Perception & Pattern Recognition

- Sensation
- Perception
- Pattern Recognition
- Theories of Pattern Recognition
- Bottom-up vs. Top-Down Processing & Pattern Recognition

1

Sensation

- Process by which our senses (e.g. vision, audition) register external stimuli.
- Sensation is *bottom-up* or stimulus-driven processing.
- Unaffected by your knowledge (e.g. 'K' is not the letter K but dark and light information)

2

Perception

Process that uses our previous knowledge to gather and *interpret* stimuli that our senses register

Perception uses bottom-up (stimulus-driven) and top-down (knowledge-driven) information processing.

3

Pattern Recognition

- Perceptual identification of a complex arrangement of sensory stimuli
- The stimulus ‘K’ is recognized as a familiar pattern – i.e. the letter ‘K’
- A series of musical notes recognized as a melody or musical phrase

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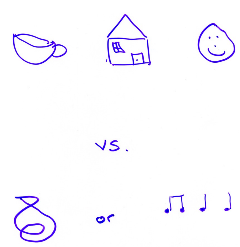
Patterns



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An Illustration of the Variety of Patterns that are Easily Categorized by Adult Readers

Glory may be fleeting, but obscurity is forever.

Glory may be fleeting, but obscurity is forever.

Glory may be fleeting, but obscurity is forever.

Glory may be fleeting, but obscurity is forever.

Glory may be fleeting, but obscurity is forever.

GLORY MAY BE FLEETING, BUT OBSCURITY IS FOREVER.

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FIGURE 2.1

Various Versions of the Letter Z.

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Theories of Pattern Recognition

- Template Matching Theories
- Distinctive Features Theories
- Recognition by Components Model

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Template Matching Theory

- Compare a new stimulus (e.g. 'T' or '5') to a set of specific patterns stored in memory
- Stored pattern most closely matching stimulus identifies it.
- To work – must be a single match
- Used in machine recognition

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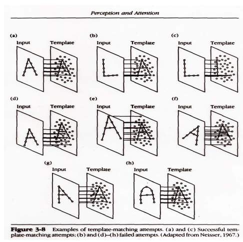
Examples of Template Matching Attempts



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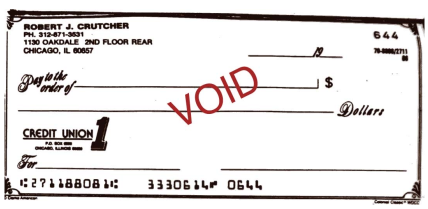
Used in machine recognition



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Problems for Template Matching

- Inefficient - large # of stored patterns required
- Extremely inflexible
- Works only for isolated letters and simple objects

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Distinctive Features Models

- Comparison of stimulus features to a stored list of features
- Distinctive features differentiate one pattern from another
- Can discriminate stimuli on the basis of a small # of characteristics – features
- Assumption: feature identification possible

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Distinctive Features Models: Evidence

- Consistent with physiological research
- Psychological Evidence
  - Gibson 1969
  - Neisser 1964
  - Waltz 1975
  - Pritchard 1961

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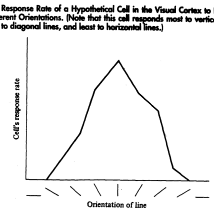
The Response Rate of a Hypothetical Cell in the Visual Cortex to Lines of Different Orientations. (Note that this cell responds most to vertical lines, less to diagonal lines, and least to horizontal lines.)



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A DISTINCTIVE-FEATURES APPROACH (FROM GIBSON, 1969).

Eleanor Gibson proposed that letters differ from each other with respect to their distinctive features. She proposed the table that is reproduced below. Notice the top three kinds of features—straight, curve, and intersection. Notice that *P* and *R* share many features. However, *Z* and *O* have none of these kinds of features in common. Compare the following pairs of letters to determine the number of distinctive features they share: (1) *E* and *F*; (2) *K* and *M*; (3) *Z* and *B*; (4) *N* and *M*.

Features	A	E	F	H	I	L	T	K	M	N	V	W	X	Y	Z	B	C	D	G	J	O	P	R	Q	S	U
Straight																										
horizontal	+	+	+	+		+	+								+				+							
vertical		+	+	+	+	+	+	+	+	+				+		+		+				+	+			
diagonal /	+							+	+		+	+	+	+	+											
diagonal \	+							+	+	+	+	+	+	+									+	+		
Curve																										
closed																+		+			+	+	+	+		
open V																				+						+
open H																	+		+	+					+	
Intersection	+	+	+	+			+	+					+			+						+	+	+		
Redundancy																										
cyclic change		+							+			+				+									+	
symmetry	+	+		+	+		+	+	+		+	+	+	+		+	+	+			+					+
Discontinuity																										
vertical	+		+	+	+		+	+	+	+				+								+	+			
horizontal		+	+			+	+								+											

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Can we empirically test the distinctive features theory?

- In other words, can we show that we must be processing features when we identify and distinguish one pattern from another – e.g. letters?
- There are many ways we can test a feature-based theory.
- For example:

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Scan for the letter 'Z' in the first column of letter strings.

Scan for the letter 'Z' in the second column of letter strings.

Where did you find the 'Z' faster: in column 1 or 2?
What does this show?

(1)	(2)
ODUGQR	IVMXEW
QCDUGO	EWVMIX
CQOGRD	EXWMVI
QUGCDR	IXEMWV
URDCQO	VXWEMI
GRUQDO	MXVEWI
DUZGRO	XVWZEI
UCGROD	MWXVIE
DQRCGU	VIMEXW
QDOCGU	EXVWIM

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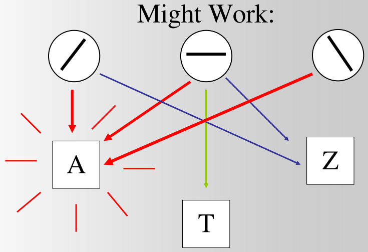
How a Distinctive Features Model Might Work:



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Letter Detection Task

Decide whether the pair of letters are the same or different: Yes or No

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Letter Pairs

L T
T T
K M
G N
S T
G G

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Task Analysis and Predictions (based on distinctive features model)

L	T
T	T
K	M
G	N
S	T
G	G

1. Focus on the letter pairs that are different (there are 4 of them: LT, KM, GN, and ST)
2. Which would produce the fastest 'different' decision RT? The slowest? Why?
3. Can you order the 4 pairs (fastest to slowest)? Explain your reasoning.
4. What is the purpose of the 'same' pairs (e.g. T T) in the experiment?

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Distinctive Features - Summary

- Theory must specify how the features are combined/joined
- These models deal most easily with fairly simple stimuli -- e.g. letters
- Shapes in nature more complex -- e.g. dog, human, car, telephone, etc
- What would the features here be?

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Recognition by Components Model

- Irving Biederman (1987, 1990)
- Given view of object can be represented as arrangement of basic 3-D shapes (geons)
- Geons = derived features or higher level features
- In general 3 geons usually sufficient to identify an object

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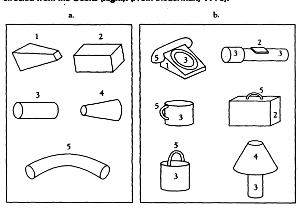
Examples of Geons

Examples of Geons (Left) and Representative Objects That Can Be Constructed from the Geons (Right). (From Biederman, 1990).



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Recognition by Components

- ✓ Pro – Biederman found that obscuring vertices impairs object recognition while obscuring other parts of objects has a lesser effect.

Which is easiest to recognize as a cup? The left or right?

- ✓ **Con – Biederman – Not all natural objects can be decomposed into geons. What about a shoe?**

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Summary

- Distinctive Features and Recognition by Components currently strongest theories
- Evidence from cognitive experiments and cognitive/behavioral neuroscience.
- However, pattern recognition is too rapid and efficient to be completely explained by these models

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Thought Experiment

- Assume each letter 5 feature detections involved
- Page of text approximately 250-300 words of 5 letters per word on average
- Each page: 5 x 5 x 250-300 = 6250 - 7500 feature detections
- Typical reader 250 words/min reading
- 6250/60 secs =100 feature detections per second

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Two types of Processing

- Bottom-up or data-driven processing emphasizes stimulus characteristics
- Top-down or conceptually driven processing- emphasizes prior knowledge, expectations, memory
- Most cognitive tasks involve both bottom-up and top-down processing

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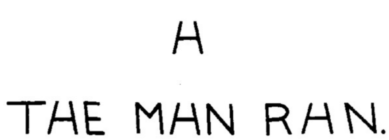
What letter is this?



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Read this

FIDO IS DRUNK

IS

14,157,393

31

IS

FIDO IS DRUNK

14,157,393

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Word Superiority Effect

We can identify a single letter more rapidly and more accurately when it appears in a word than when it appears in a non-word.

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Demonstration

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Identifying a letter

- Your task: Identify the letter at the end of each word ('D' or 'K')
- The target letter will always occur at the end of the *string* of letters.
- The string may be a word (e.g. book) or a nonword (e.g. obok)

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What letter do you see?

OWRD

36

What letter do you see?

WORK

37

What letter do you see?

WROK

38

What letter do you see?

WORD

39

You saw each of these 4 strings

OWRD

WORK

WROK

WORD

40

Word Superiority Effect

We can identify a letter (e.g. 'k') more rapidly when it appears in a word (e.g. 'work') than when it appears in a non-word (e.g. 'wrok').

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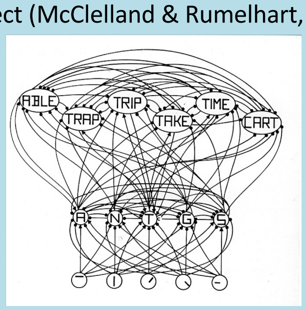
Interactive Activation Model of the Word Superiority Effect (McClelland & Rumelhart, 1981)



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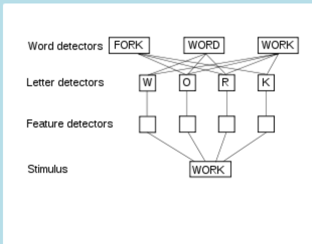
Interactive Activation McClelland Model of the Word Superiority Effect (& Rumelhart, 1981)



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What if?

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Single Letter ‘K’ vs ‘K’ in a word

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What letter do you see?

K

46

What letter do you see?

WORD

47

What letter do you see?

WORK

48

What letter do you see?

D

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How surprising!

- We recognize a single letter (e.g. 'k') faster when it is embedded in a word (e.g. 'work')
  - For example: 'work'
- Than when it appears all by itself:
  - For example: 'k'

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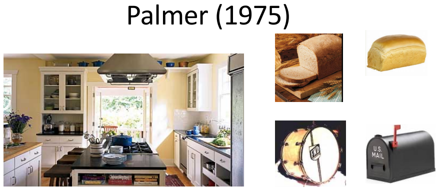
Palmer (1975)



Palmer (1975) using stimuli like the picture of the kitchen first present a scene context and then briefly flashed a picture of an object (e.g. the drum, the bread, or the mailbox). Subjects were asked to identify the object. Subjects correctly identified objects appropriate to the scene (like the loaf of bread) 80 percent of the time versus 40 percent of the time for the objects that did not fit into the scene.

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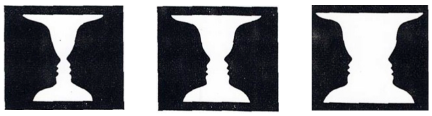
What do you see?



When the white area is smaller, the vase is more likely to be seen.

You may see a pair of black faces or a white vase.

When the black area is smaller, the faces are more likely to be seen.

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Specialized Visual Recognition Processes – Face Recognition

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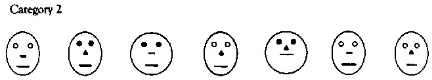
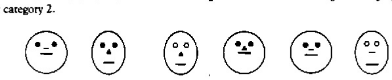
Examine the faces below, which belong to two different categories.

Category 1

Category 2



Now look at each of the faces below and figure out whether it belongs to category 1 or category 2.



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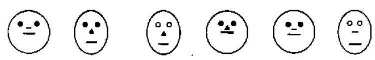

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Prototype Theories

- Store <u>abstract</u>, idealized patterns (or prototypes) in memory
- Summary - some aspects of stimulus stored but not others
- Matches need not be exact

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Prototypes - Evaluation

- Family resemblances (e.g. birds, faces, etc.)
- Evidence supporting prototypes
- Problems - Vague; less well-specified theory of pattern recognition

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Recognizing Faces vs. Recognizing Other Objects

- Face perception as “special”
- Tanaka & Farah – facial features in context vs. isolation
- Individual feature identification vs. holistic or configural recognition
- Like a gestalt

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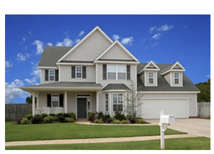
Do you recognize this object

59

Do you recognize this object?



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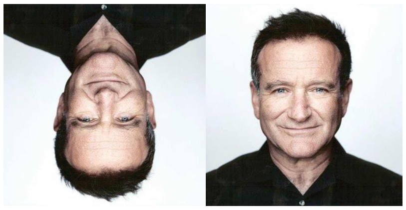
Do you recognize this face?



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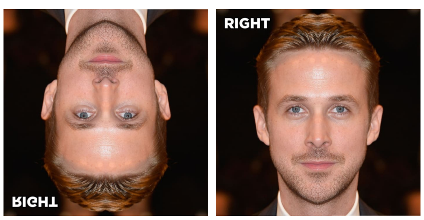
Do you recognize this face?



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Do you recognize this face?

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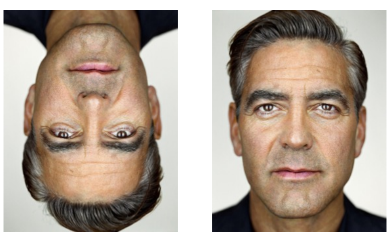
Do you recognize this face?

64

64

Do you recognize this face?



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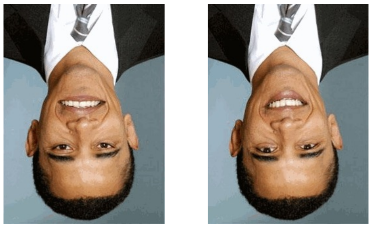
Do you recognize this face?

66

66



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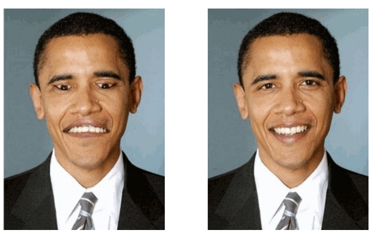

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Cognitive Neuroscience Research on Face Recognition

- Fusiform Face Area in temporal cortex
- Face recognition cells in monkeys
- fMRI studies
  - Brain responses to faces in upright versus inverted (upside-down) position
  - Face Inversion Effect
- Prospagnosia

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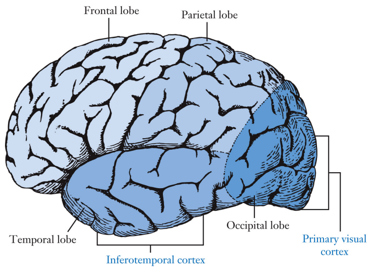
Cerebral Cortex, as Seen from the Left Side, Showing 4 Lobes of the Brain



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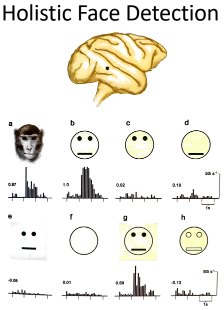
Holistic Face Detection



3·3 Holistic face detection. *Top*: Recording site and location of a face cell. *Bottom* (a–h): the height of the bars indicates the firing rate of action potentials and thus the strength of face recognition in response to various types of facial stimuli.

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