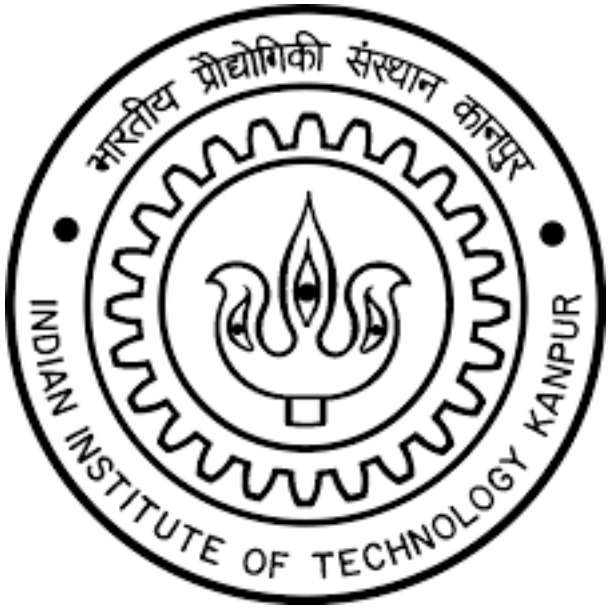


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Course Title:

# Basic Cognitive Processes

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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.

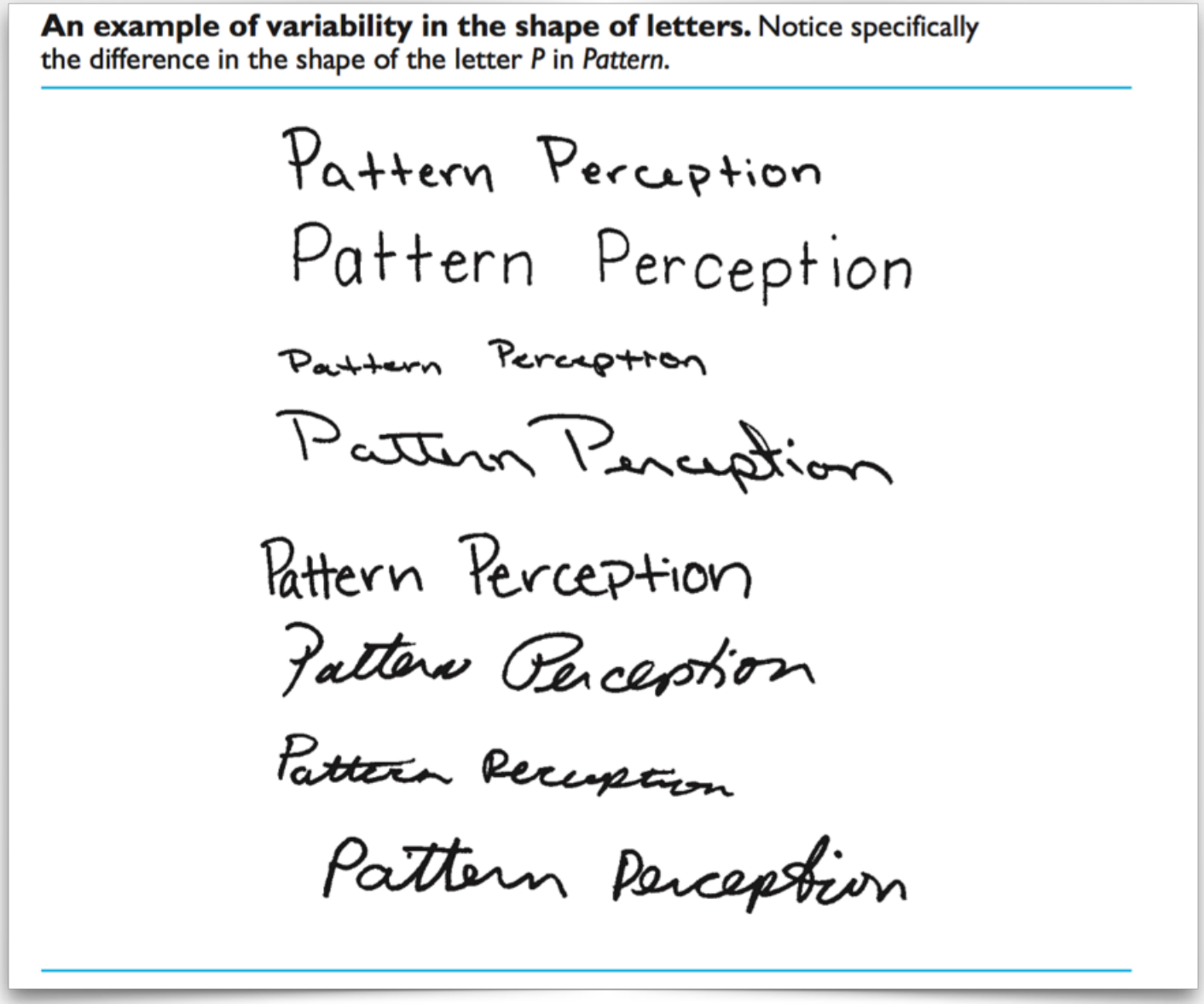



Image: Matlin M. W. (2008). Cognition. *Wiley*.7th Ed. (Fig. 2.4; p. 39).

- 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.

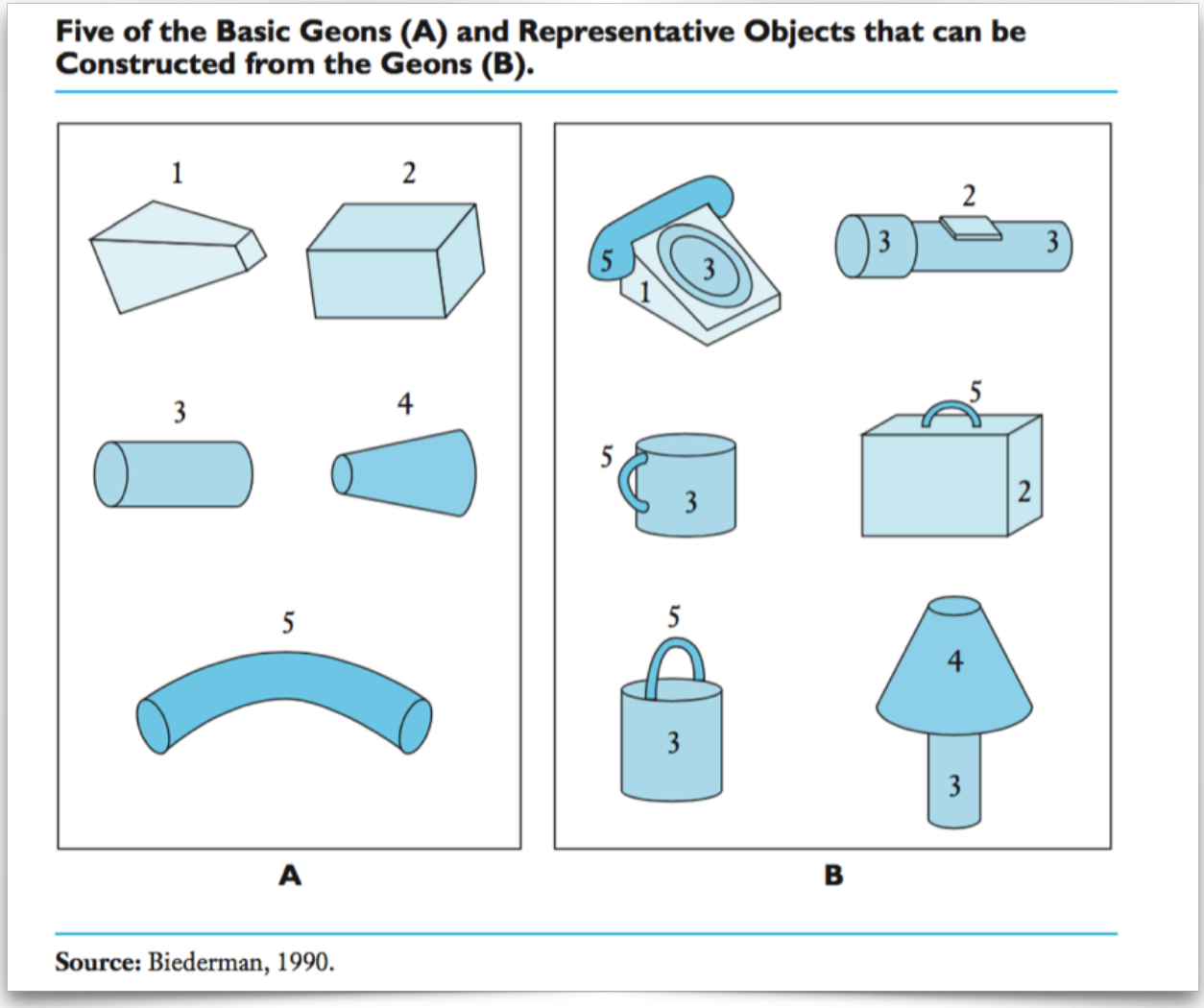



Image: Matlin M. W. (2008). Cognition. *Wiley*.7th Ed. (Fig. 2.5; p. 42).

- 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.

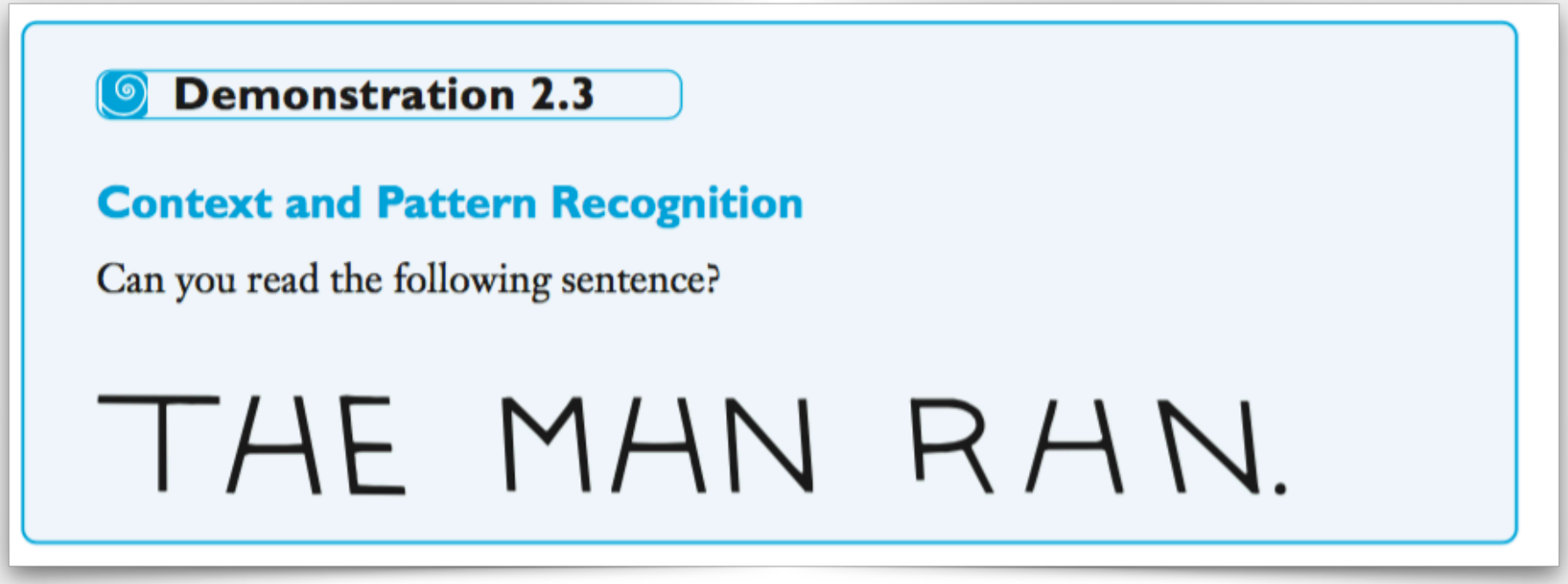
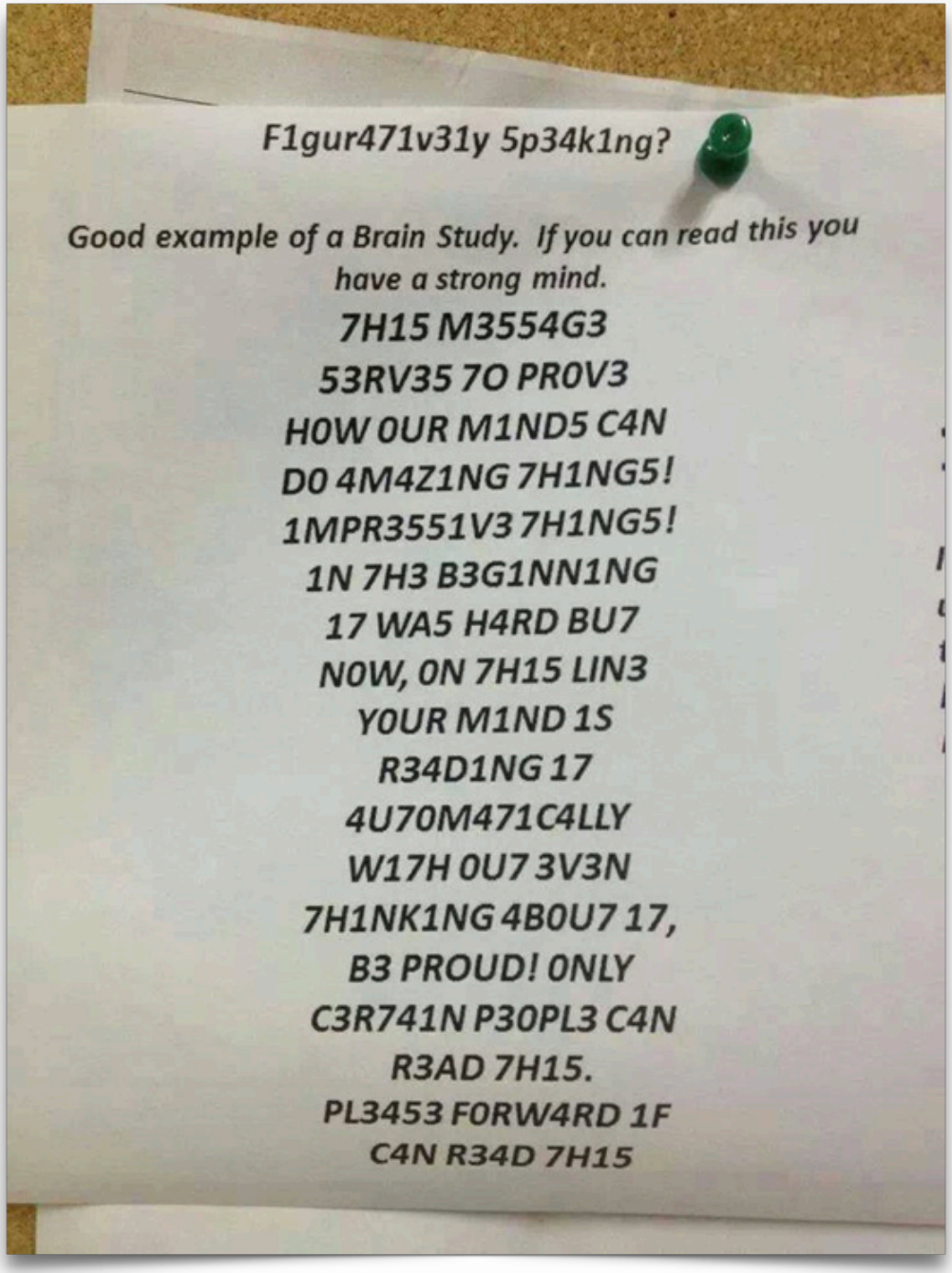



Image: Matlin M. W. (2008). Cognition. *Wiley*.7th Ed. (Demo. 2.3; p. 45).


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.

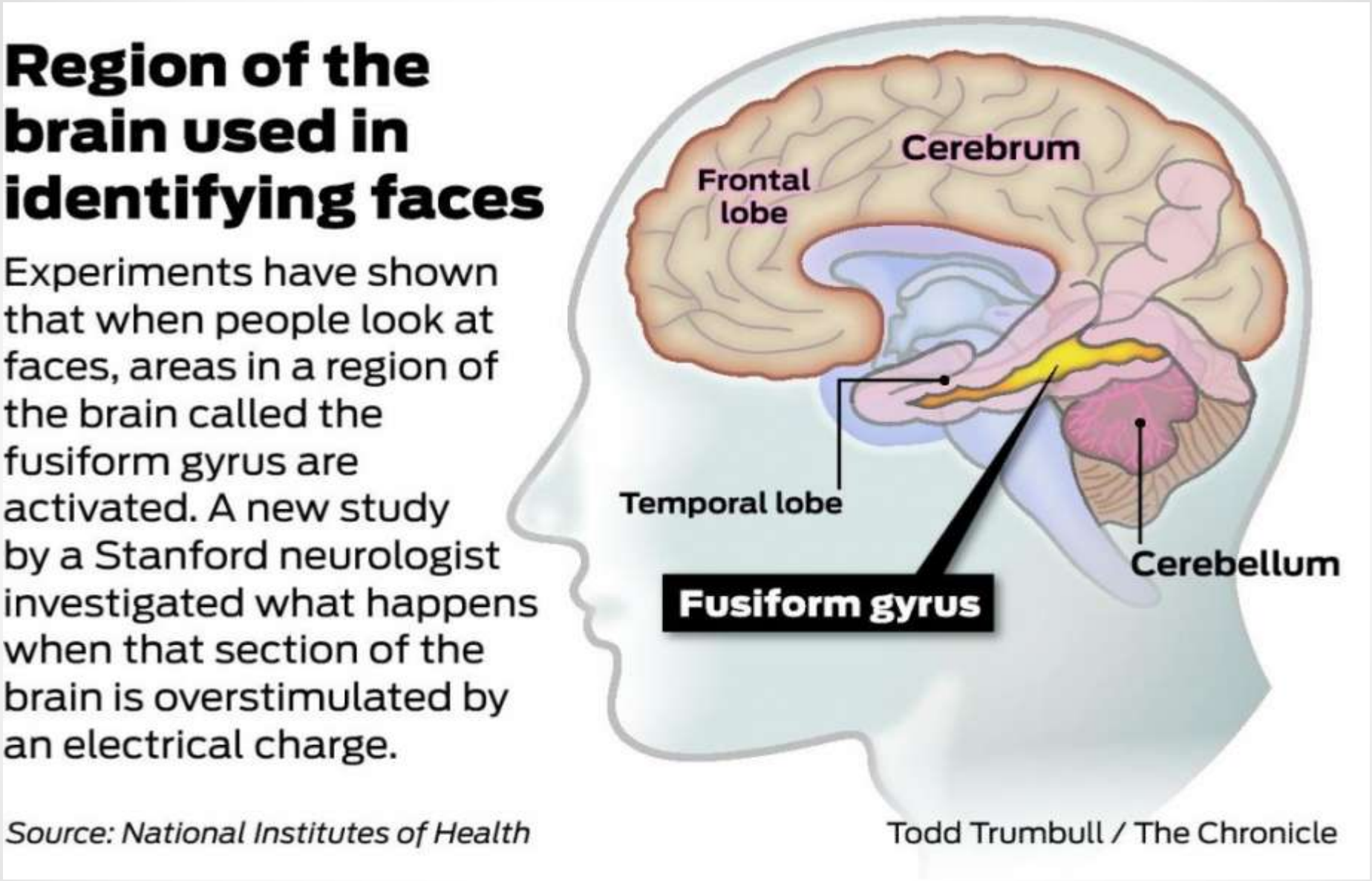
- it thus makes sense that face perception has a special status, given the importance of our social interactions (Farah, 2004; Fox, 2005).

- 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.