairing of the tone and shock on day 1; it recievs anisomycin on day 2 & then freezes to the tone when rested on day 3.
    - This is along the expected lines because the conditioning occurs on day 1 & the drug isn't injected till day 2.
- In condition 2, thhe rat recieves the pairing of the tone & shock on day1, but the drug is injected immediately, before the consolidation has occurred.
    - As the drug has blocked consolidation , the rat does not freeze to the tone on day 3.

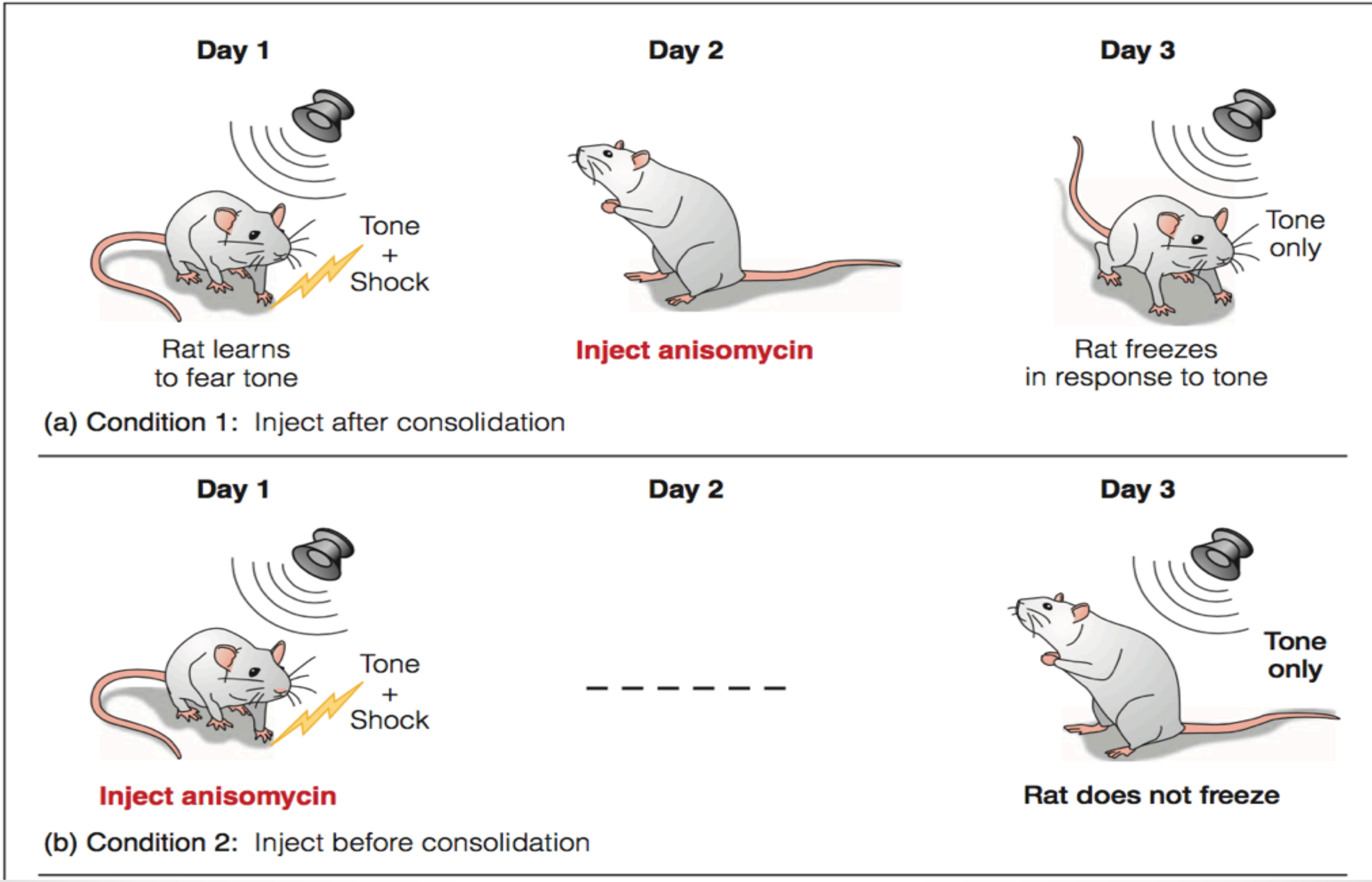


Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (Fig. 7.22, p. 194)

- In condition 3, the memory becomes reacticated 7 becomes fragile, just as it was immediately after it was formed.

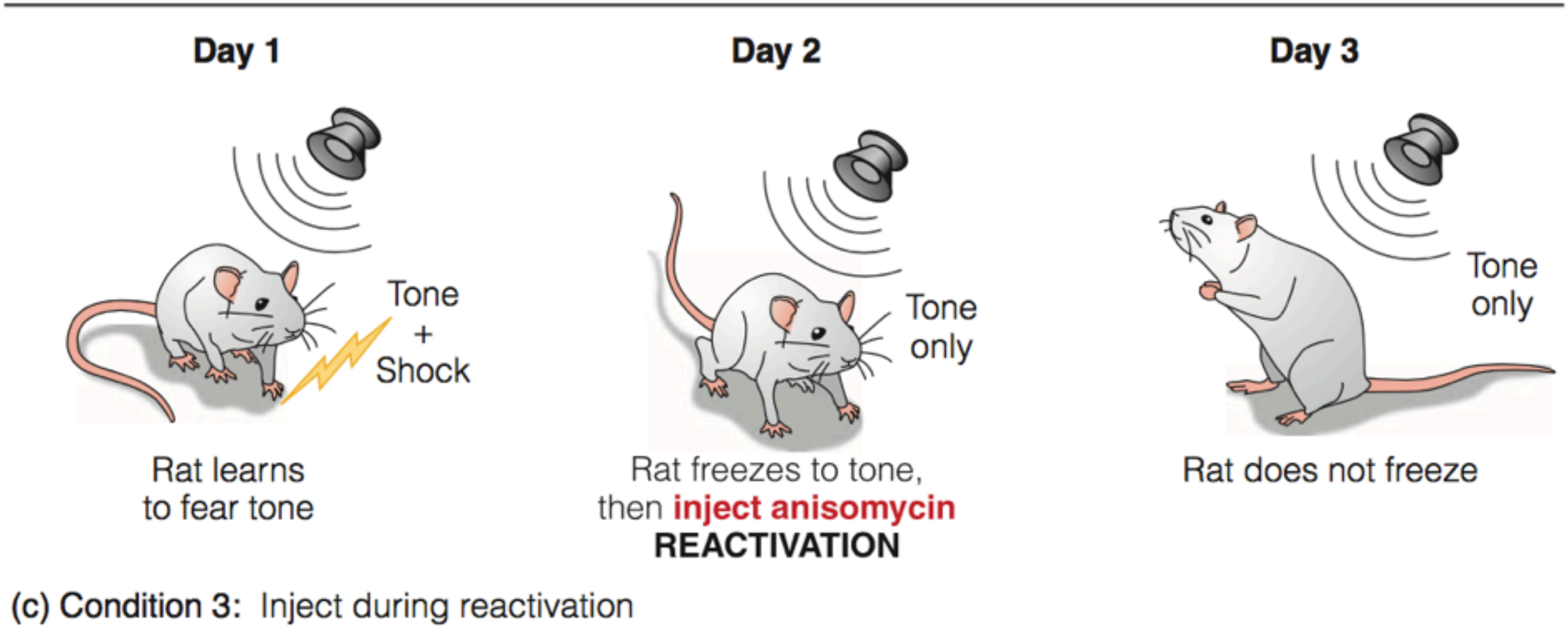


FIGURE 7.23 The Nader et al. (2000a) experiment on the effect on fear conditioning of injecting anisomycin.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (Fig. 7.22, p. 194)

- **Does it occur in humans?**
  - Some evidence that it does (Nader, 2003). In an experiment by Hupbach & colleagues (2007), participants learned a list of words (List 1) on Day 1.
  - On Day 2, one group (the non – reminder group) learned a new list of words (List 2). Another group, (the reminder group) also learned the new list on Day 2, but just before learning the list, they were asked to remember their Day 1 training sesion (without actually recalling the List 1 words), thus reminding them of their learning.

- When on Day 3, these two groups were asked to remember List 1, the no – reminder group recalled 45% of the words from List 1 but mistakenly 5% of the words from List 2.
- The reminder group recalled 36% of the words from List 1, but in adition mistakenly recalled 24% of the words from List 2.
- Ac.. to Hupbach & colleagues, what happened was that the reminder on day 2 reactivated the memory for List 1, making it vulnerable to being changed.
- As participants immediately learned List 2, some of the words from List 2 became integrated into the participants memory for List 1.

- A practical implication outcome of research on reconsolidation is a possible treatment for post – traumatic stress disorder.
  - Clinical psychologist Alain Brunet (2008) tested the idea that reactivation of a memory followed by reconsolidation can provide a way to alleviate the symptoms of PTSD, such as having the flashback of the truma.
  - The idea is to reactivated the person's memory for the traumatic event & then administer the drug ***probanolol,*** which blocks production of a stress hormone in the amygdala.

- Brunet ran two groups; one group of PTSD patients listened to a 30 second recording describing the circumstances of their traumatic experience and received *probanolol* & the other group listened to the recording describing their experience but received a placebo.
- One week later, both groups were told to imagine their traumatic experience, while again listening to the 30 - second recording.
- To determine their reaction to imagining their experience, skin conductance response & blood pressure were being monitored.

- Brunet found that the *probanolol* group experienced much smaller increases in their heart rate & skin conductance than the placebo group. He has used this procedure to treat patients with PTSD, and many of the patients report significant decrease in their symptoms even months after treatment (Singer, 2009).

References

- Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed.

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Course Title:

Basic Cognitive Processes

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Lecture 36: Everyday Memory & Memory Errors!!!

I am 34 years old and since I was eleven I have had this unbelievable ability to recall my past.…I can take a date between 1974 and today, and tell you what day it falls on, what I was doing that day and if anything of great importance…occurred on that day I can describe that to you as well.…Whenever I see a date flash on the television (or anywhere else for that matter) I automatically go back to that day and remember where I was, what I was doing, what day it fell on and on and on and on and on. It is non-stop, uncontrollable and totally exhausting.…I run my entire life through my head every day and it drives me crazy!!!

Excerpt: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 4th Ed. (pp. 204).

- The experiences revealed are those of a woman called A.J. who can remember what happened on each day of her life, from the age of 11 onwards.

- She contacted James McGaugh, a memory researcher at the UCLA. & has undergone a series of tests etc. details of which are published in a paper Parker, Cahill & McGaugh (2006).

- A.J. describes her memories as happening automatically & not being under her conscious control.

- When given a date she would, within seconds relate personal experiences and also special events that occurred on that day, & these recollections proved to be accurate when checked against a diary of daily events that A.J. had been keeping for 24 years.

- A.J.'s memories cause her distress because she has trouble turning off the "movie" of her life & she cannot forget negative events from her past, though positive memories keep her "sane".

- A.J. has an exceptional memory for personal experiences, things that make up what is called *autobiographical memory*.

Autobiographical Memory

- has been defined as recollected events that along to a person's past (Rubin, 2005). e.g an AM of a childhood birthday party might include images of the cake, people at the party, games being played (episodic memory) and also when the party occurred, where was your family living at the time, general idea of parties (Semantic memory) (Cabeza & St. Jacques, 2007).

- AM are far more complex than memory that might be measured in the laboratory by asking a person to remember a list of words. AM are multidimensional because they consist of spatial, emotional & sensory components.

- Greenberg & Rubin (2003) found that patients who had lost their ability to recognise visual objects because of damage to visual areas of the cortex, also experienced a loss to AM.

- Cabeza & coworkers (2004) measured the brain activation caused by two sets of stimulus photos - one that the participant took and another set that was taken by someone else

- These photos were taken by 12 Duke University students who were asked to take pictures of 40 specified campus locations over a 10 day period.

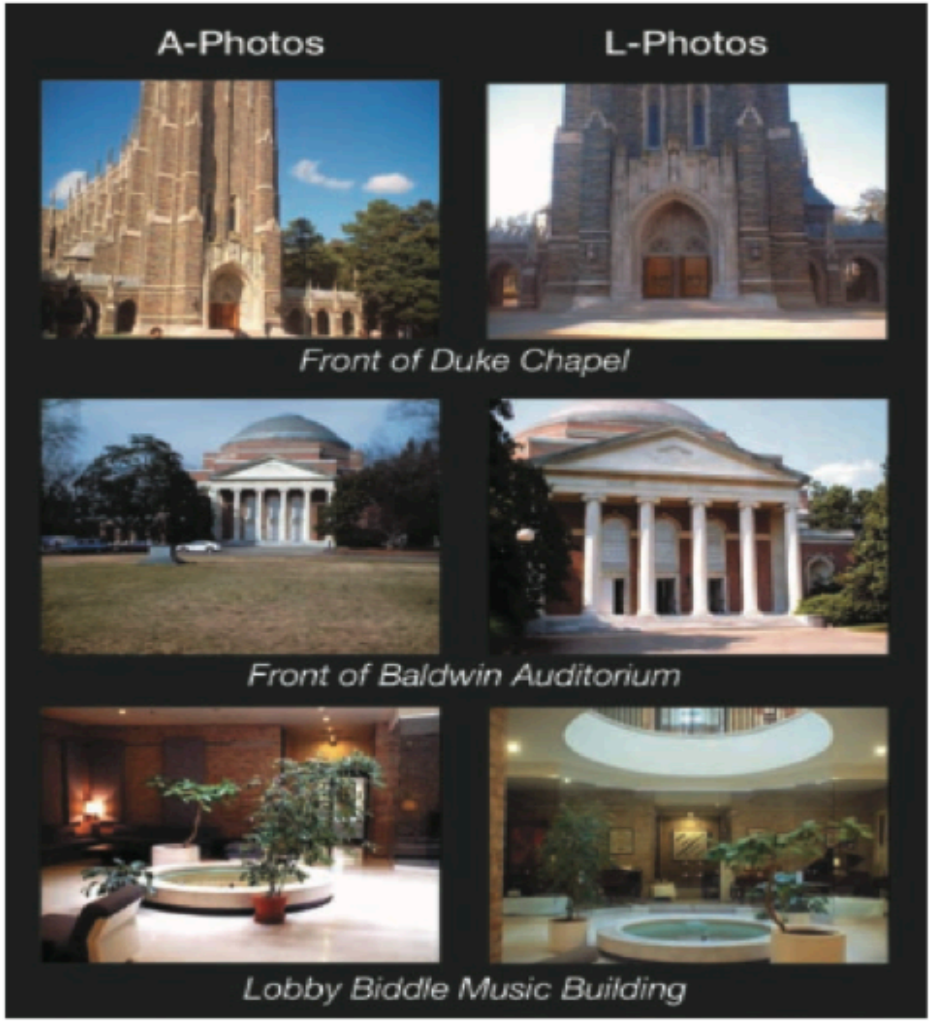


FIGURE 8.1 Photographs from Cabeza and coworkers' (2004) experiment. A-photos ("autobiographical photographs") were taken by the participant; L-photos ("laboratory photographs") were taken by someone else.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 4th Ed. (Fig. 8.1; pp. 205).

- After taking the photographs, each participant was shown his/her own photos (A - photos) or photos taken by other participants (L- photos).
- A few days later they were shown photos (L - photos) they had sen before & some new they had never seen. & they were asked to indicate whether each stimulus was an A - photo, a seen L - photo or a new L - photo.
- The brain scans of these participants showed that while A photos & L - photos activated many of the same structures in the brain - mainly ones like the MTL that are associated with episodic memory; the A- photos also activated regions associated with processing information about self, with memory for visual space & those linked with recollection.

- These activations reflect the richness of experiencing autobiographical memories as compared to laboratory memories.

- What kind of memories stay on?

  - personal milestones; transition points etc.

  - When participants over 40 are asked to remember events in their lives; memory is found to be high for recent events and for events experienced in the adolescence & early adulthood - this is called **reminiscence bump.**

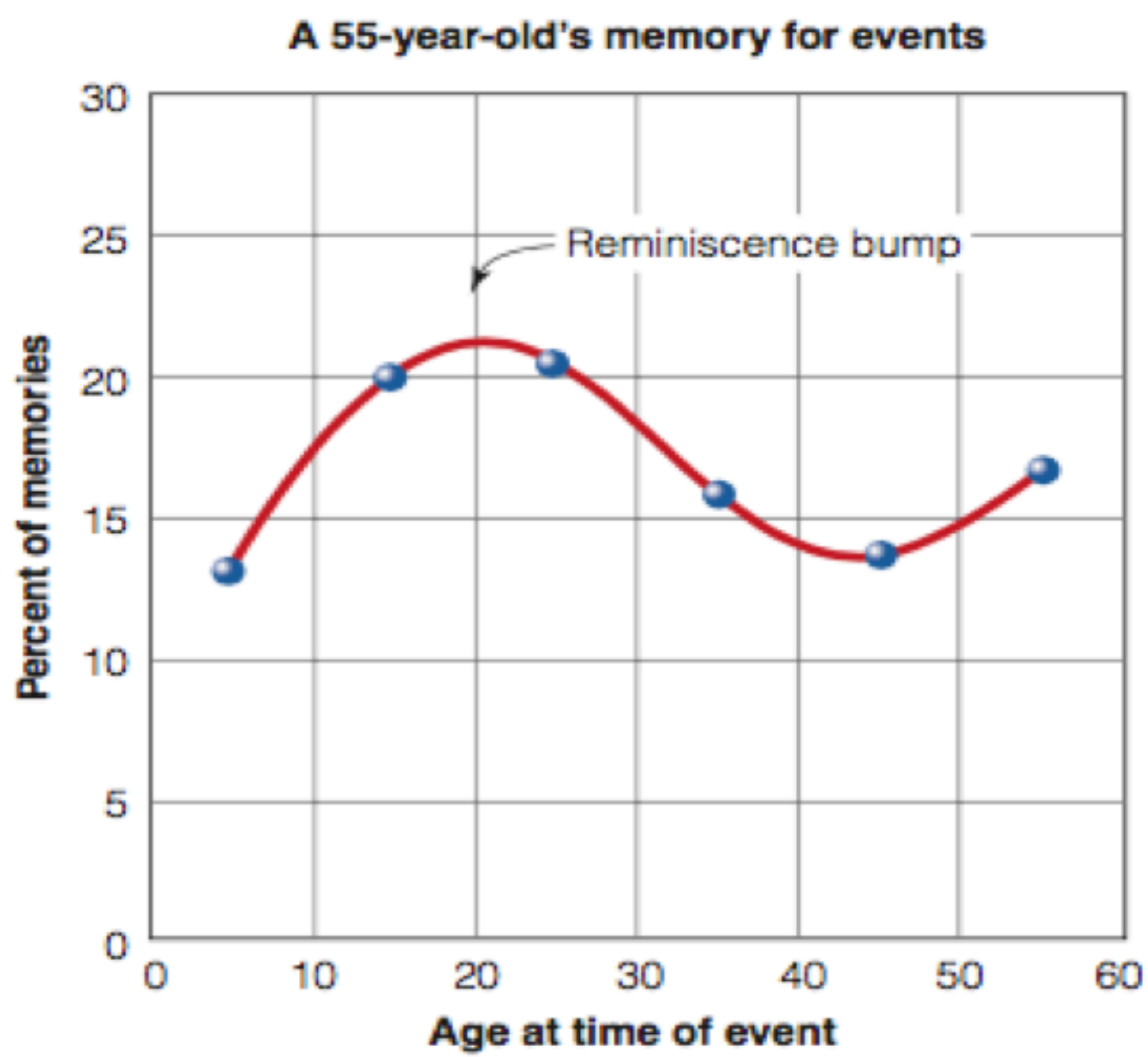


FIGURE 8.3 Percentage of memories from different ages, recalled by a 55-year-old, showing the reminiscence bump. (Source: R. W. Schrauf & D. C. Rubin,

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 4th Ed. (Fig. 8.3; 207).

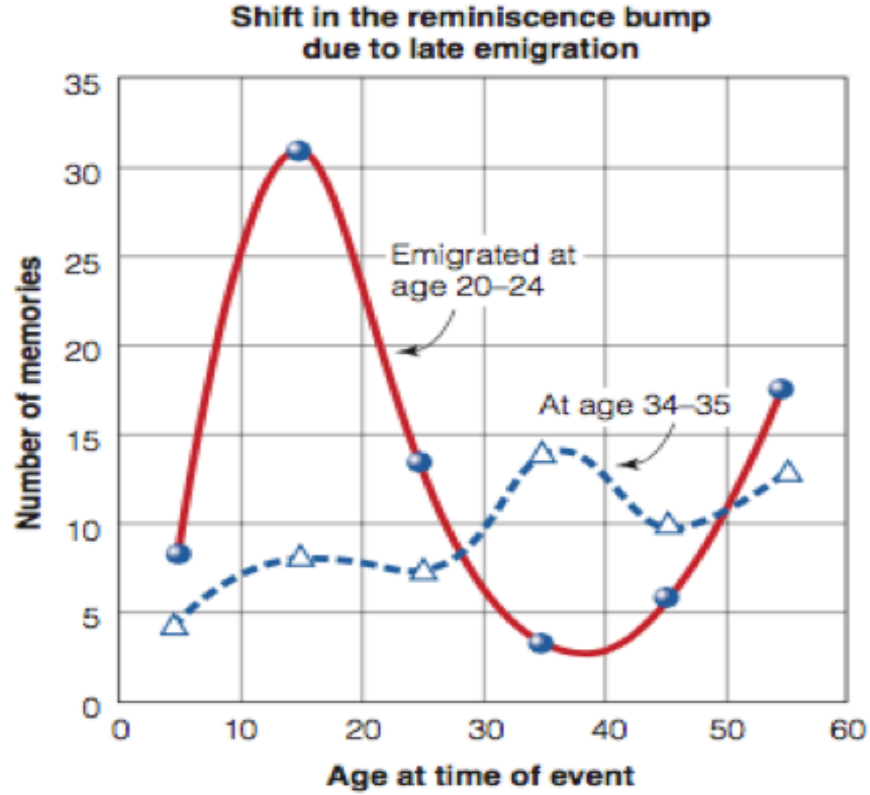


FIGURE 8.4 The reminiscence bump for people who emigrated at age 34 to 35 is shifted toward older ages, compared to the bump for people who emigrated between the ages of 20 to 24. (Source: R. W. Schrauf & D. C. Rubin, "Bilingual Autobiographical Memory in Older Adult Immigrants: A Test of Cognitive Explanations of the Reminiscence Bump and the Linguistic Encoding of Memories," *Journal of Memory and Language, 39*, 437–445, Fig. 1. Copyright © 1998 Elsevier Ltd. Republished with permission.)

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 4th Ed. (Fig. 8.4; 207).

- Possible Explanations:

    - Rathbone & coworkers (2008) propose that memory is enhanced for events that occur as a person's self image or life - identity is being formed: the self image hypothesis.

    - The cognitive hypothesis proposes that periods of rapid change that are followed by stability cause stronger encoding of memories. adolescence & young adulthood fit this description.

    - Finally, the cultural life script hypothesis distinguishes between person's life story i.e. all events in a person's life & a cultural life script, i.e. events happening at a particular time.

TABLE 8.1 Explanations for the Reminiscence Bump

Explanation	Basic Characteristic
Self-image	Period of assuming person's self-image.
Cognitive	Encoding is better during periods of rapid change.
Cultural life script	Culturally shared expectations structure recall.

Table: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 4th Ed. (Table 8.1; 207).

- **Memory & Emotion:** Personal events such as the beginning or ending of relationships, or events experienced by many people simultaneously like the 9/11 attacks seem to be remembered more easily & vividly than less emotionally charged events.

- LaBar & Phelps (1998) tested participant's ability to recall arousing words and neutral words immediately after they were presented & observed better memory for arousing words.

- Dolcos & coworkers (2005) tested participants' ability to recognise emotional & neutral pictures 1 year after they were presented and observed better memory for the emotional pictures.

- the Amygdala seems important in memorising emotional information. For example: Dolcos & coworkers obtained fMRI scans while people were remembering lists of words and revealed higher amygdala activity for emotional words.

- Similarly, the patient B.P who had amygdala damage had preserved memory for non - emotional part of a story shown to him via a slide show but much worse memory for the emotional part of a story narrated to him (Cahill et al., 1995).

- It appears therefore that emotional may trigger mechanisms in the amygdala that help us remember events that are associated with emotions.

- **Flashbulb Memories**: What were you doing when you heard about the 9/11 attack? India won the Cricket WC?
- memories that refer to memory for circumstances surrounding hearing about shocking highly charged events but not memory for the event itself.
- Acc. to Brown & Kulik, there is something special about the mechanisms for flashbulb memories.
- these memories not only occur under highly emotional circumstances, but also are remembered for long periods of time & are specially vivid and detailed. they referred to the mechanism as a “Now Print” mechanism.

- However, it has been shown that although people report that these flashbulb memories are especially vivid, they are often inaccurate or lacking in detail.
  - for example, Neisser & Harsch (1992) did a study in which they asked participants about how they had heard about the explosion of the space shuttle Challenger.
  - participants in the experiment filled out a questionnaire within a day after the explosion and then filled out the same questionnaire 2.5 - 3 years later.
- It was found that for a large number of participants they first reported hearing about the explosion at one place but later changed that to hearing on TV.

I was in my religion class and some people walked in and started talking about [it]. I didn't know any details except that it had exploded and the schoolteacher's students had all been watching, which I thought was so sad. Then after class I went to my room and watched the TV program talking about it, and I got all the details from that.

Excerpt: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 4th Ed. (p. 210).

Two and a half years later, her memory had changed to the following:

> When I first heard about the explosion I was sitting in my freshman dorm room with my roommate, and we were watching TV. It came on a news flash, and we were both totally shocked. I was really upset, and I went upstairs to talk to a friend of mine, and then I called my parents.

Excerpt: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 4th Ed. (p. 210).

- Similarly, another experiment by Talarico & Rubin (2003) tested a group of college students on September 12, 2001 for their memory of when they heard of the 9/11 World Trade Tower incident.

- Some questions were about ("When did you first hear the news?") & other were similar questions about an everyday event in the person's life that occurred in the days just preceding the attacks.

- after picking the everyday event, the participant created a 2 - 3 word description that could act as a cue for the event, in the future. Some participants were re - tested 1 week later, some 6 weeks later & some 32 weeks later.

- One result of this experiment was that the participant remembered fewer details and made more errors at longer intervals after the events, with little difference between the results for the flashbulb and everyday memories.

- However, another result did indicate a difference between the flashbulb memories & everyday memories: People's *belief* that their memories were accurate stayed high and constant for the flashbulb memories but dropped for the everyday memories.

- Thus the idea that flashbulb memories are special seems based partly on the idea that people **think** that there memories are stronger and more accurate, though in **reality** there was little or no difference in the amount & accuracy of the memories.

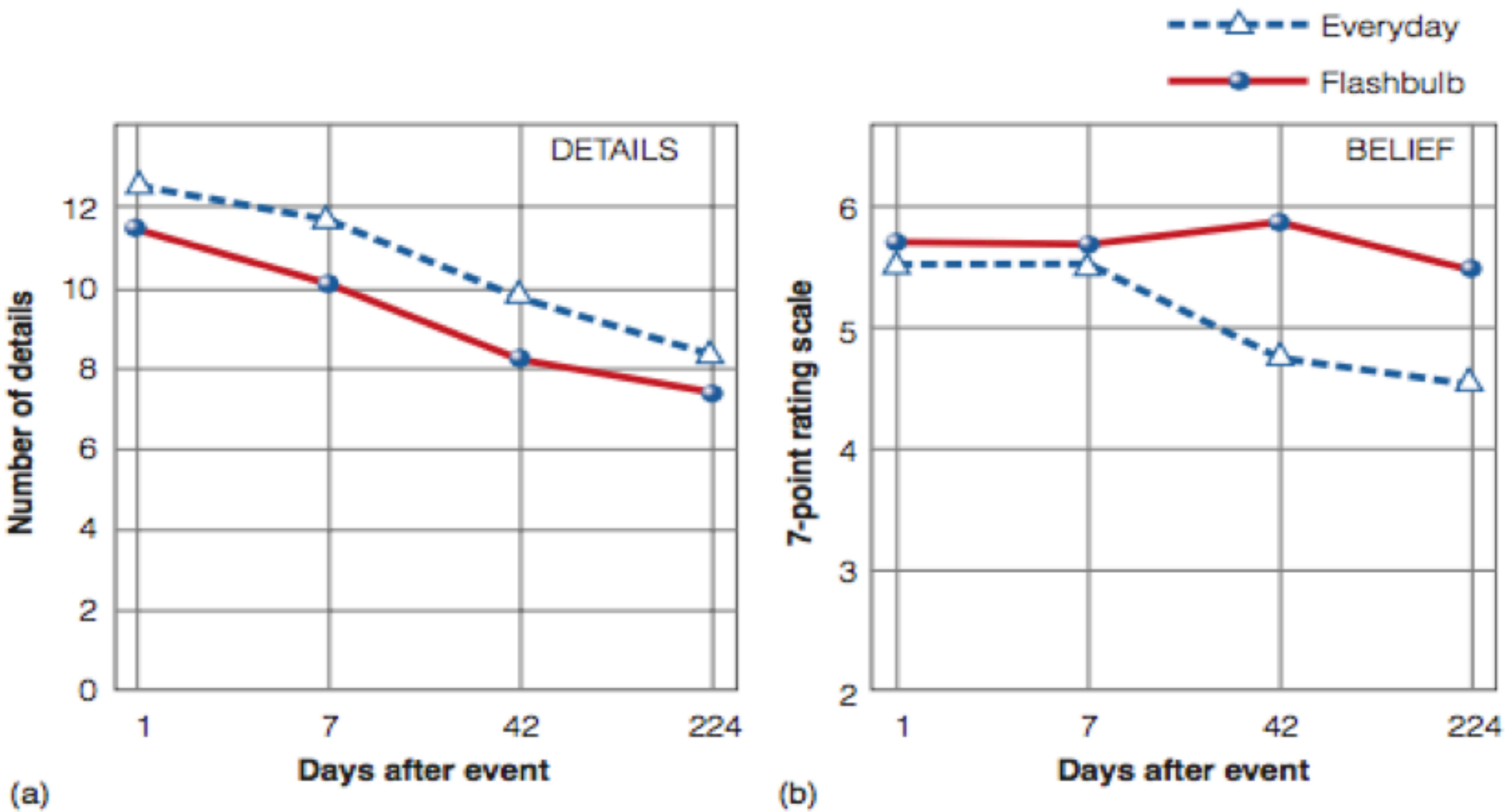


FIGURE 8.8 Results of Talarico and Rubin's (2003) flashbulb memory experiment. (a) The decrease in the number of details remembered was similar for memories of 9/11 and for memories of an everyday event. (b) Participants' belief that their memory was accurate remained high for 9/11, but decreased for memories of the everyday event. (Source: J. M. Talarico & D. C. Rubin, "Consistency and Key Properties of Flashbulb and Everyday Memories," *Psychological Science, 14*, 5, Fig. 1 & 2. Copyright © 2003 American Psychological Society. Reproduced by permission.)

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 4th Ed. (Fig. 8.8; p. 211).

- In another experiment, shortly after the 9/11 attacks, Davidson & coworkers (2006) asked participants questions such as “How did you hear the news?”, “Where were you when you heard about the attack?”, and “Who was present?”. They also had participants answer questions for an everyday event - the most interesting event that had occurred in the few days preceding 9/11.

- One year later, the participants were contacted for a surprise memory test in which they were asked the same questions as before.

- they were given 0 points if they could not remember or remembered very inaccurately, 1 point if they memory was partially correct or less specific than the original memory & 2 points if their memory was very similar to the original report.

- The resulting congruence store was determined by adding points for all the questions and scaling the total so that 1.0 was the maximum score possible.

- Congruence score for 9/11 memories was fairly high (0.77) 1 year later, but the score for everyday events was much lower (0.33).

- Also, whereas all the participants had no trouble remembering 9/11, only 65% of them were able to recall what the everyday event was, even after being given the cue.

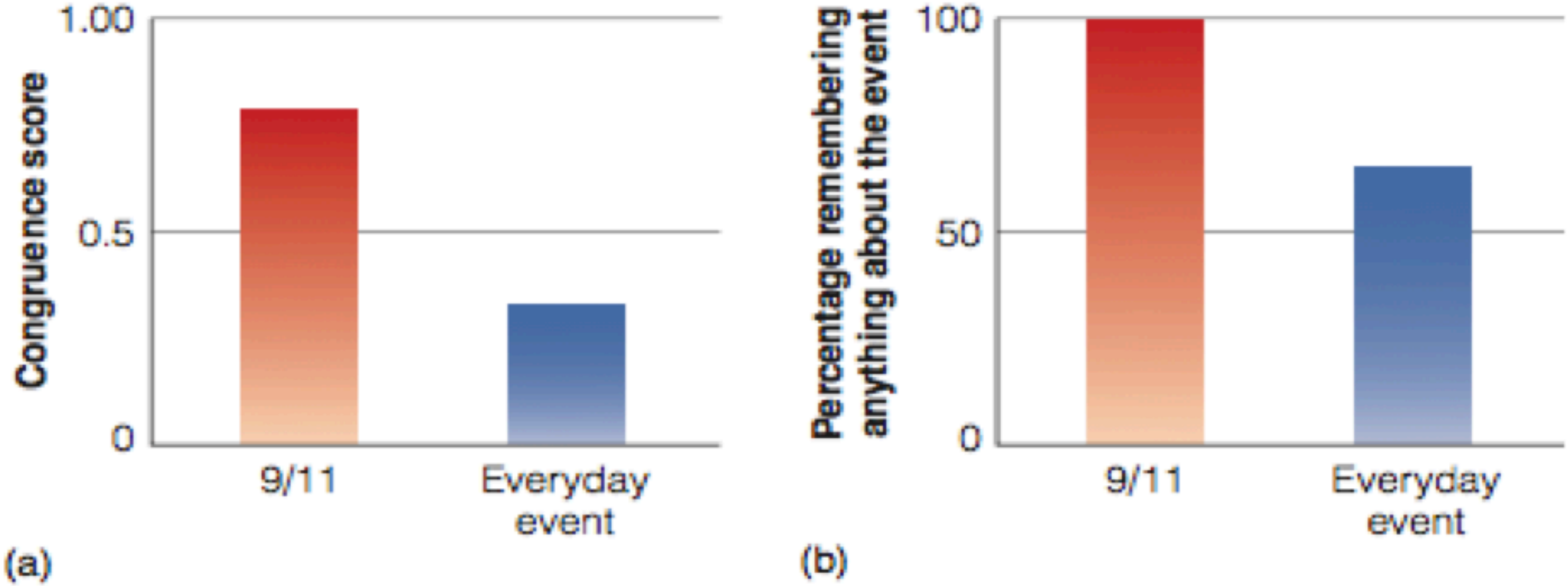


FIGURE 8.9 Results of Davidson et al.'s (2006) flashbulb memory experiment. (a) Congruence score for 9/11 memories and memories for the everyday event, measured 1 year after the events. (b) Percent of participants who were able to remember at least something about the 9/11 and everyday events. Note that 35 percent of the participants could not remember anything about the everyday event. (Based on data from Davidson et al., 2006, and personal communication.)

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing.* 4th Ed. (Fig. 8.9; p. 212).

- The results of both the studies show that memory for flashbulb events does decline over time & are not like a photograph (as earlier proposed.
- The poor recall of everyday events in the latter study could be due to lack of good quality retrieval cues.

- Better memory for events like 9/11 is probably due to 2 characteristics: first, they involve high emotions & second, that of the added rehearsal viz. the *narrative rehearsal hypothesis.*

- multiple repetitions of these kinds of events can be come across in the media, conversations & discussions.

- **The Constructive Nature of Memory**: - what people report as memories are partly constructed by them based on what actually happened plus additional factors such as the person's knowledge, experiences & expectations.

- The mind constructs memories based on a number of sources of information.

- An interesting example was Frederick Bartlett's "War of the Ghosts" experiment, published in 1932 but which was run before WWI.

- participants read the following story from Canadian Indian Folklore:

The War of the Ghosts

One night two young men from Egulac went down to the river to hunt seals, and while they were there it became foggy and calm. Then they heard war cries, and they thought: "Maybe this is a war party." They escaped to the shore and hid behind a log. Now canoes came up, and they heard the noise of paddles and saw one canoe coming up to them. There were five men in the canoe, and they said:

"What do you think? We wish to take you along. We are going up the river to make war on the people."

One of the young men said: "I have no arrows." "Arrows are in the canoe," they said. "I will not go along. I might be killed. My relatives do not know where I have gone. But you," he said, turning to the other, "may go with them."

So one of the young men went, but the other returned home. And the warriors went on up the river to a town on the other side of Kalama. The people came down to the water, and they began to fight, and many were killed. But presently the young man heard one of the warriors say: "Quick, let us go home; that Indian has been hit." Now he thought: "Oh, they are ghosts." He did not feel sick, but they said he had been shot.

So the canoes went back to Egulac, and the young man went ashore to his house and made a fire. And he told everybody and said: "Behold I accompanied the ghosts, and we went to fight. Many of our fellows were killed, and many of those who attacked us were killed. They said I was hit, and I did not feel sick."

He told it all, and then he became quiet. When the sun rose, he fell down. Something black came out of his mouth. His face became contorted. The people jumped up and cried. He was dead. (Bartlett, 1932, p. 65)

Excerpt: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing. 4th Ed.* (p. 214).

- After his participants read tis story, Bartlett asked them to recall it as accurately as possible. He then used the technique of **repeated reproduction,** in which the same participants came back a number of times to try to remember the story at longer & longer intervals after they first read it.

- At longer times after reading the story, participants forgot much of the information in the story. Most of the participant's reproductions of the story were shorter than the original and contained many omissions and inaccuracies.

- Could have happened that participants created their memories from two sources: one was the original story & the other was what they knew about stories in their own culture.

- The idea calls for the importance of **source monitoring**.

- **Source Monitoring** is the process of determine the origins of our memories, knowledge or beliefs (Johnson et al., 1993). e.g. Who told you about that latest gossip?

- source monitoring errors are also called **source misattributions,** because the memory is attributed to the wrong source.

- Source monitoring provides an example of the constructive nature of memory because we remember something, we usually retrieve the memory first and then use a decisions process to determine where that memory came from.

- Source monitoring errors are common, and we are often unaware of them.

- Some of the more sensational example of source monitoring errors are cases **cryptomnesia**, i.e. unconscious plagiarism of others. For example, Beatle George Harrison was sued for appropriating the melody from the song *He's So Fine* (originally recorded un 1960s group The Chiffons) for his song *My Sweet Lord*.

- Source Monitoring errors are important because the mechanisms responsible for them are also involved in creating memories in general.

- Johnson (2006) describes memory as a process that makes use of a number of types of information:

  - primary source of information is information form the actual event. &

  - additional sources of information that influence memory will include their knowledge of the world, preceding events etc.

- An experiment was done by Jacob and coworkers (1989) demonstrates an effect of source monitoring errors by testing participant's ability to distinguish between famous & non - famous names.

- In the acquisition part of the experiment, participants had read a number of non - famous names like Sebastian Weissdorf etc..

- In the immediate test, which was presented right after the participants saw the list of non famous faces, participants were told to pick out the names of famous people from a list containing 1) the non famous names they had just seen 2) new non famous names & 3) famous names.

- Just before this test, they were told that all of the names they had sen in the first part were all non famous.

- Because the test had been given immediately, participants correctly recognised most of the old non famous names,

- But in the delayed test, 24 hours later, when tested on the same list of names; participants were more likely to recognise the old non famous names as famous.

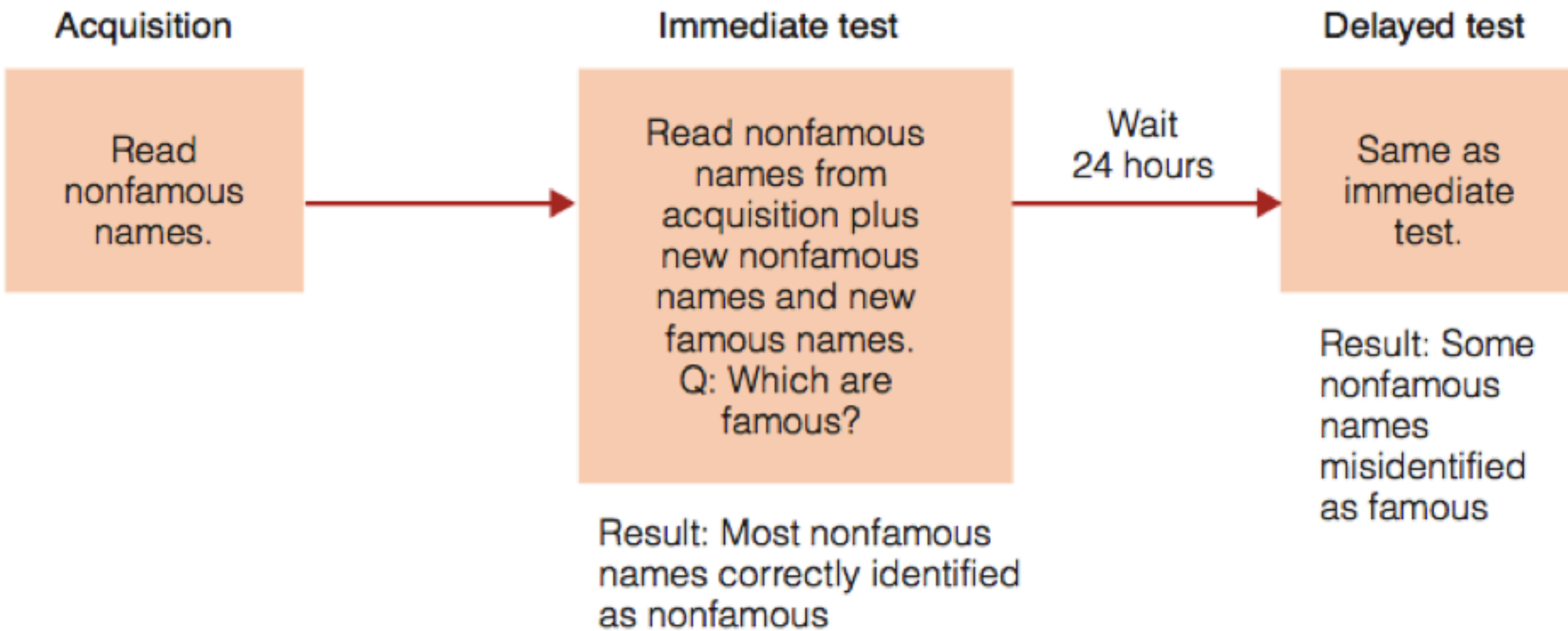
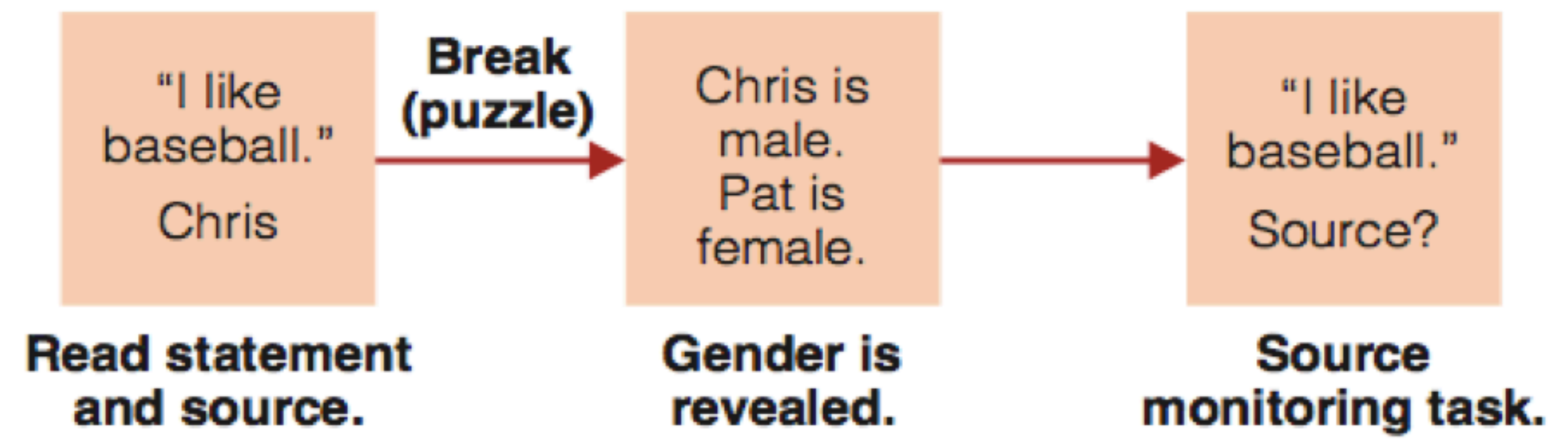


FIGURE 8.10 Design of Jacoby et al.'s (1989) "Becoming Famous Overnight" experiment.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 4th Ed. (Fig. 8.10; p. 216).

- Source Monitoring & Gender Stereotypes: Marsh & coworkers (2006) showed that people’s performance on a source monitoring task can be influenced by gender stereotypes.



● **FIGURE 8.11** Design of Marsh and coworkers' (2006) source monitoring and gender stereotype experiment.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 4th Ed. (Fig. 8.11; p. 217).

- The results indicate that gender labels affected the participants memory judgments.
- 83% of the masculine statements were associated with the male, but only 65% of the masculine statements were associated with the female. & vice - versa.

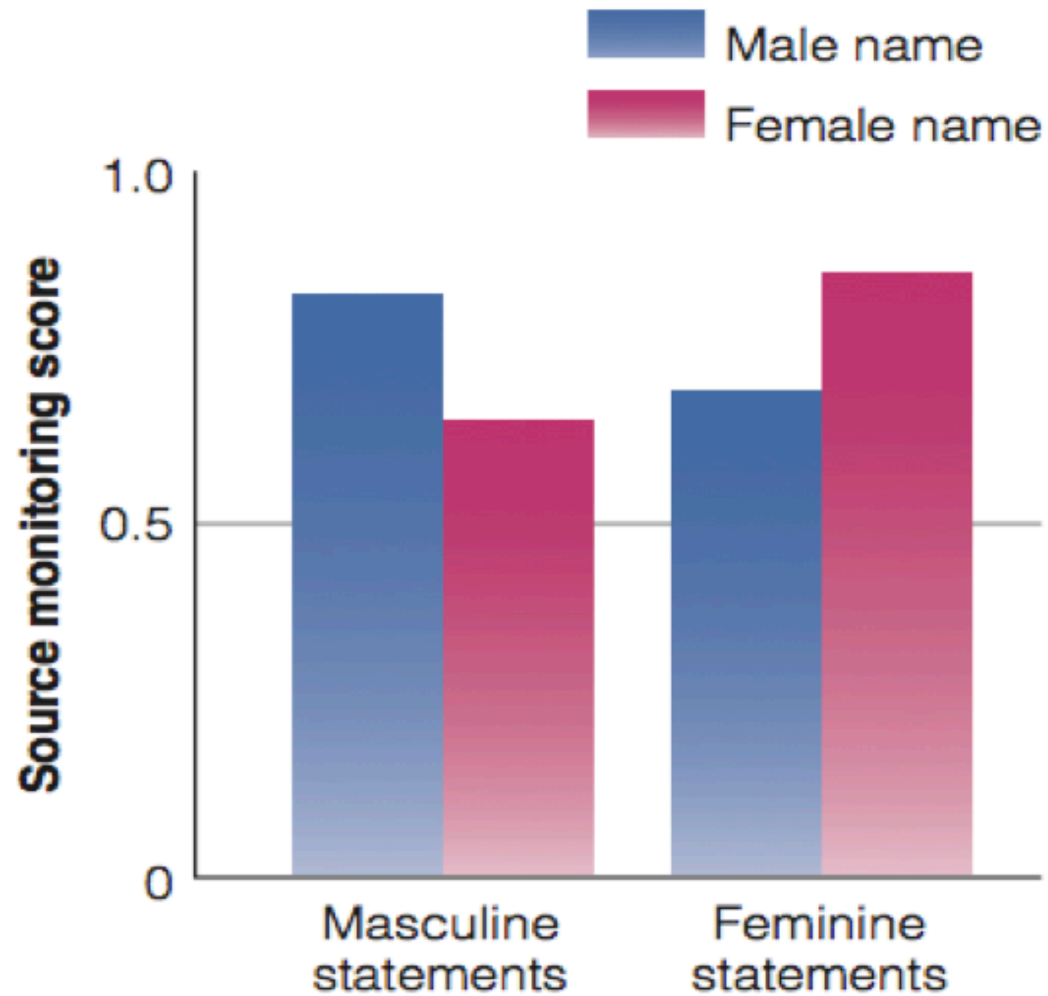


FIGURE 8.12 Result of March and coworkers' (2006) experiment.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 4th Ed. (Fig. 8.12; p. 217).

- Real world knowledge also affects memory formation as people make inferences about stuff based on their experiences and knowledge.

- In a classic experiment, Bransford & Johnson (1973) had participants read a number of actions statements in the acquisition part of the experiment and then tested their memory for the statements later.

1. *Experimental Group:* John was trying to fix the birdhouse. He was pounding the nail when his father came out to watch him and help him do the work.
2. *Control Group:* John was trying to fix the birdhouse. He was looking for the nail when his father came out to watch him and help him do the work.

Excerpt: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 4th Ed. (p. 218).

- Both the groups of participants were tested by presenting a number of statements that they had not seen and were asked to indicate whether they had seen before.

3. *Experimental and Control Groups:* John was using a hammer to fix the birdhouse when his father came out to watch him and help him do the work.

Excerpt: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 4th Ed. (p. 218).

- Participants in the experimental group said they had previously seen 57% of the test statements, but participants in the control group said they had previously seen only 20% of the statements.

- Apparently, participants in the experimental group inferred from the use of the word *pounding*, that a hammer had been used, even though it was never mentioned.

- This is an example of participants' inference causing an error of memory.

FIGURE 8.13
Design and results of Bransford and Johnson's (1973) experiment that tested people's memory for the wording of action statements. More errors were made by participants in the experimental group, who identified more sentences as being originally presented even though they were not.

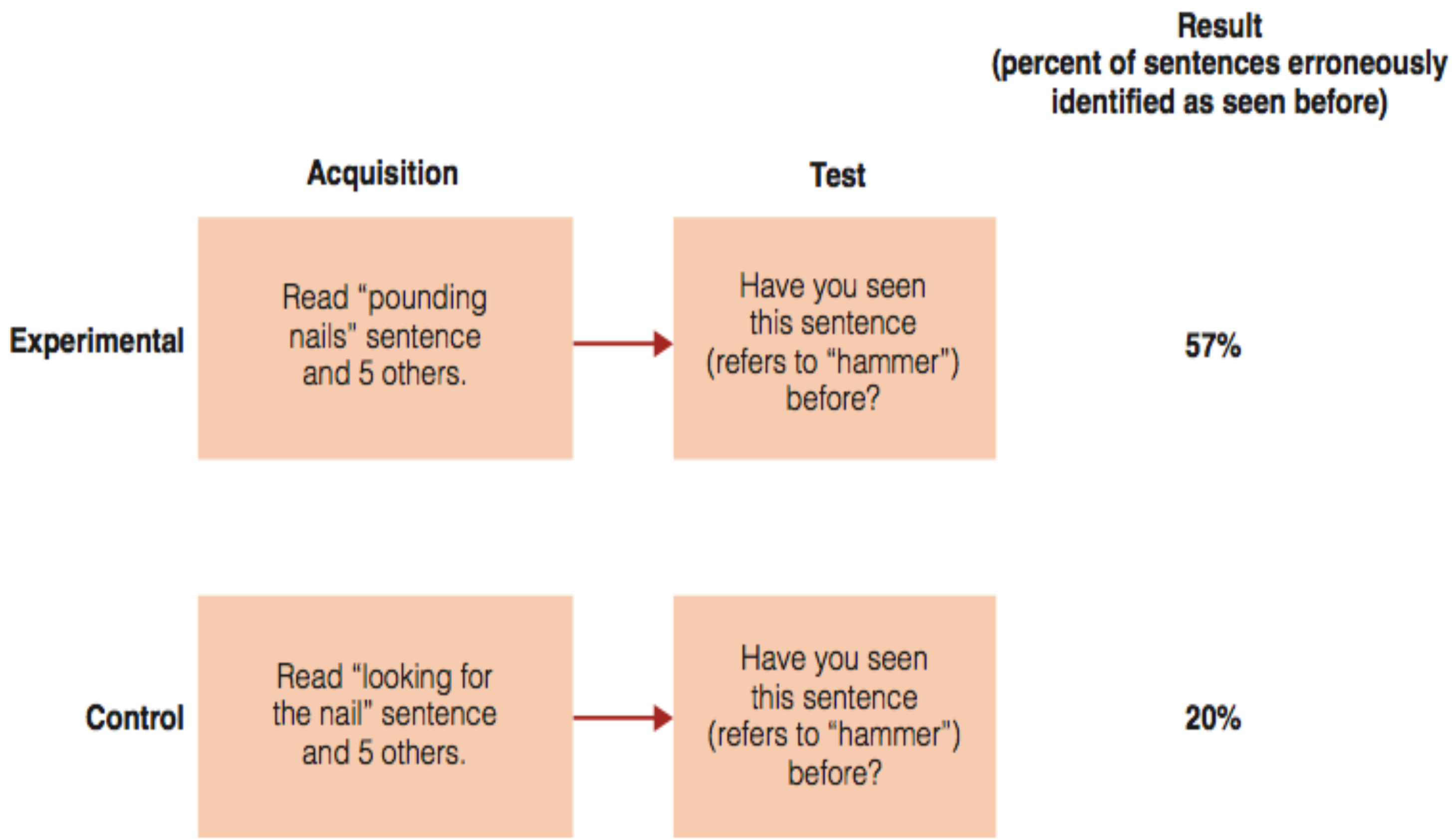


Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 4th Ed. (Fig. 8.13; p. 218).

- **The Misinformation Effect**: misleading information presented after a person witnesses an event can change how the person describes that event later.

- This misleading information is referred to as misleading post event information.

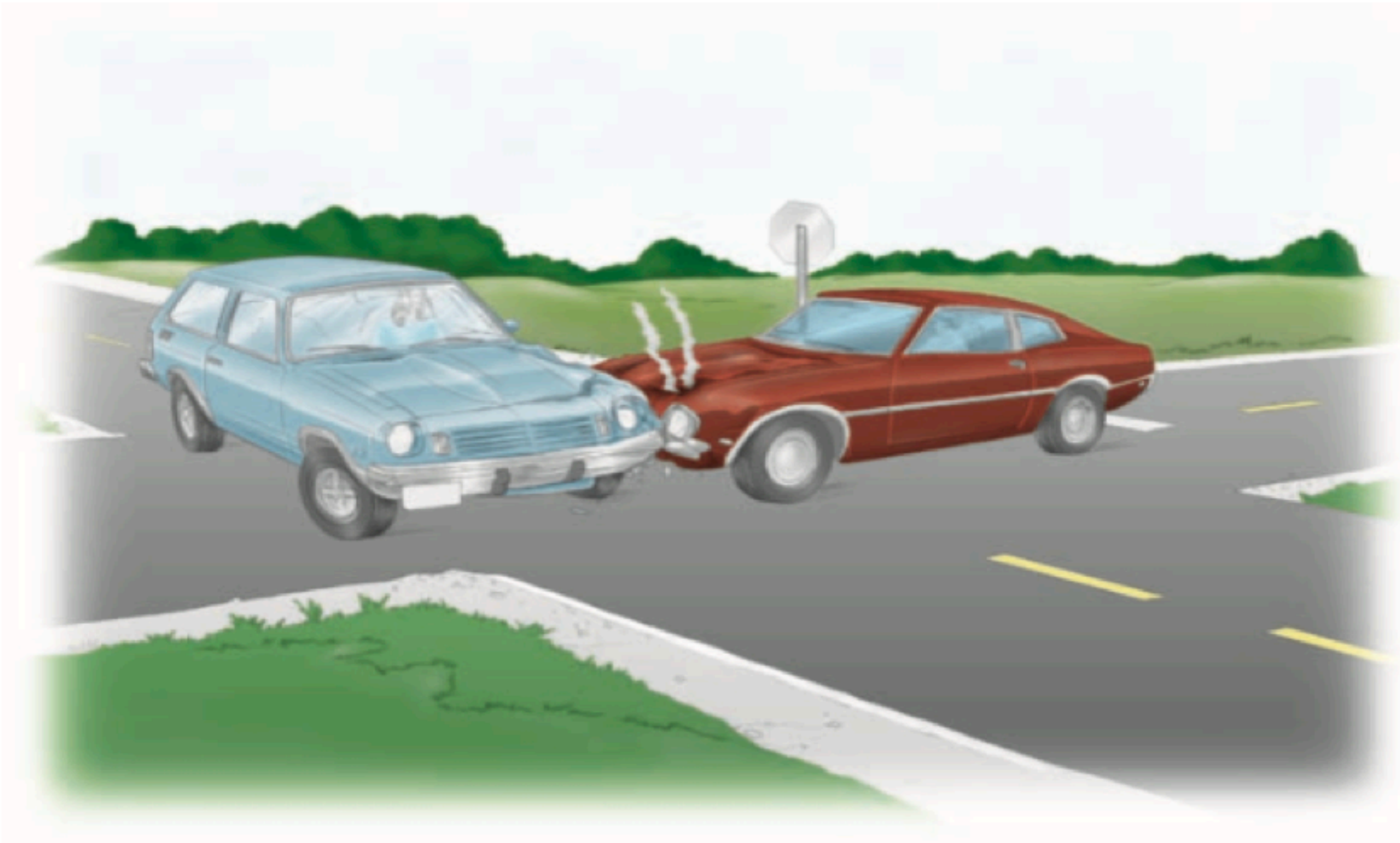
  - A classic experiment was done by Loftus & coworkers (1978) where participants saw a series of slides in which a car stops at a stop sign and then turns the corner & hits a pedestrian.

- Some of the participants then answered a number of questions including “Did another car pass the red Datsun while it was stopped at the stop sign?” Other participants (MPI group) answered “Did another car pass the red Datsun while it was stopped at the yield sign?”

- Those in the MPI group were more likely to say that they had seen the picture of the car stopped at the yield sign.

- In another similar experiment, Loftus & Palmer (1974) showed participants films of a car crash & then asked either 1) How fast were the cars going when they *smashed into* each other? or 2) How fast were the cars going when they *hit* each other?.

- Although both groups saw the same event, the average speed estimated by the participants who heard “smashed” was 41 miles per hour as opposed to those who heard the word “hit” who estimated that to be at 31 miles per hour.



• **FIGURE 8.16** Participants in the Loftus and Palmer (1974) experiment saw a film of a car crash, with scenes similar to the picture shown here, and were then asked leading questions about the crash.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 4th Ed. (Fig. 8.16; p. 223).

- MPI as:
  - **replacing the original memory**: acc. to the memory trace replacement hypothesis which states that MPI impairs or replaces memories that were formed during the original experience of the event.
  - **causing interference**: original information is forgotten because of retroactive interference, which occurs when more recent informatio interferes with memory for something that happened in the past.
  - **causing source monitoring errors**: acc. to source monitoring the person incorrectly concludes that the source of his memory was the slide show & not the actual experience.

- **Eyewitness Testimony:** testimony by an eyewitness to a crime about he or she saw during the commission of the crime.
- EWT is one of the most convincing types of evidence to a jury, but unfortunately many innocent people have been incarcerated based on mistaken identification by eyewitnesses.
- These errors may be caused due to a variety of reasons: for example difficulty in perceiving the person's face & others by inaccurate memory for what was perceived.

- **Errors Associated with attention**: emotions run high during commission of a crime & this can affect what a person pays attention to and what the person remembers later.

- an example is weapons focus, i.e. the tendency to focus attention on a weapon results in narrowing of attention, so witnesses might miss seeing relevant information as the perpetrator's face.

- Stanny & Johnson (2000) studied weapons focus by measuring how well participants remembered details of a filmed simulated crime. They found that participants were more likely to recall the details of the perpetrator, the victim, and the weapon , in the "no-shoot" condition than in the "shoot condition".

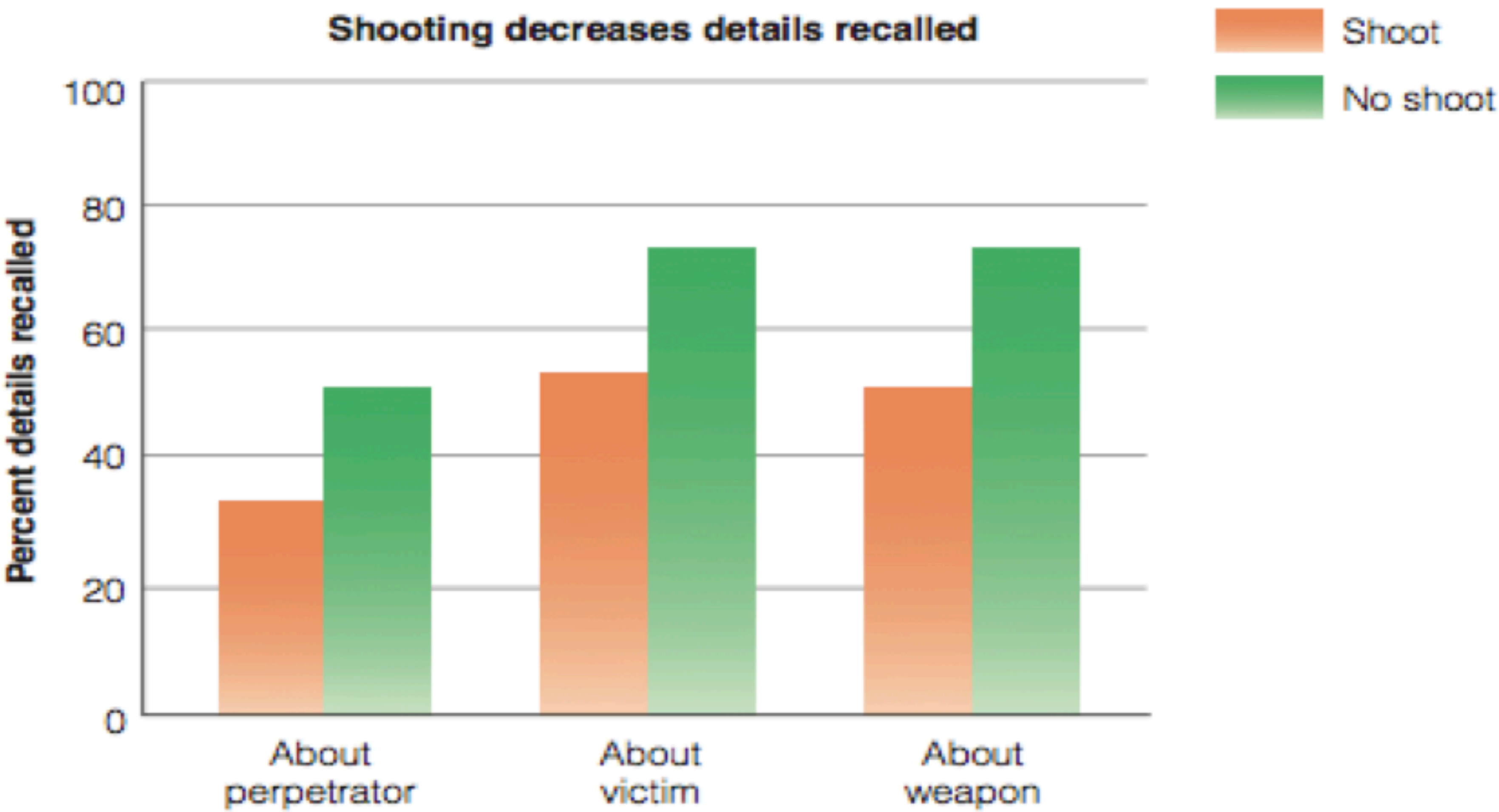


FIGURE 8.19 Results of Stanny and Johnson's (2000) weapons focus experiment. Presence of a weapon that was fired is associated with a decrease in memory about the perpetrator, the victim, and the weapon.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 4^{th} Ed. (Fig. 8.19; p. 228).

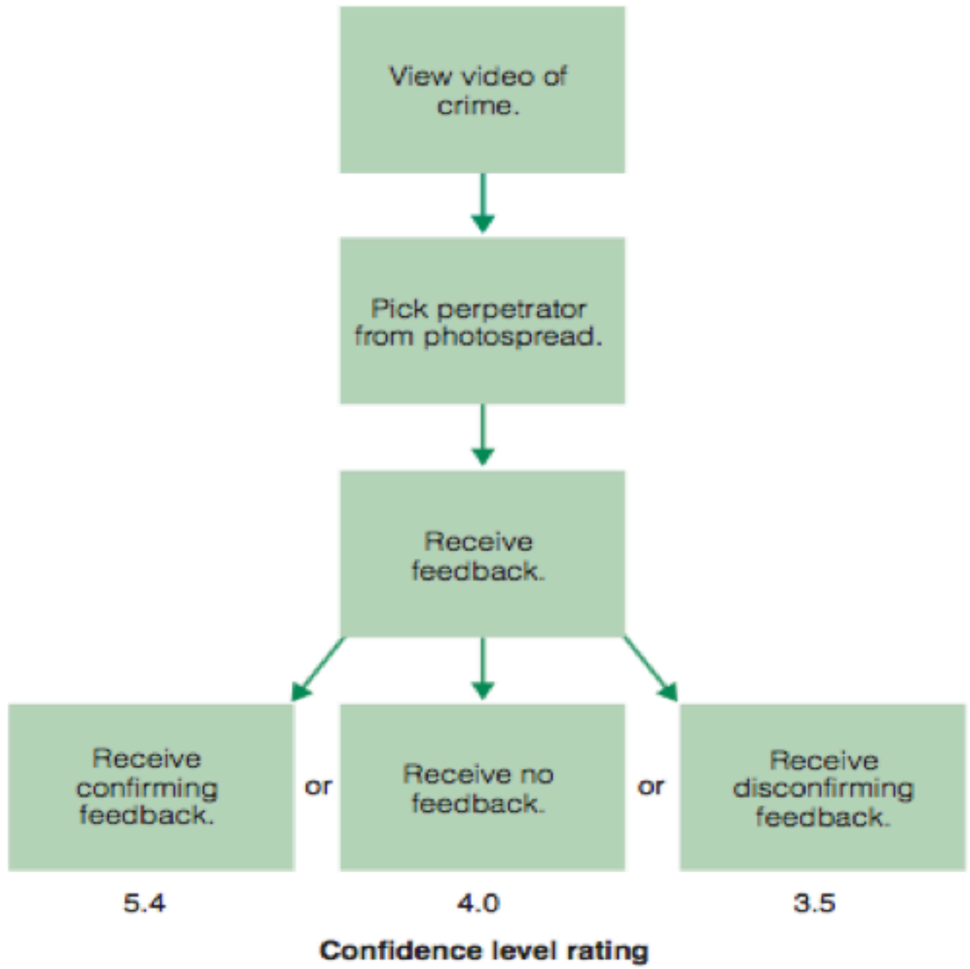
- **Errors due to familiarity:** Crime not only involves a perpetrator & a victim, but often includes innocent bystanders.
- These bystanders add yet another dimension to the testimony of the eyewitnesses as there is a chance that a bystander could be mistakenly identified as perpetrator because of familiarity. for example: a ticket agent at a railway station was robbed and subsequently identified a sailor as being the robber. Luckily for the sailor, he was able to show that he was somewhere else at the time of the crime.
- when asked why he identified the sailor, the ticket agent said that he looked familiar. The sailor looked familiar because he lived near the station and regularly bought tickets from the agent.

- **Errors due to suggestion:** It is possible that a police officer asking a witness, "did you see the white car?" could influence the testimony of the witness about what he/she saw.

    - In a paper titled, "Good You Identified the Suspect", Wells & Bradfield (1998) had participants view a video of an actual crime and then asked them to identify the perpetrator from a photodpread that did not actually contain the perpetrator.

    - All of the participants picked one of the photographs & following their choice, witnesses received either confirming feedback from the experimenter ("Good, you identified the suspect."), no feedback, or disconfirming feedback ("Actually the suspect was..")

- A short time later, the participants were asked how confident they felt about their identification.
- The results indicate that the participants who received the confirming feedback were more confident of their choice.
- Wells & Bradfield called this the **post identification feedback effect.**
    - this creates a serious problem in the criminal justice system because jurors are strongly influenced by the confidence of the eyewitnesses' judgments.



● **FIGURE 8.21** Design and results of Wells and Bradfield's (1998) "Good, You Identified the Suspect" experiment. The type of feedback from the experimenter influenced participants' confidence in their identification, with confirming feedback resulting in the highest confidence.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 4th Ed. (Fig. 8.21; p. 230).

- **The Effect of Post - event Questioning:** In another experiment, Chan & coworkers consider the question:

- How does taking a recall test after witnessing an event and before being exposed to misleading post event information influence the memory of the event?

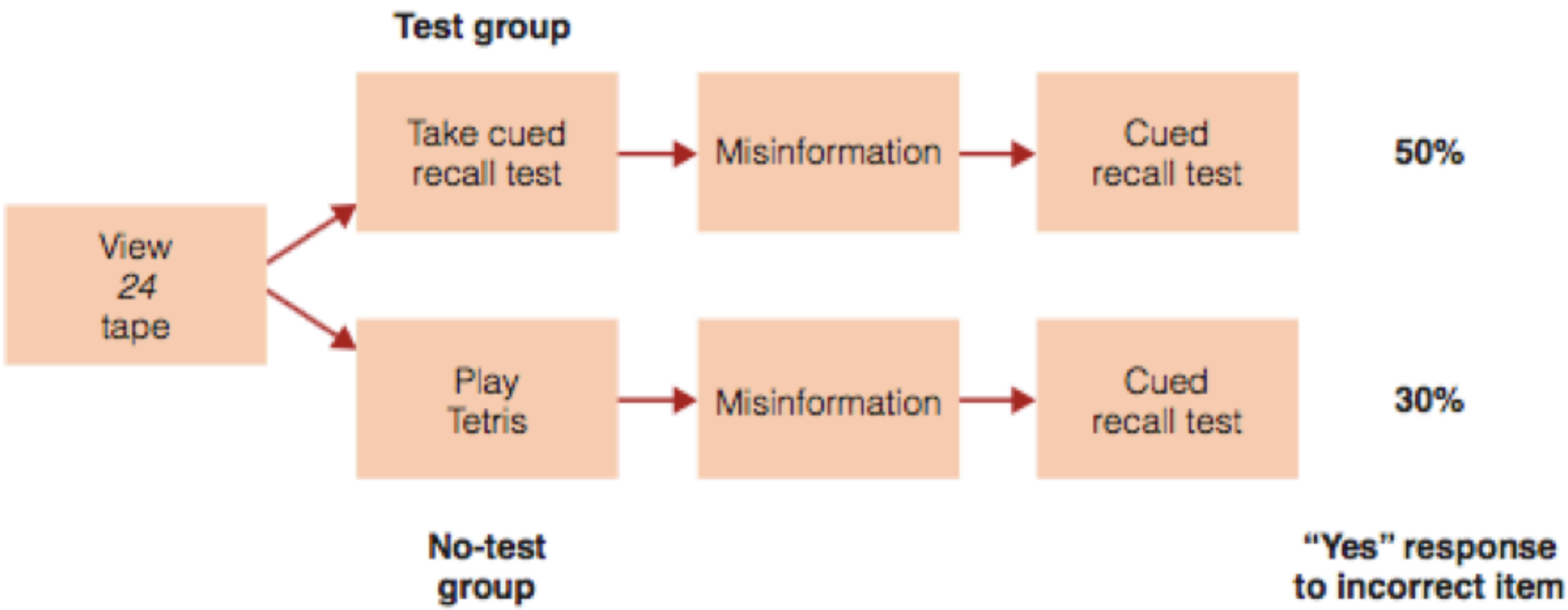


FIGURE 8.22 Design and results of Chan et al.'s (2009) experiment that demonstrated the reverse testing effect. Participants were presented with a distraction task before receiving the misinformation.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 4th Ed. (Fig. 8.22; p. 230).

- The results show that participants who took a recall test after the event said yes to the incorrect information 50% of the time.

- This result called the **reverse testing effect** shows that taking a recall test right after seeing the program became more sensitive to the misinformation.

- Why?
    - reconsolidation?

References

- Goldstein (2010). Cognitive Psychology: Connecting Mind, Research & Everyday Experience. *Wadsworth Publishing*. 4th Ed.

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Course Title:

Basic Cognitive Processes

By: Dr. Ark Verma,
Assistant Professor of Psychology,
Department of Humanities & Social Sciences,
IIT Kanpur

Lecture 37: Disorders for Perception & Attention

Why study disorders?

- A well functioning system does little to tell you about "how" it is functioning?
- Only when it is broken, or needs to be repaired, one comes to know the various components & their functionality.
- The idea behind studying disorders of cognitive functions is that it will help us better understand normal function and find better ways to help patients cope with impairments.

Synaesthesia

- Have you ever wondered on questions like?
  - What color is number 7?
  - What does Monday taste like? Or
  - What is it like to touch blue?

- While some of you will find these questions difficult to grasp, a very small minority of you might completely understand these questions. Those small minority are referred to as *synaesthete,* i.e. persons having synaesthesia.

- When people with synaesthesia are presented with a stimulus, they tend to consistenly and automatically experience another sensory event; which could either be in the same modality (e.g. vision) or in another modality (e.g. vision & gustation/olfaction etc.).

- the commonly reported experiences include experiencing a colour on seeing or hearing a letter, number or word.

- Similar examples could be lining colours with faces, days or weeks but also things like feeling sounds, seeing musical notes, seeing tastes and tasting colours (Baron – Cohen et al., 1996).

- Synaesthetes also report that inducers which follow a reliable sequence (e.g. letters of alphabet etc.) are experiences in a specific spatial arrangement.

- Early incidence of synaesthesia was reported in a famous paper by Baron – Cohen et al. (1987), who examined a synaesthete called EP; who called herself as ‘an artist who has experienced the life – long condition of hearing words and sounds in colour’.

- Baron – Cohen tested & established the replicability of EP’s synaesthetic experiences (100% vs. 17% by non – synaesthete.

- While for many synaesthetes, the colour induced by the first letter determines the apparent colour of the word; EP’s synaesthetic experience was mix of colours induced by each letter of the word (on pseudo words)

- *Nature of Synaesthesia*

  - Mattingley et al. (2001) reported accuracy levels of 80 – 100% in a group of 15 synaesthetes compared with 30 – 35 percent in 15 non – synaesthete controls in reporting synaesthetic experience.

  - Moreover, the reports were more consistent over a 3 month period of test – retest interval as compared to that of non synaesthetes after a delay of just one month.

  - Synaesthesia is usually a uni – directional process; a letter may give rise to the perception of red but no vice versa.

- For most synaesthetes, simply imagining the inducer can be enough to produce the synaesthetic response.
- Although, synaesthetic experiences are limited to fairly low – level percepts such as colour or spatial location rather than the appearance of a face or an object (Grossenbacher & Lovelace, 2001).
- Also, some synaesthetic experiences have been traced to developmental experiences. For e.g. Witthoft & Winawer (2013) linked consistent letter – color associations in 11 synaesthetes to a specific Fisher – Price colored letter set, which participants recall seeing in their childhood.

- Carpenter (2001) report that most synaesthetes regard their condition as a good thing, though one of them was identified as having problems.

- Steven & Blakemore (2004) reported the details of six synaesthetes who experienced seeing colors on hearing or thinking about letters or numbers, despite being blind for many years.

- Steven & Blakemore (2004) comment that this suggests that synaesthesia, 'persists for very long periods with little or no natural experience in the referred modality' (2004:855).

- *Incidence & Familiarity*

  - Baron – Cohen et al. (1996) estimated the incidence of synaesthesia at about 1 in 2,000, with about 80% being female.

  - Ward (2013) cites prevalence rates from 0.2 per cent of the population for taste – shape synaethetes, 1.4 for letter/number-color, & up to 20 percent for those who image sequences into spatial arrays; suggesting that an approximate equal number of men and women have synaesthetic experiences.

Experimental Studies of Synaesthesia

- Several researchers (e.g. Mills et al., 1999; Mattingley et al., 2001) have used versions of the Stroop test (Stroop, 1935) to investigate synaesthesia.
  - Typically, a synaesthete is asked to identify the actual colour of a series of stimuli, some of which are inducers and some not.
  - When the inducer color matches the synaesthetic colour, responses are significantly faster than on neutral, non-inducer, trials.
  - When an inducer has a different colour, it interferes with performance and responses are significantly slower than neutrak trials.

- These findings suggest that synaesthesia cannot be ‘switched off’; and hence are termed mandatory or automatic.
- Mattingley et al., (2001) modified the Strop task to investigate whether conscious processing of an inducer is necessary for a synaesthetic response.
    - Inducers were presented very briefly followed by a visual mask. It is known that such brief masked presentations are registered in the brain at some level because they can influence responses to subsequent related material.

- However, this technique prevents conscious awareness, and neither the synaesthetes nor the control participants were able to report what they had seen.
- Under these conditions, no synaesthetic interference was found.
- Hence, it was concluded that conscious awareness is therefore necessary for synaesthetic responses to occur.

- Such a finding is also supported by studies that have used visual search paradigms.
  - When asked to search for a red F amongst blue letters; synaesthetes did not have any added advantage as a blue F does not pop out because of their experience of the letter as red.
  - Suggesting that conscious attention to the inducer is necessary before the synaesthetic experience to occur.

- ***Brain Imaging Studies of Synaesthesia***

  - Functional brain – imaging techniques such as fMRI, allow researchers to examine changes in the measures of brain function as volunteers perform different task. Areas that are involved predominantly during any of these tasks receive more oxygenated blood, which can be tracked & hence give a spatial map of brain function..

  - EEG: records minute changes in voltage detectable from electrodes harmlessly resting on the scalp. The measures are very sensitive to ms by ms changes but give only a rough idea about the spatial locations of neural activity.

- **Transcranial magnetic stimulation** as a method allows some inference about the functional involvement of a brain area in process.

    - An electromagnetic coil near the scalp is used to induce an electrical pulse in the underlying cortical region, which can cause excitation, or with repeated stimulation, a period of under – excitability, resembling a temporary lesion.

- Nunn et al., (2002), used fMRI to report that synaesthetes showed increased activity in V4, region of the brain linked with colour perception, when listening to inducer compared with non – inducer words.
  - This signal was not found in non – synaesthetic control participants who also had been asked to associated colours & words.
  - Consistent findings were reported by Hubbard & Ramachandran (2005).

- These findings showed that synaesthetic colour experience was represented in exactly the same system as that based on 'real' colour experience.

- Though some other studies have also failed to detect similar activity & there are suggestions that different forms of synaesthesia may be associated with different patterns.

- *Last words:*

- Competing theories have been proposed to explain the occurrence of synaesthesia.

    - One of them proposed maintains that all of us were synaesthetes during early stages of childhood but have lost those connections during the course of development.

        - Ramachandran & Hubbard (2002) note than brain areas involved in colour perception (V4) are immediately adjacent to the areas active during letter reading.

- Grossenbacher & Lovelace (2001) put forward a ‘disinhibted – feedback’ theory suggesting that connections between different sensory pathways exist in ‘normal’ brains but that the activity of these pathways is usually inhibited to prevent unadaptive cross – talk between sensory modalities.

  - Interesting evidence has been reported supporting the disinhibition hypothesis; as Neufeld et al., (2001) found no difference between 14 auditory – visual synaesthetes and non – synaesthete fMRI participants in terms of functional connectivity between auditory & visual areas but greater connectivity between sensory areas and the IPS in the synaesthetic group; suggesting that it may be links via this integration area that are suppressed in non – synaesthetes.

Blindsight

- Poppel et al., (1973) studied a group of ex – servicemen who had suffered visual field deficits as a result of gunshot wounds to the striate cortex, & asked the participants to make judgments about the correct location of a flash of light presented to their 'blind side'.

- As the servicemen, could not see the flashes, the light was paired with the sound of a buzzer, and on hearing the buzzer the servicemen were asked to move their eyes in the direction of the light source.

- While the servicemen found this a difficult task, all of them were able to direct their gaze towards the light which they could not see.

- Weiskrantz et al., (1974) described a patient DB who seemed to demonstrate the same remarkable ability; i.e. he could report details of objects appearing in the blind areas of his visual field despite having no conscious experience of seeing them. Weiskrantz coined the term ‘blindsight’ to describe this phenomenon.

- In a series of experiments, Weiskrantz & colleagues were able to systematically investigate the perceptual abilities preserved in the blind areas of DB’s visual field.

  - DB was able to detect the presence of an object, & indicate it’s location in space by pointing. He could discriminate between moving & stationary objects; horizontal & vertical lines & the letter X from the letter O. However, he could not distinguish between X & a triangle.

- *Blindsight*: Cowey (2004) summarized the arguments put forward by sceptics such as Campion et al., (1983).
    - **The stray light hypothesis**: Campion et al. favored the stray light explanation of blind sight, which suggested that the blindsight patients responded to light reflected from the object onto the functioning areas of the visual field.
    - they described a patient who reported that he was using such a strategy to distinguish between vertical & horizontal bars presented to the blind areas of his visual field.
    - The patient claimed that he could see a faint glow in the preserved areas of his visual field and used this cue to undertake the task.

- Campion et al., demonstrated that such a strategy could lead to the accurate localization of a light in a ‘blind’ area of the visual field of normal subjects whose vision had been masked.
- However, some of these explanations did not hold up, as they could not explain DB’s ability to distinguish letters such as X and O or two different spatial frequency gratings with the same averag brightness.
- In addition DB could locate objects even against a bright background, whereas Campion et al.,’s normal subjects could only locate a light source against a low level of background illumination.

- **Spared islands of residual vision**

  - Wessinger et a., (1997) suggested that blindsight was attributable to small areas or islands in the scotoma i.e. areas of blindness in the visual field, within which vision is spared & that blindsight may be mediated by what is left of the primary visual pathway rather than other secondary pathways.

  - Kentridge et al., (1997) tested the suggestion while looking for scattered regions of spared vision in a patient using a procedure which ensured no effects of eye movements.

  - Kentridge et al., noted that blindsight did note xtend across the whole area of the scotoma, but was evident in some areas even after eye – movements had been eliminated.

- However, these lead to the conclusion that even though there may be some spared islands within the scotoma, these areas cannot account for all blindsight.

- Furthermore, Cowey (2004) reported results from an fMRI study wherein fMRI scannig of several blindsight patients has shown ‘not a shred of evidence’ of any sparing of the striate cortex in the area of the scotoma.

- *Final Words*:
  - One of the possible explanations or implications of blindsight that have been put forward is that we have two separate visual systems, one primitive non – striate system and a more advanced striate system.
  - The primitive non – striate system might be sensitive to movement, speed, & other potentially important characteristics of a stimulus without giving rise to conscious perception.

- Another similar explanation was that the striate & non – striate systems have evolved for different roles for e.g. the striate system has evolved to allow the identification of an object whereas the non – striate system has evolved to allow the localisation of the object in space.

- It is possible that during blindsight only the striate system is damaged whereas the non – striate one remains active.

Unilateral Spatial Neglect

- In unilateral spatial neglect – patients fail to respond to stimuli which they can see.

- A patient can have normal visin yet fail to react to objects or events to one side of the space – hence the term unilateral. The condition has also been referred to as *hemi – attention, contralateral neglect, & spatial neglect*.

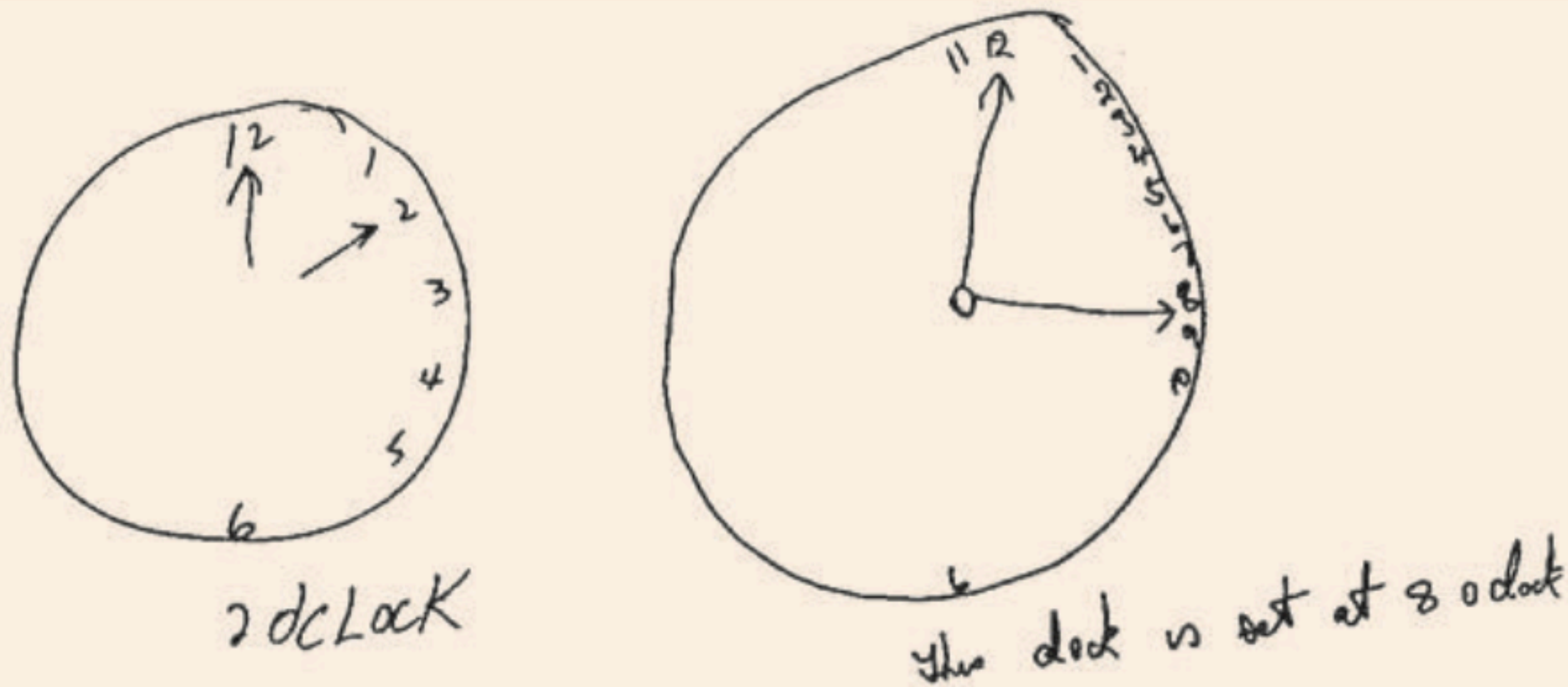

Image: Groome D. et al. (2013). An Introduction to Cognitive Psychology: Processes and Disorders. *Psychology Press.* 3rd Ed. (Fig. 4.3; pp. 114)

- The main cause of unilateral spatial neglect is stroke, an interruption to the brain's blood supply.

- Up to 84 percent of patients with damage to the right hemisphere of the brain from stroke will show evidence of ignoring information on their left visual field. Similarly upto 64 percent of patients with left hemisphere damage could show the opposite pattern.

- For some reason, left neglect following right – hemisphere lesion is markedly more severe & persistent than it's right neglect/left hemisphere equivalent.

- Patients with USN may fail to notice an object in ‘clear view’ on the left , ignore people approaching from the left, eat food only from the right side of the plate, or wah & dress only the right side of their own body.

- USN impact upon many activities of daily living, can exclude people from rehab and is associated with longer hospital stays and dependence on other.

- A disorder of attention?
  - USN is a failure of or difficulty in responding to information on one side of space that cannot be explained by basic sensory loss.
  - The obvious difference between USN & visual field loss is that the former can exert an influence across modalities, while the latter is restricted to vision.
    - USN has been reported in audition, tactile exploration, touch & body sensation (Vallar et al., 1993; McIntosh et al., 2002), imagery (Bisiach & Luzzatti, 1978) & even smell (Bellas et al., 1988).
  - While visual field losses are strictly retinotopic; USN varies in different spatial frameworks, i.e. it may occur for objects to the left side of the body or for objects on the left side of something regardless of where this is in relation to the person.

- USN may occur for the left side of each object within a scene (Driver & Halligan, 1991).

- Marshall & Halligan (1993) describe how patients kept on drawing only the left side of plants when asked to copy pictures.

- Is USN a disorder of attention?
    - Patients have been shown to attend to the left if cued to do so or if particularly salient events draw attention there.
    - Also, if a stimulus appears in face of competition with a rival on a good side, it is inevitably ignored.
    - There seems to be a gradient between left to right & not a clear boundary.

- Also, case studies by Bisiach & Luzzatti (1978) – patients were asked to describe the Piazza del Duomo in Milan form memory – they could describe the landmarks on their right; but when they were asked to describe the same landmark from the other end, the previously ignored landmarks could come back to attention and by Marshall & Halligan (1988) demonstrate that USN certainly seems to be more of a disorder of attention than of visual perception.

- Rehabilitation in USN
    - Encouraging patients to look towards & be aware of the left has not produced the desirable outcomes, though movement of the left arm/hand has been found to generally enhance the visual awareness of the left side.

- Explaining USN:
    - USN occurs at remarkably high frequency following stroke & has also been reported following damage to a wide variety of brain areas including the parietal, temporal & frontal lobes and even subcortical ares (Mort et al., 2003).
        - This has led to the idea that normal spatial attention may reflect a dynamic & easily disrupted competitive balance between the widely distributed networks in the hemispheres (Mesulam, 1999).
        - In this view the left hemisphere is pushing attention into the right space & the right hemisphere is pushing attention back to the left.
        - So, in USN we are not just seeing the effect of the lesioned hemisphere but its exaggeration due the suppressing effects of the undamaged rival hemisphere (Kinsbourne, 1977).

Visual Agnosia

- Agnosia – a Greek work meaning 'non – knowledge'.
  - Patients with visual agnosia are not blind and the sensory processes are usually intact. However, the condition refers to an impairment in the ability to visually recognise objects.
  - They can move around & navigate spatially; can also recognise objects through other sensory modalities, but they just cannot recognise objects visually.

- Apperceptive & Associative Agnosia:
  - Someone suffering from apperceptive agnosia can be thought to have normal visual acuity with an inability vto draw an object, to say whether two similar objects were the same or different or event to describe the component parts of an object.

  - Someone suffering from an associative agnosia would be able to draw an object, to match similar objects and be able to describe the component parts but they would be unable to recognise the objects they had just seen or drawn.

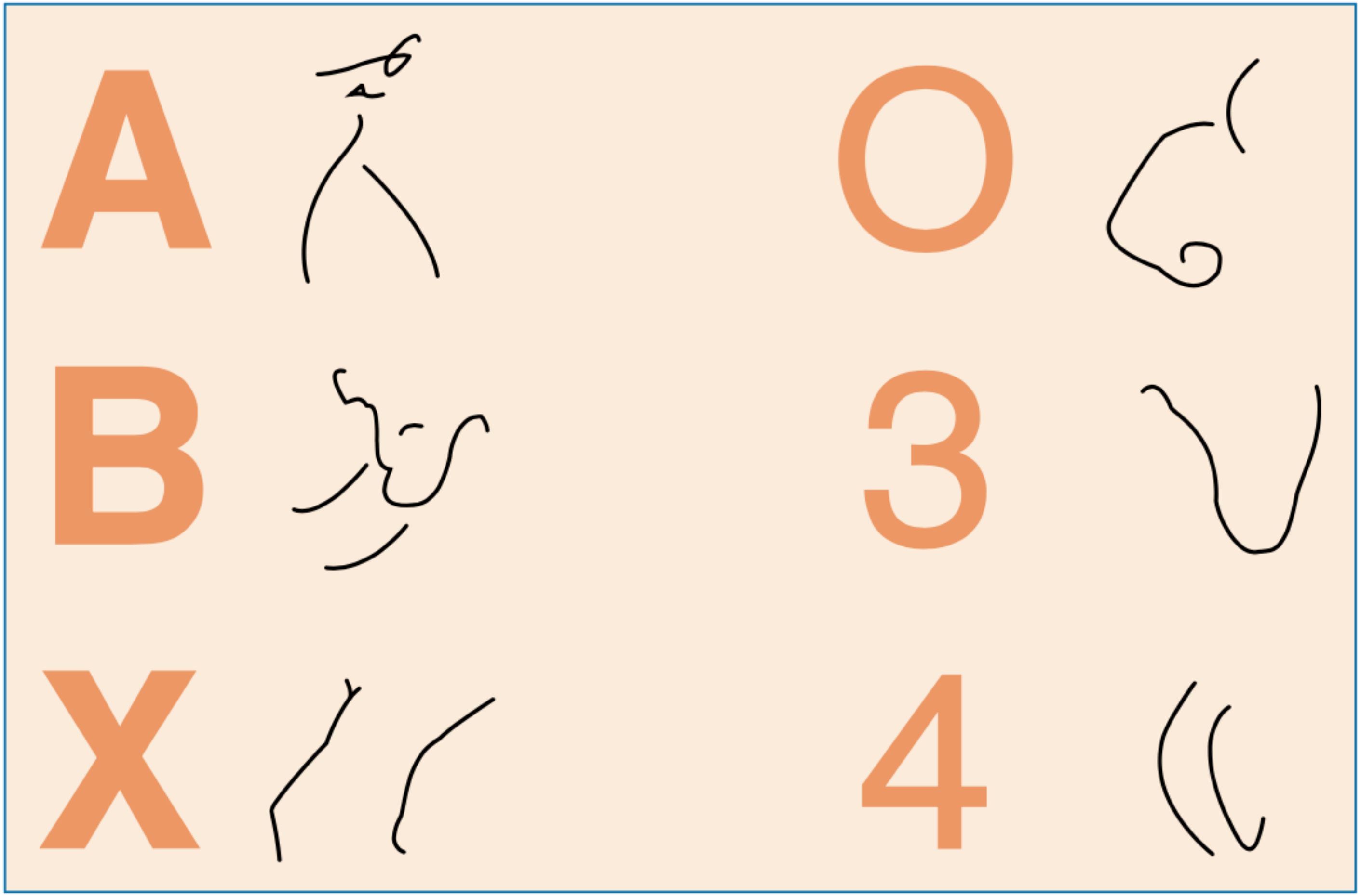

Figure 4.4 The attempts of a patient with apperceptive agnosia to copy six simple figures.

Source: Farah (1990), reproduced by permission of MIT Press.

Image: Groome et al. (2013). An Introduction to Cognitive Psychology: Processes & Disorders. *Psychology Press*. (Fig. 4.4; pp. 119).

- Lissauer (1890) proposed that these two stages were serial & hierarchical.
  - So, in the apperceptive stage the elements or components of the object are established & in then in the associative stage these elements are integrated into a representation of the whole object which enables recognition & identification.
  - This means that the patient with pure apperceptive agnosia have na intact store of knowledge about objects, but as they are unable to distinguish the shape of objects they are unable to identify the objects visually.
  - but patients with pure associative agnosia are able to perceive the objects but are often unable to identify them.

  - This principle was found useful in differentiating the patients with pure apperceptive or associative agnosia; those who could not copy had the former while the other kind had the latter.

- Form & Integrative Agnosia

  - Form agnosia is used for patients who are unable to discriminate between objects and are unable to copy line – drawings of objects (Farah, 2004).

  - Integrative Agnosia is the accepted term for associative agnoisa as it reflects the processing difficulties experienced by the patients. So it is used to refer to patients who can perceive the individual shapes and elements of objects but are unable to integrate these into a representation of the whole object.
    - Integrative agnosia has been reported with incidents of stroke, brain trauma & AD.

- Life with Visual Agnosia
  - Patients (like HJA, Humphreys & Riddoch, 1987) with visual form agnosia experience a very confused & distorted visual world in which almost nothing seems familiar and even basic forms are indistinguishable from each other.
    - Almost like looking at the world through a very powerful microscope; wherein despite seeing the details of the objects around it is hard to put together a mental picture of the overall structure.
    - Goodale & Milner (2004) describe such a patient Dee, who has severe visual form agnosia as a result of CO poisoning. Despite being unable to recognise objects or their shape, she uses the surface characteristics like texturte & colour to help recognize objects.

- Animate vs. Inanimate Objects
  - A patient SA could identify animate objects much better than inanimate object while another HJA showed the reverse pattern.
  - Similarly, JBR could name drawings of many non – living objects 9such as a spade or hairbrush), but he could not name the drawings of living things (such as dog or fly) or musical instruments (such as a trumpet) (Warrington & Shallice, 1984).

- Farah & McClelland (1991) argue that there is a difference between identifying living versus non – living things may infact be an artefact.
  - In most cases where there is impaired knowledge of perceptual attributes with intact knowledge of functional properties, there is also an impairment for inanimate objects.
  - Because perceptual attributes (colour, size, shape etc.) are crucial for identifying animate objects; the identification of inanimate objects is crucially linked to functional attributes in semantic memory (Riddoch & Humphreys, 1987).

Prosopagnosia

- Is a form of agnosia that relates to faces.
  - The term prosopagnosia was first used by Bodamer (1947), who examined 3 patients, who, he believed showed a face – specific deficit, as they were unable to recognisenon-face objects normally.
- People with prosopagnosia cannot recognise familiar faces of family members, friends & even themselves in the mirror, though their visual or sensory processes are intact.

- However, individual with PA are often able to use other cues such as voice to recognise familiar people.
    - Meaning that identity & semantic information has not been lost.
- Bruce & Young (1986) used evidence gained from studying individuals with face processing deficits and from studies of normal individuals to propose a model of face processing.
    - The model suggests that the recognition of identity, expression & facial speech analysis are independent processes, & subsequent evidence from brain damaged patients largely supports this view.

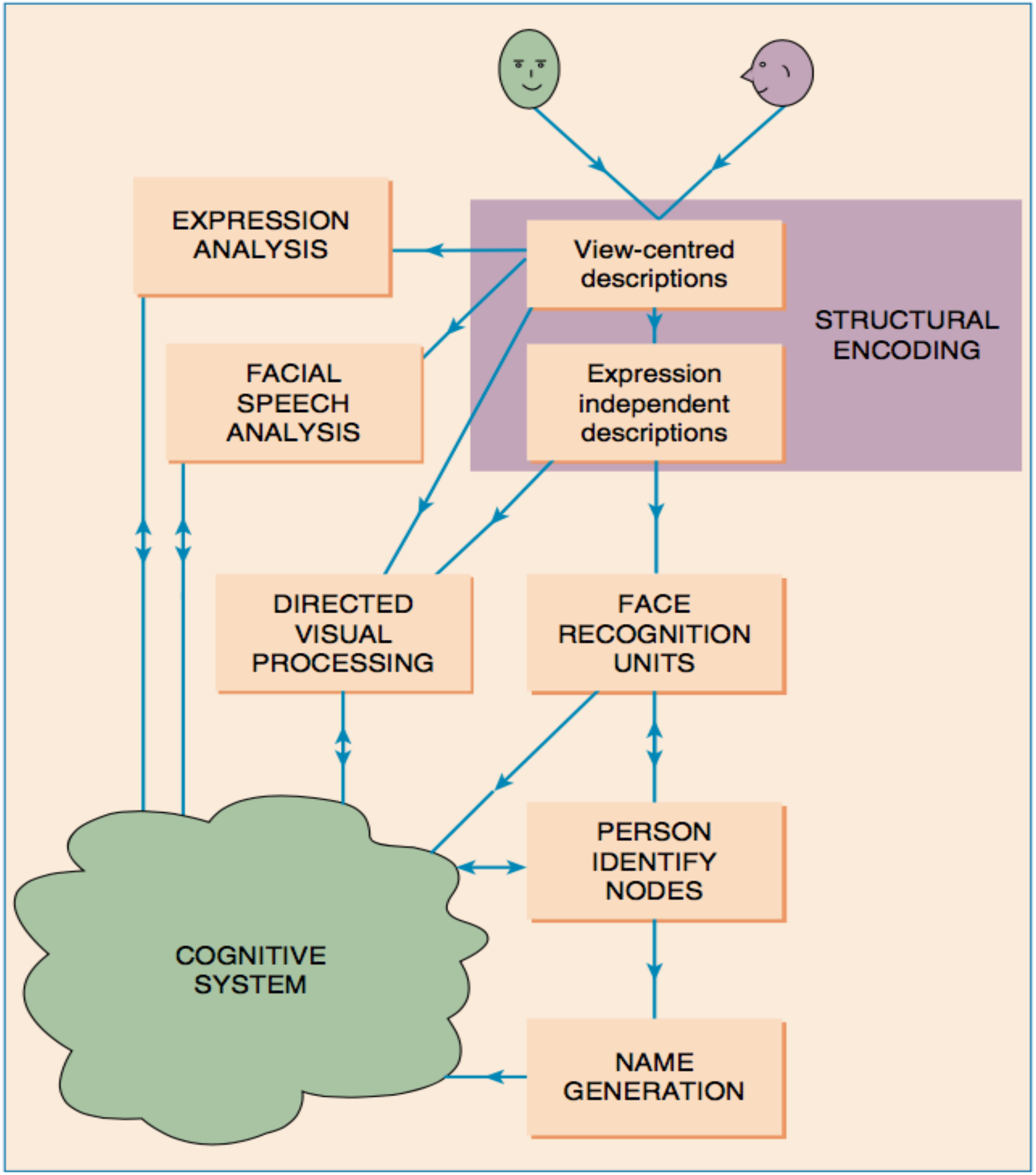

Figure 4.8 Bruce and Young's model of face processing showing independent pathways for face recognition, expression analysis and speech analysis.

Source: Bruce and Young (1986), reproduced by permission of the British Psychological Society.

Image: Groome et al. (2013). An Introduction to Cognitive Psychology: Processes and Disorders. *Psychology Press*. (Fig. 4.8; pp. 127).

- Given, that face recognition is one of the most demanding and sophisticated tasks that our visual system undertakes, it is unsurprising that an impairment in this ability can be acquired through brain damage.

  - However, brain damage rarely leads to complete destruction of the ability to recognise faces & there is a lot of variation in the severity of impairment, the associated deficits and types of face processing skills as well as in the location of and type of lesions that result in acquired prospagnosia (Barton, 2008).

- Living with prosopagnosia
  - Data from imaging studies has also demonstrated that most cases of prosopagnosia have damage in the fusiform and lingual gyri, although there are also cases of damage in more anterior temporal areas (e.g. Gainotti et al., 2003).
  - The FA has been shown to be a key structure in face & object processing, & numerous studies have shown that the fusiform gyrus contains an area dedicated to face processing called the *fusiform face area* (FFA) (e.g. Haxby et al., 1994).
  - There is variability however, in the location of the FFA across individuals, & this may help to explain why prosopagnosia sometimes seems to occur with damage only in on hemisphere (Bruce & Young, 2012).

- Such variation has led researchers to think that there is no single area in the bran that is responsible for processing faces – rather a distributed neural network made of many bilateral regions is involved (Haxby et al., 2000).
- Barton (2008) reviewed the data from 10 patients & concluded that most severe impairments were found in patients who had bilateral occipito – temporal lesions involving the fusiform gyri.
- Also, he concluded that the right fusiform gyrus was involved in configural processing of faces & that memory for faces was more severely disrupted when these bilateral lesions included the right anterior temporal lobe damage.

- Prosopagnosia – face specific disorder

  - Riddoch et al., (2008) studied a patient FB & found that she was unable to identify faces of famous people that she was previously familiar with; but could make age, genfer & expressin judgments. Also, she could learn object names fast& could also respond to parts of faces ; but not whole faces. It can be safely concluded that she demonstrates a relatively pure form of prosopagnosia.

  - McNeil & Warrington (1993) describe the case of WJ, who took up farming after becoming prosopagnosic and remarkably showed evidenc of being albne to recognize his sheep; despite remaining prosopagnosic to human faces.

- Assal et al., (1984) described a farmer who was initially unable to recognise either humans or cows but after 6 months recovered the ability to recognise human faces but not cows.

- But while, there are such dissociations in the literature, Duchaine & Garrido (2008) argue that dissociations are not enough to provide support for face – specificity in prosopagnosia.
  - They state, ‘a network of areas is involved in face processing & their interactions remain poorly understood’.

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Indian Institute of Technology
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Presents

Course Title:

Basic Cognitive Processes

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Lecture 38: Disorders of Memory

AMNESIA

- Amnesia is the name given to disorders of memory.
  - Normally involves forgetfulness, which goes beyond the everyday forgetting observed in normal people; to the extent that it may interfere with the activities of normal life.
  - A person suffering from amnesia may be quite unable to remember any recent events like the happenings of the current day or previous minutes, hours etc.
  - Amnesia therefore is a very disabling condition.

Causes of Amnesia

- Amnesias may arise from a number of different causes, which can be divided into two main groups:
    - **Organic Amnesias:** caused by some form of physical damage inflicted on the brain. For e.g. brain infections, strokes, head injuries, & degenerative disorders such as Alzheimer's disease.
    - Organic amnesias tend to be severe and disabling, & they are also irreversible in the majority of the cases because the brain lesions usually do not heal.

- **Psychogenic Amnesias** are caused by pychological factors and usually involve the temporary suppression of disturbing memories which are unacceptable to the patient at some subconscious level.

- Psychogenic amnesias can be disorientating & disruptive to the patient, but they are rarely completely disabling, & as there is no actual brain damage they are reversible and in most cases will eventually disappear.

- Four kinds of organic amnesias:
  - **Alzheimer's Disease (AD):** is a degenerative brain disorder which first appears as an impairment of memory but later develops into a more general dementia, affecting all aspects of cognition.
  - AD happens mostly in the senile population, affecting upto about 20% of the elderly.
  - AD is a basic neuro –degenerative disorder which involves tangling of neuronal fibres, something which has been shown to be responsible for other kinds of senile dementia as well.
  - However, because of the overlap with symptoms of general dementia, AD is not considered to be a pure form of amnesia & it becomes rather difficult to investigate the nature of memory damage in AD.

- **Korsakoff Syndrome:** is a brain disorder resulting usually from excessive alcoholism & being characterized by a memory impairment that affects both recent & past memories. First reported by Korsakoff (1987), it is one of the most studied forms of amnesia as it is not marred by additional complications of extensive dementia or retardation.

- **Hepres simplex encephalitis (HSE)** is a viral infection of the brain which can lead to severe amnesia. It has a relatively sudden onset as compared to the slow increase of degenerative diseases like dementias & AD.

- **Temporal Lobe Surgery:** a small number of patients become amnesic because of brain lesions caused by surgical procedures. Usually temporal love surgery can lead to amnesia. An example of the case was H.M. a amensia patient post surgical treatment for epilepsy.

- **Post – ECT amnesia:** Sometimes the use of electroconvulsive therapy for alleviating depression in patients ,ay also lead to amnesia. ECT involves administering electric shocks to the front of the patient's head. Patients experience periods of amnesia post the electric shock which may continue for longer periods as well. This has been extensively studied in order to evaluate the usefulness of the treatment & as a side – effect.

Amnesia: Long Term Memory

- One of the symptoms of the organic amnesic syndrome is the impairment of the Long Term Memory; i.e. organic amnesics will have difficulty in consolidating new information into their long term memory store, & also they often have problems retrieving old memories from storage.
- Interestingly, organic amnesics generally have an intact short term memory and are generally able to carry on a normal conversation, only unable to recall past events but able to talk about current things.

- Talland (1965) acrried out a study involving 29 Korsakoff patients, all significantly impaired on a whole battery of long term memory; but found that their scores on tests of short term memory were close to that of normal individuals.

- Others like Baddeley & Warrington (1970) also reporte dnormal STM span in Korsakoff patients; which led Pujol & Kopelman (2003) conclude that Korsakoff's patients showed normal performance on tests of both verbal & non –verbal STM.

Anterograde & Retrograde Amnesia

- AA: involves impairment of memory for events occurring since the onset of amnesia.

- RA: involves impairment of memory for events occurring before the onset of amnesia.

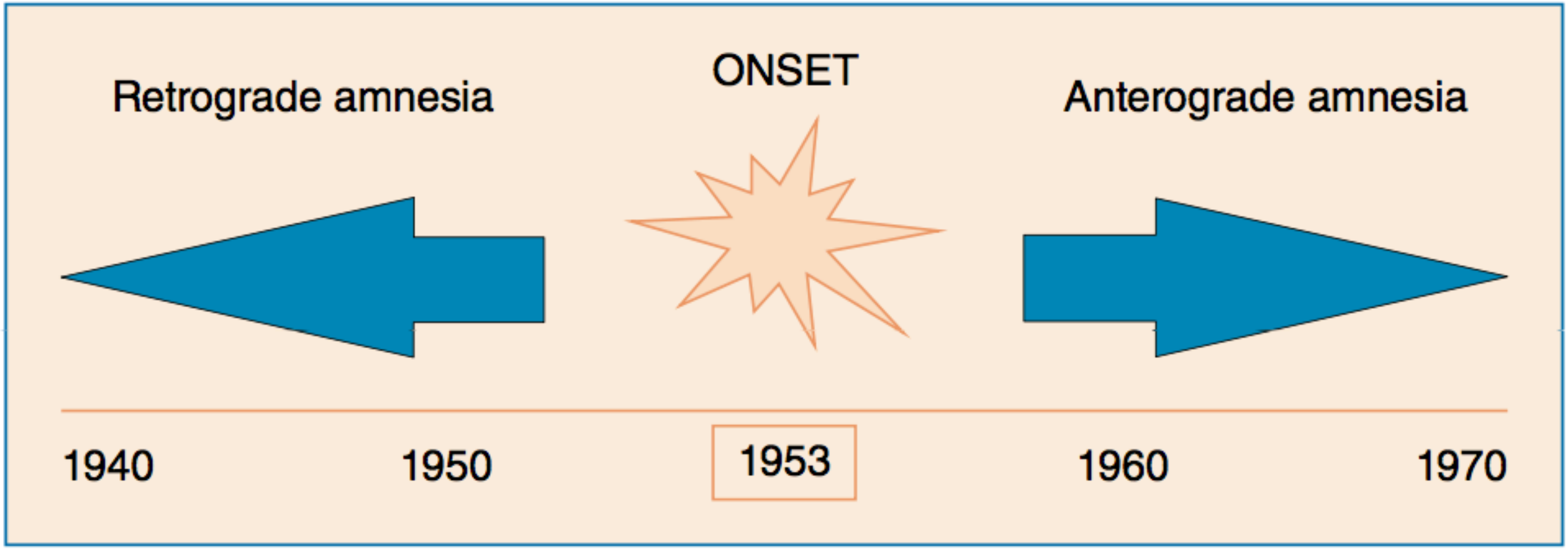

Figure 7.2 Anterograde and retrograde amnesia shown in relation to the moment of onset (in this case for patient HM).

Image: Groome et al., (2013). An Introduction to Cognitive Psychology: Processes & Disorders. *Psychology Press.* (Fig. 7.2; pp. 211).

- This distinction between AA & RA provides a way of distinguishing the locus of amnesia as either a learning or a retrieval disorder.
    - Wherein AA can be more indicative of a learning disorder while RA can be used to indicate a retrieval disorder. Obviously it is possible for a patient to have both the disorders; in which case both AA & RA will be observed.
    - An interesting observation was made by Ribot (1882) who concluded that RA of amnesic patients showed a temporal gradient where the degree of impairment with the recency of the event & childhood or most remote memories are somewhat spared. This has been referred to as ***Ribot's Law.***

Testing Retrograde & Anterograde Amnesia

- As AA is more of a learning disorder, testing is easier; as the patients can be simply given the task of learning new materials like words, stories, pictures etc. and then tested for the retrieval at a later time.

- Testing for RA, however is slightly complicated as testing has to be done for events & materials unknown to the tester.

- Tests for remote memory therefore can either involve testing of past public events or the test of past personal events which only the patient or close ones might know of.

  - Test of past public events is slightly easier as the events are known to a wide variety of people and similar test items can be given to many different people and hence it is possible to devise a standardized test with well specified performance norms. For e.g. the Boston Remote Memory Test (Albert et al., 1979)

  - Test of past personal events have test items pertaining to autobiographical information about the patient. However because this information can vary widely from individual to individual, the scores of these test are not easily comparable. Also it is difficult to check for the accuracy of the given responses.

Anterograde & Retrograde Impairment in Organic Amnesia

- Both Ribot (1882) & Korsakoff (1887) suggested that most amnesic patients have both AA & RA.

  - AA together with RA has been observed in dementing AD patients (wilson et al., 1981) & Korsakoff patients (Albert et al., 1979); also in patients with HSE.

  - Pujol & Koppelman (2003) have reported that in RA in Korsakoff patients can extend back to a period of 30 years or more before onset & shows a marked temporal gradient.

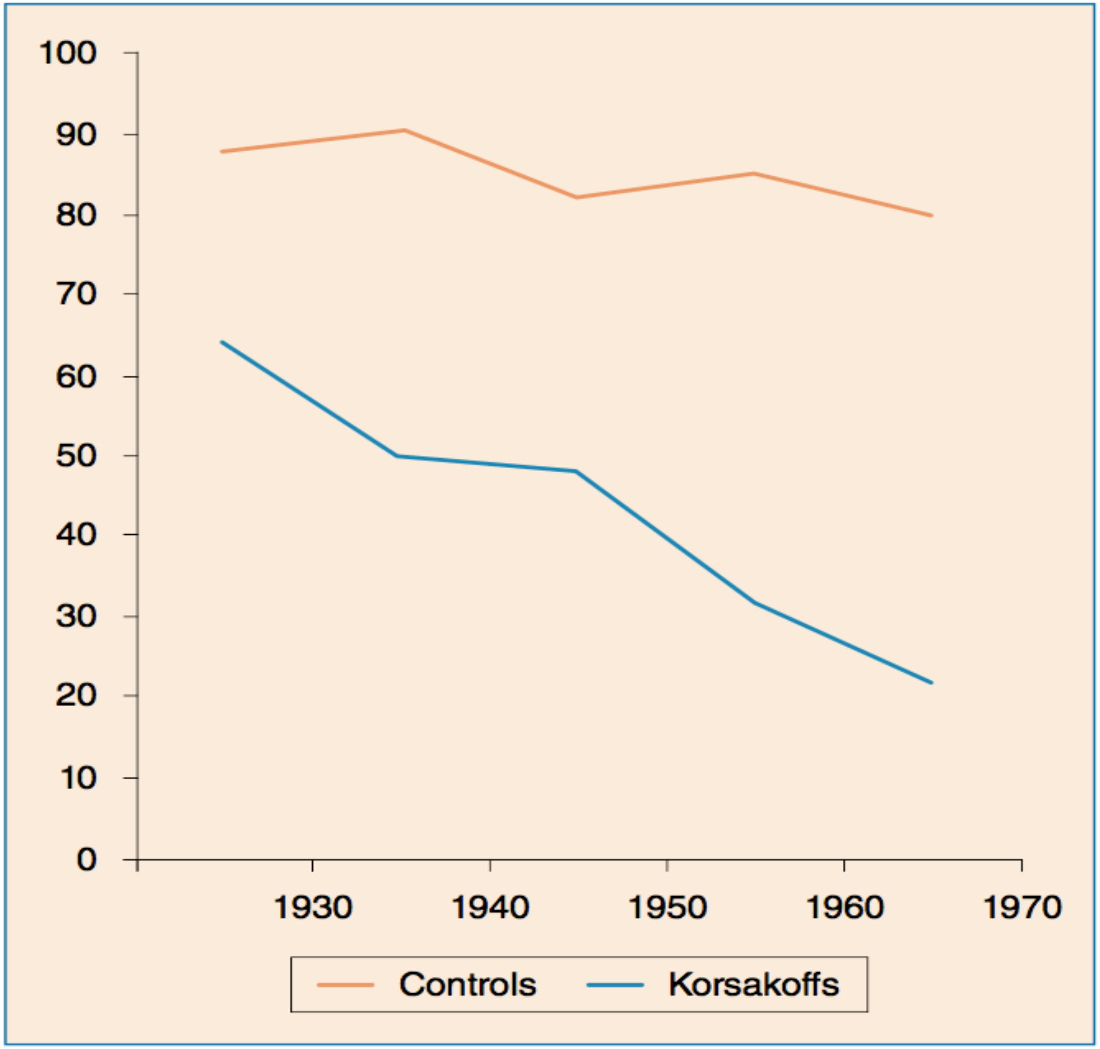

Figure 7.3 Memory performance for different periods from the past.

Source: Albert *et al.* (1979).

Image: Groome et al., (2013). An Introduction to Cognitive Psychology: Processes and Disorders. *Psychology Press*. (Fig. 7.3; pp. 213).

- However, the said pattern is not found everywhere, i.e. there could be some patients who show severe AA but have very limited RA. For e.g. H.M. had severe AA, but RA was only up to about 3 years before the onset.

- **FOCAL RA & AA**:

- few cases of focal AA (without RA) have been reported.
  - For e.g. Mair et al. (1979) studied two Korsakoff patients who had focal AA & Cohen and Squire (1981) also studied NA, a patient who had focal AA after an accident. NA's injury & few other studies have confirmed that damage in focal AA could be mostly restricted to the anterior thalamus (Kapur et al., 1996).
- focal RA cases are usually rare, but some patients with severe head injuries (Kapur et al., 1992), Hse infection (O'Connor et al., 1992) & following epileptic seizures (Sehm et al., 2011) have been reported to have focal RA.

- Focal RA has been associated with lesions to various brain areas, but most commonly it tends to involve lesions in the temporal cortex (Sehm et al., 2011).

- About the temporal gradient in RA:
  - o Ribot (1882) reported that amnesics tend to retrieve older memories better than recent memories. The same has been confirmed in more recent studies (Brown, 2002).
  - o A possible explanation is put forward by Squire (1982) is that older memories may be more durable because they have developed various retrieval routes over the period of years.
    - Squire (1992) suggest that the consolidation of a new memory may take several years to complete, and that it becomes increasingly resilient over time. - *standard model of consolidation.*
    - Moscovitch et al. (1999) proposes that memories recent events are more vulnerable as they are still held as individual episodic memories. These episodic memories combine to produce a semantic memory which is more lasting and does not depend on hippocampal activity with time.

- **Brain Lesions with AA & RA**
    - Several of the brain's regions have been implicated in cases of organic amnesia. To name a few, *temporal lobes, hippocampus, thalamus & the prefrontal lobes.*

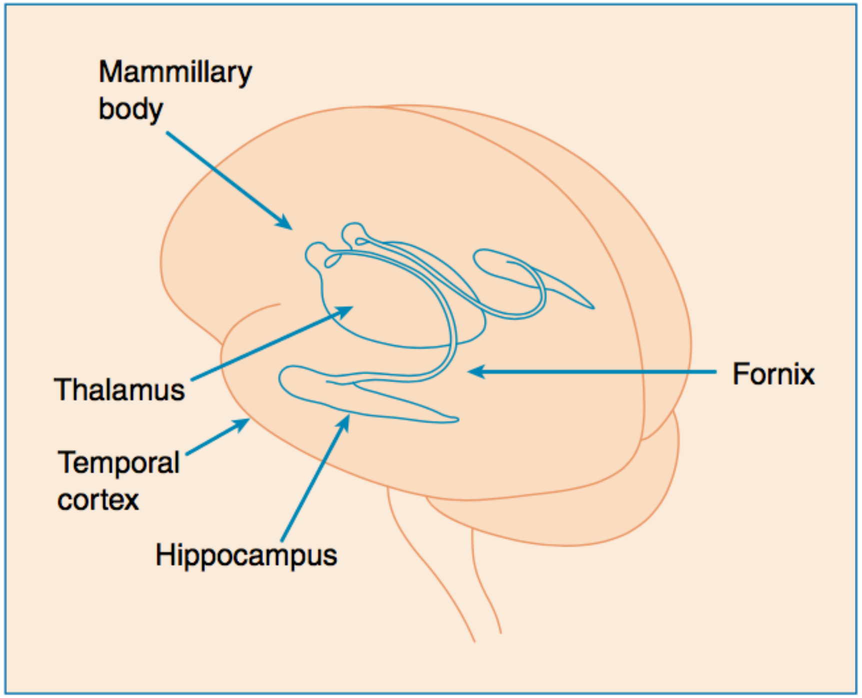

Figure 7.4 Brain structures involved in memory storage and consolidation.

Image: Groome et al., (2013). An Introduction to Cognitive Psychology: Processes & Disorders. *Psychology Press.* (Fig. 7.4; pp. 216).

- The temporal lobes contain the hippocampus, & this structure is of particular importance to the creation of new memories.

    - Surgical removal of the hippocampus an dparts of the medial temporal lobes of the patient HM was found to have a devastating effect on his memory, especially his ability to acquire and consolidate new memories (Scoville & Milner, 1957).

    - The temporal lobes & the hippocampus are aso damaged in case of HSE, AD. Though the lesions may get more extensive and cover right from the majority of the temporal cortex but the frontal brain regions as well.

- other areas of lesions could be the *diecephalon a region including the thalamus & mammilary bodies*. These areas are damaged in Korsakoff Syndrome patients (Victor et al., 1989; Reed et al., 2003) along with lesions in the anterior thalamic nuclei (Harding et al., 2000).

- Retrieval of past memories may involve different regions of the brain, most notably the *temporal & prefrontal cortex*.
  - Korsakoff patients have been shown to have retrieval problems associated with prefrontal lesions.
  - Koppelman (2001) established that in Korsakoff syndrom the severity of AA is related to thalamic damage, whereas the severity of AA is correlated with the extent of prefrontal damage.

- Finally, lesions in the temporal cortex have also found to be linked with retrieval problems (Reed & Squire, 1998),

- HSE patients whose lesions extend beyond the hippocampus to include large areas of the temporal cortex are usually found to exhibit severe RA in addition to their dense AA (Cermak & O' Connor, 1983).

- Stefanacci et al. (2001) reported that in HSE patients AA correlates with extent of hippocampal lesions whilst the RA extent correlates with lateral temporal lobe lesions.

Intact & Impaired Memory Systems

- **Motor Skills**: there is considerable evidence that motor skills are preserved in organic amnesics. Amnesics retain their previously learned motor skills & can also learn new skills post onset of amnesia. (remember H.M. learned mirror drawing).
    - HSE patient Clive W. retained most of his piano skills (both in conducting & playing); but is unaware of them. Another patient PQ also retained his ability to play the piano & also learn to play new pieces.

- Glisky et al. (1986) reported that amnesics could be successfully trained to carry out simple computer tasks withh time & patience; however there was little or no generalization of the learning observed.

- Cavaco et al., (2004) reported normal performance of 10 amnesic patients with temporal lesions caused by HSE on a range of motor skills including weaving, figure – tracing & target tracking.

- With these results in mind Cohen & Squire (1980) suggested that amnesics might have a preserved procedural memory but an impaired declarative memory.

- **Implicit Memory**: it has been shown that amnesics might still retain aspects of implicit memory like priming/conditioning wherein their behaviour may be influenced by previous experience, though they may not remember the specific experience.
  - E.g. Claparede (1911) pin – handshake experiment.
    - Warrington & Weiskrantz (1968) showed Korsakoff patients degraded pictures of common objects or words; starting with the most incomplete to the complete version & demonstrated that the Korsakoff patients exhibited an increase in their ability to identify the object after a few trials.
    - Graf et al., (1984) used the primiing of verbal material to demonstrate intact implicit memory in Korsakoff patients, in a task where subjects were presented with word fragments and asked to complete them. It was found that the patients responded with previously primed words.

- **Familiarity & Context based recollection**: Mandler (1980) suggested that familiarity & recollection represent two alternative routes to recognition.
  - Mandler believed tat a familiarity judgment is an automatic process, occurring without any conscious effort whereas recollection, is a controlled process requiring conscious effort and is deliberately carried out.
  - Studies have shown that organic amnesics retain the ability to detect familiarity of a previously encountered item, though they may find it difficult recollecting the context. For e.g. Clive W found his old friends familiar but could not locate them in memory.

- Huppert & Piercy (1976) devised an experimental procedure wherein he showed Korsakoff patients and Controls two sets of pictures, first set on day 1 & the second set on day 2.
  - Shortly after the presentation of the second set, the subjects were tested for their ability to judge whether particular pictures were familiar (previously presented /new).
  - Also, after the above they were asked to identify which pictures were shown on day 1 & which on day 2.
  - While the performance of the amnesics & control participants was equivalent on familiarity judgment; amnesics could not do well at all in the task where they had to identify the pictures presented on specific days.

- Huppert & Piercy (1978) further demonstrated that the recognition performance of the Korsakoff patients was mainly based on judgment of the general familiarity of pictures. The same has been confirmed in other studies as well (King et al., 2004; Gardiner et al., 2008).

- **Episodic & Semantic Memory**: ?
  - Episodic memory: memory for specific events in our lives
  - Semantic memory: store of knowledge acquired over time.

  - Tulving (1989) suggested that amnesics exhibit a selective impairment of episodic memory while their semantic memory stays intact.
    - General observation points out that indeed, amnesics usually retain a normal vocabulary despite their inability to remember any recent events in their lives.
    - However, other studies show that in some cases the semantic memory may be jeopardised too. For e.g. studies of Korsakoff patients have been shown to have severely impaired episodic memory along with semantic memory impairments.

- Further, Alzheimer patients are also generally found to show impairments of both episodic & semantic memory; though the former is more severely impaired.
    - Addis & Tippet (2004) reported that Alzheimer patients tend to suffer impaired autobiographical memory extending back over their entire lifespan, but theyalso exhibit limited semantic memory impairment.
- Overall, it can be said that both semantic & episodic memories are affected in most organic amnesics; leaving less support for Tulving's proposal.
    - Though at least a couple of known patients (K.C.; & Jon) were found to have almost no episodic memory (termed episodic amnesia) but relatively normal semantic memory (before amnesic onset).

- **Theories of Amnesia:**
- Encoding Deficit Theories:
  - Milner (1966) argues that HM's impairment was essentially a failure to learn new information, i.e. he was unable to consolidate memories from a temporary STM trace to a permanent LTM trace.
  - Similar explanations could also be thought to account for deficits such as those in the Korsakoff Syndrome. Basically, it could be argued that the apprent occurrence of RA in K patients might actually be an anterograde impairment that could not be detected in time & continued deteriorating.
  - However, the theory cannot explain the occurrence of RA. For e.g. in case of HSE patients having genuine RA with the precise date of onset.

- Retrieval Deficit Theories: Warrington & Weiskrantz (1970) proposed retrieval impairment as the basic deficit underlying organic amnesia.
  - A retrieval impairment could explain both the anterograde & retrograde components of amnesia, as it would explain a failure of the retrieval mechanism of both past & recent memories.
  - But, a retrieval based theory would predict equally severe AA & RA; though we know that amnesic patients suffer far more severe AA than RA, indicating that past memories are somehow more durable.
  - The retrieval based account can explain the temporal gradient in RA, by proposing that the earliest memories would be the most rehearsed as compared to more recent memories (Squire et al., 1984).

- However, the account cannot readily explain the variations in the severity of AA & RA between different patients and also why some amnesics have virtually no RA at all.
- Also, the account cannot explain how AA & RA impairments can sometimes occur in isolation (as in focal AA & RA).

- Separate Impairments of Encoding & Retrieval
  - o As either of the accounts cannot explain the deficits in amnesia alone, it has been suggested that impairments of encoding & retrieval are independent of one another (Parkin, 1996).
  - o The finding that impairments of learning & retrieval are associated with lesions in different areas of the brain lend support to this view.
    - It has been suggested that amnesics may exhibit both AA & RA because the brain regions mainly involved in eencoding & retrieval of information are physically qute close to each other and are extensively interconnected.
- In all, it can be concluded that most amnesics suffer from both AA & RA, though their relative severity may vary from patient to patient.

- The Standard Model of Consolidation
  - Squire (1992) that in addition to the STM consolidation process, a slower form of consolidation continues to strengthen the memory traces for two to tree years after its acquisition.
  - The trace therefore remains vulnerable for few years post input, until fully consolidated.
  - Squire proposes that this long – term consolidation process involves the hippocampus, which plays a role in the initial encoding of the new information as well it's consolidation over the period of few years.
  - Hence, the relatively limited RA in patients such as HM may result from the disruption of the slow consolidation process post hippocampus removal.

- Multiple Trace Theory
    - o Moscovitch et al., (1999) suggests that each time an item is retrieved from memory, it creates a fresh memory trace & forms new connections.
        - In the years following the acquisition of a new memory trace; this process causes episodic memories to be bound together to create semantic memories.
        - The binding is assumed to be carried out in the hippocampus, but once the semantic memory is formed it becomes independent of the hippocampus.
        - The retrieval of the episodic memory however will always require the hippocampus.

    - o This theory can explain the finding that hippocampal lesions disrupt episodic memories from all time periods, but only disrupt the most recently acquired semantic memories. Supporting evidence (Hm, WR). (Steinvorth et al., 2005).

- Other Impacts of Amnesia

    - *Impaired Declarative Memory*: Squire argues that organic amnesia is chiefly characterised by an impairment of declarative memory. Mandler (1989) argues that amnesia is essentially ‘a disease of consciousness’, since the memory functions which are damaged are those which require conscious retrieval.

- *Impaired Binding*: Cohen & Eichenbaum (1993) argue that the main feature of declarative memory is that it involves the creation of associative connections between memories – binding. In contrast, non – declarative memory seems to be restricted to the strengthening of a single response.
- Eichenbaum (2004) suggests that the hippocampus performs the associative binding function of declarative memory, whereas non – declarative memory involves the cortex & the cerebellum.
- This view has been supported by some imaging studies, for e.g. Rosenbaum et al., (1999) found that the amnesic patient KC (having hippocampal lesions) had severe retrograde amnesia for episodic memories & some autobiographical memories, but could still retrieve semantic memories before onset. They concluded that the main function of the hippocampus is to bind memories together &no just store information.

- *Impaired Perceptual Processing*: While the function of hippocampus is largely assumed to involve memory storage, animal studies have also suggested it’s role in visual perception (Gaffan et al., 2001).

    - Graham et al (2008) have presented some evidence which suggests that the hippocampus may also have a perception function in humans leading to some of their troubles with memory in amnesic patients.

    - Graham et al., suggest that memory storage involves a network of perceptual representations which are distributed throughout the cortex & are controlled & activated by the hippocampus.

- Damage to the hippocampus would therefore impair the retrieval of old memories as well as the processing of new input.
- One problem of this theory is that studies of amnesic have mostly failed to identify a amajor perceptual impairment. For e.g. Hartley et al., (2007) tested four amnesics with focal hippocampal lesions & only two of them showed any perceptual impairment. Interestingly though, all four individuals were found deficient on spatial memory.
- Similarly, Lee et al., (2012) found evidence for the involvement of the hippocampus in the visual discrimination of complex scene stimuli.

Other Types of Memory Disorders

- *Impairment of Short Term Memory*:
  - Impairments of STM occur sometimes, but involve a quite different pattern of brain lesions to those found in typical organic amnesia.
  - AD patients may also show severe WM impairments, chiefly involving executive function (Storandt, 2008).

- *Concussion Amnesia*
  - People who suffer from a concussion on the head due to an accident or injury usually suffer from both RA & AA; whicch could be extensive in the beginning but diminshes slowly.
    - A footballer concussed by a collision on – field might find it difficult to remember events immediately preceding the collision.
    - Amnesias of the kind are known as *concussion amnesia* and fall into the category of post – traumatic amnesias, which includes all kind of closed – head injury.
  - Russel (1971) surveyed a large number of concussion victims to find that typically retrograde amnesia affected memories for a period extending only to a minute or two prior to the accident; but in rare cases could upto days or weeks.

- Characteristics of concussion amnesia resemble those of organic amnesia; for e.g. for the period immediately following the accident the patients is likely to show impairment on LTM tasks, but do ok on WM tasks.

- Although the effects of a concussion on memory are usually temporary, a minority of mild to moderate head injuries may leave a more lasting impairment – post concussive syndrome.

- *ECT & Memory Loss*:
    - While ECT has been shown to be useful in treating depression in some patients, these benefits are only temporary & therefore must be compared with possibilities of lasting brain damage caused by ECT.
    - In the period following an ECT shock, the patient typically shows both AA & RA (Squire et al., 1981), which might seem extensive initially but fades off gradually to leave only a fairly limited amnesia for the treatment period.
    - It seems however, that for most patients ECT caused only a limited impairment (Weeks et al., 1980; Meeter et al., 2011).

- A recent review of previous ECT studies (Read & Bentall, 2010) concluded that ECT treatment produces no lasting benefits but it does cause significant memory loss in some patients.

- Overall, a growing number of researchers argue that the limited benefits of ECT cannot be justified in view of its damaging effects on memory & cognition (Johnstone, 2003; Read & Bentall, 2010).

- *Frontal Lobe Lesions*
    - o Patients with frontal lobe lesions often show some impairment of memory, though these tend to be rather different in nature to those associated with temporal lobe or thalamic lesions & then mainly seem to involve impaired retrieval.
    - o More specifically, patients with frontal lobe lesions tend to have particular difficulty in retrieving contextual information (Parkin et al., 1995).
        - Possibly because they have an impairment of the central executive component of their working memory (Shallice, 1988).

- Another characteristic of patients with frontal obe lesions is a tendency to confabulation (Moscovitch, 1989), implying that the patient describes memories for events which did not really take place and are apparently invented.
    - Confabulation is also associated with impaired executive function & with the consequent loss of mental flexibility (Nys et al., 2004).
- Also, it must be noted that frontal lobe lesions may sometime co – exist with other types of lesion. For e.g. many Korsakoff patients have been found to have frontal lobe lesions along with diencephalic lesions (Shimamura et al., 1988) & these individuals often exhibit a marked tendency to confabulation and retrieval problems in addition to the more usual amnesic symptoms found in Korsakoff patients.

- *Memory Loss in the Normal Elderly*
  - o There is some evidence for age – related decline in memory, though not readily detectable until the age of about 65 – 70.
    - The degree of impairments is usually not very great (Verhaeghen, 2011).
  - o Studies have indicated that the norma elderly may show a decline in recall ability but not in recognition (craik & McDowd, 1987).
  - o Elderly subjects tend to show a a deterioration of explicit memory; though their implicit memory remains unimpaired (Fleischman et al., 2004); seem to have problems in retrieving contextual information (temporal context, Parkin et al., 1995).

- Parkin & Walter (1992) demonstrated that elderly people were able to rcognise a familiar item but had poor recall of context.

- Interestingly, the amount of decline in context recognition correlated with measures of frontal lobe impairment (Tisserand & Jolles, 2003).

- A possible explanation of age – related memory decline may be that the elderly lose some their capacity for consciously controlled processing and attention & have to rely more on an automatic process (Craik & McDowd, 1987). Further, they also show decline in speed of processing (Salthouse, 1994).

- All in all, a recent meta – analysis concludes that the actual decline in executive function in the normal elderly is very slight (Verhaeghen, 2011).

- *Psychogenic Amnesia*
  - Some amnesias may occur without any evidence of brain lesions & maybe brought on by stress and are usually temporary (Khilstrom & Schachter, 2000).
  - These included loss of memory for past events, in other words retrogrde amnesia; anterograde amnesia is fairly unusual (Kopelman, 1995).
  - The pattern of impairment in psychogenic amnesias varies widely, from case to case.
  - Kopelman (2010) points out that psychogenic amnesias may be ‘global’ or ‘situation specific’.

- The main feature which enables clinicians to distinguish between psychogenic & organic amnesias is that those of psychogenic origin do not usually match up with usual pattern of impairment found in organic amnesics.

Rehabilitation

- There are a number of ways in which the lives of organic amnesics can be significantly improved by helping them to cope with their impairment and helping them to function as effectively as possible within the limitations of their condition. - *Rehabilitation*

- *Maximising Memory Performance*
  - It might be useful to advise the amnesic patients to pay more attention to the input, to repeat what is said to them, to organize information & make meaningful associations between new input and the items already there in the memory.
  - Wilson (2004) suggests that amnesics learn one thing at a time, keep the input simple & avoid jargon or long words. Also they would perform better if their learning is not context – specific. For e.g. training imparted does not generalize to others unless specifically trained.
  - Amnesics also generally benefit through ‘spaced’ rather than ‘massed’ learning sessions.

- *External Memory Aids*

  - An option is to change the immediate environment & living conditions of the amnesic patients so as to reduce the dependence on memory. For e.g. by putting on big labels on cupboards, or labelling doors as a reminder of which is the kitchen or toilet.

  - Electronic or computerised aid system also have been devised to help out the amnesics by producing reminders to carry out a particular action at a particular time, by emitting a warning beep or alarm. An example was ‘Neuropage’ (Hersh and Treadgold, 1994).

- Another interesting device was the ‘Sensecam’ which makes use of digital camera attached to the user’s belt to take photos of events experienced each day in order to provide a reminder which can be viewed later on.

  - Loveday & Conway (2011) reported that Sensecam can significantly enhancee an amnesic’s personal memories.

  - Reviewing events recorded on Sensecam at te end of each day also helps to improve the vividness of recall, & helps to add context to an event. For e.g. by reminding the amnesic patient of the things they were doing & thinking, & their interactions with other people etc.

References

- Groome et al. (2013): Introduction to Cognitive Psychology: Processes and Disorders *Psychology Press*.