Concept Learning

- What do concepts do for us?
  - Communication
  - Conserve mental space
  - Prediction and generalization
  - Organize our world

Theories of concept learning

- Stimulus-response association
- Classical view
- Prototype model
- Exemplar model

Stimulus-response learning (Hull, 1920)

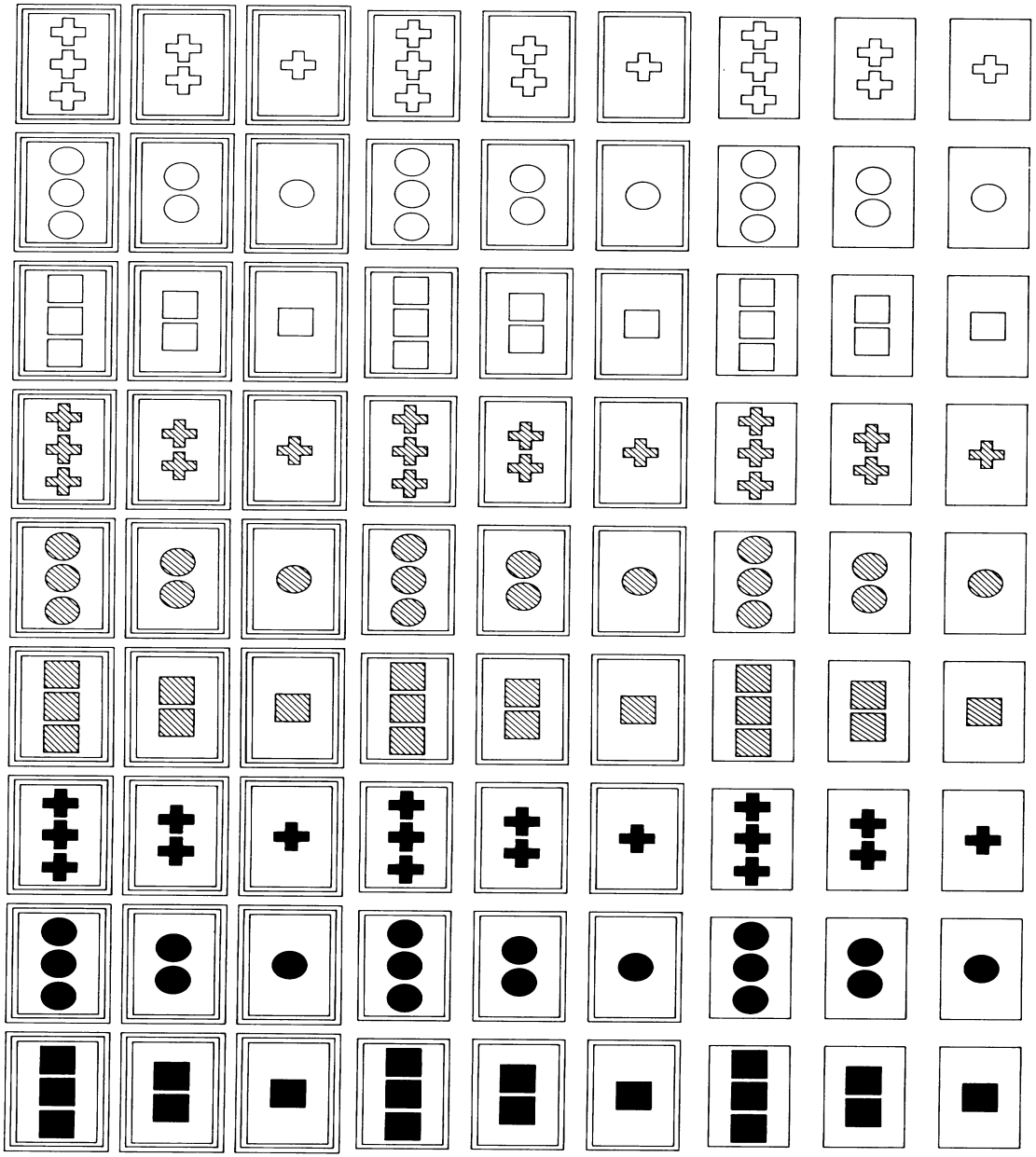
- Passive (unconscious) learning to associate physical stimulus with a category label response

Figure 7.1. *Chinese ideographs used in Hull's (1920) study of classification.*

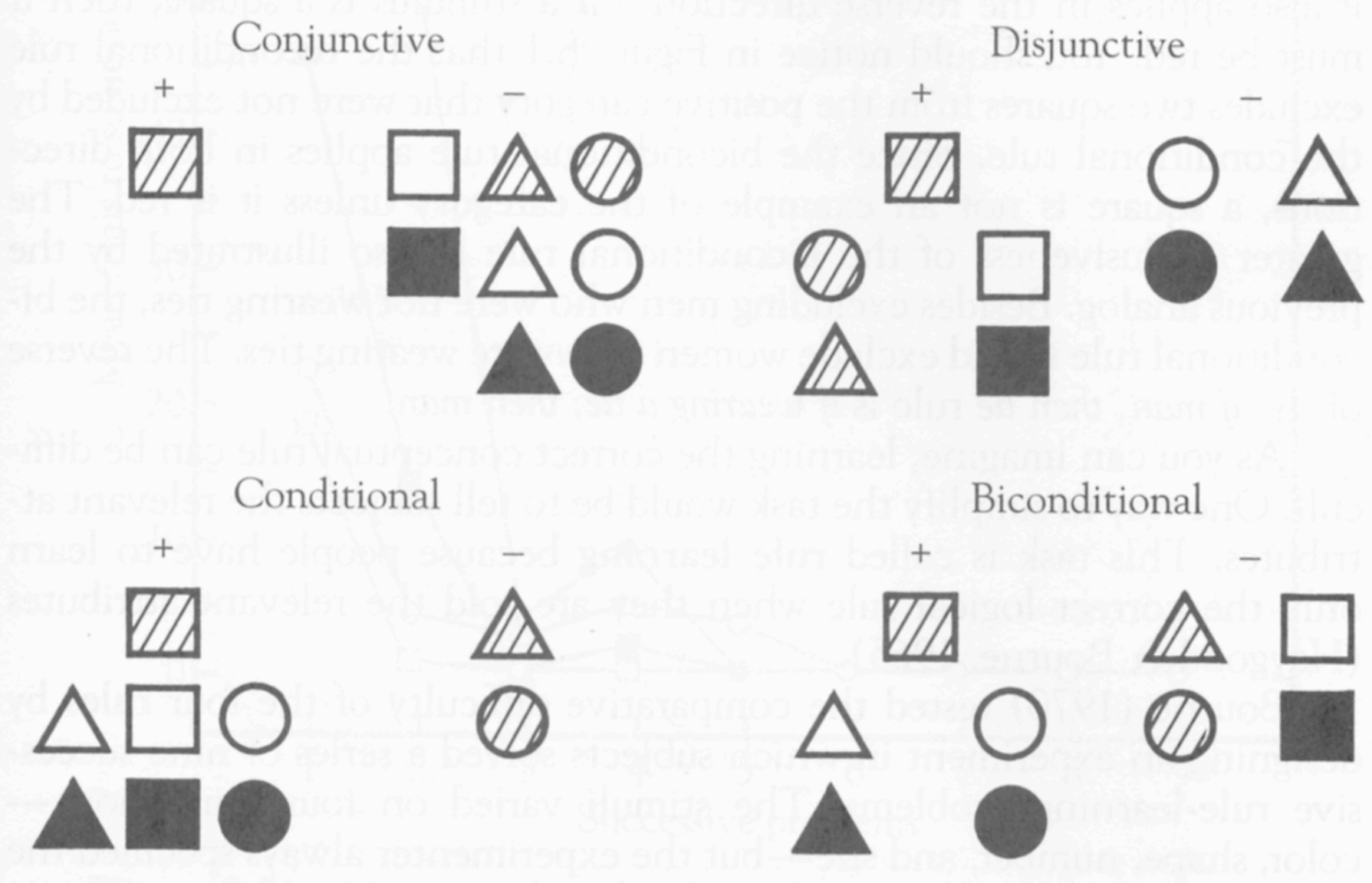
Classical view (Bruner, 1956)

- Concept learning involves active hypothesis formation and testing
- Learning a concept means finding the right rule for determining whether something belongs in the concept
- Concepts are represented by rules
  - Rules as necessary and sufficient features
  - Necessary feature: If something is a member of Concept C, then it must have Feature F
    - "Yellow" Is necessary for concept Canary, "smelly" for Skunk
  - Sufficient feature: if something has Feature F, then it must belong to Concept C
    - "Eyes that see" is sufficient for concept Animal

Rule-based categories



Rule-based categories



Problems with the classical view

- Can't specify defining features
  - Wittgenstein on "games"
- Unclear cases
  - People disagree with each other about categories
  - People also disagree with themselves!
- Typicality
  - Members of a category differ in how "good" or natural a member they are
  - Penguins and robins are both birds, but robins are more typical

Typicality ratings

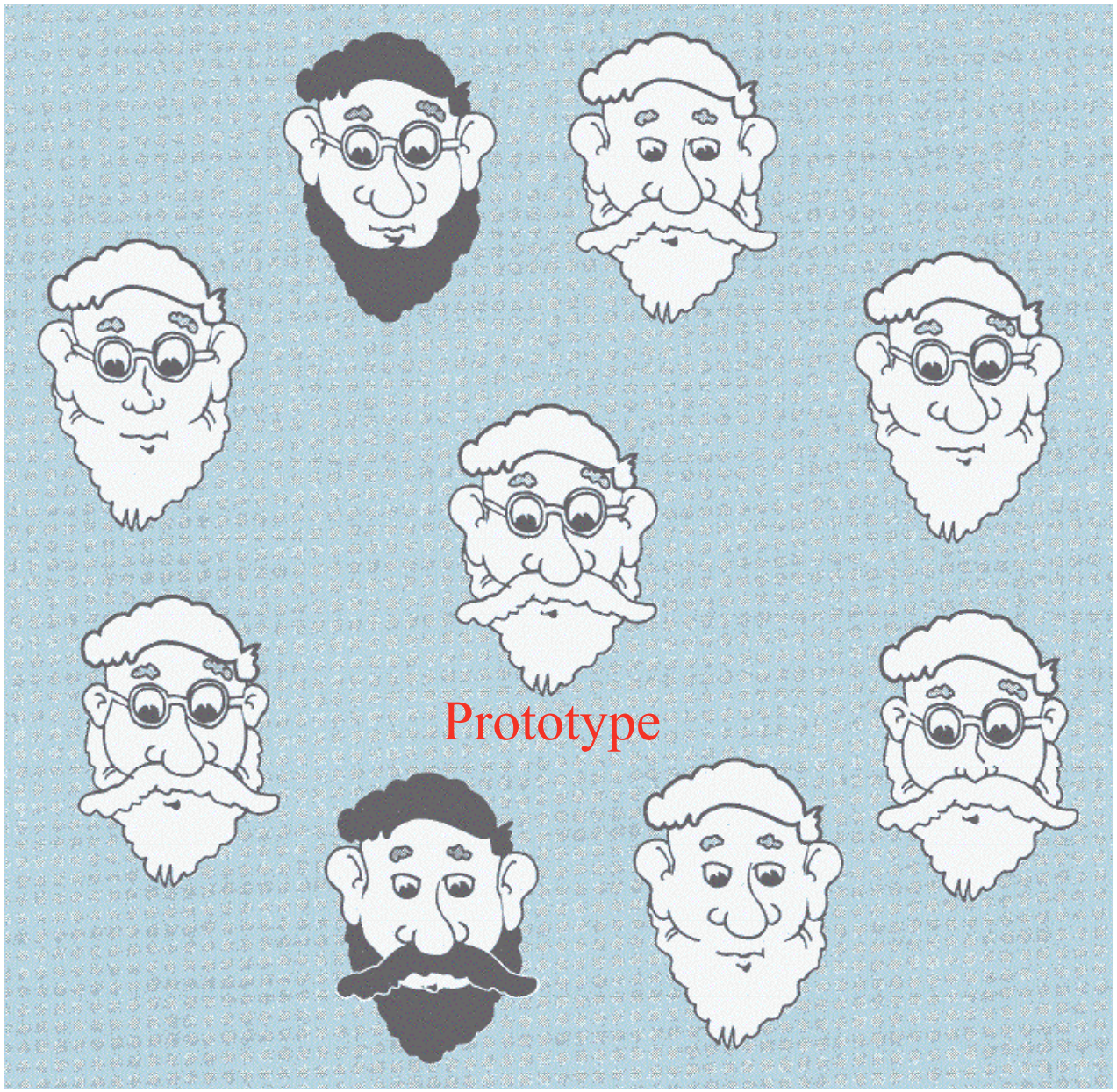
Participants' Typicality Ratings for the Category "Fruit" and the Category "Bird"

Fruit	Rating	Bird	Rating
Apple	6.25	Robin	6.89
Peach	5.81	Bluebird	6.42
Pear	5.25	Seagull	6.26
Grape	5.13	Swallow	6.16
Strawberry	5.00	Falcon	5.74
Lemon	4.86	Mockingbird	5.47
Blueberry	4.56	Starling	5.16
Watermelon	4.06	Owl	5.00
Raisin	3.75	Vulture	4.84
Fig	3.38	Sandpiper	4.47
Coconut	3.06	Chicken	3.95
Pomegranate	2.50	Flamingo	3.37
Avocado	2.38	Albatross	3.32
Pumpkin	2.31	Penguin	2.63
Olive	2.25	Bat	1.53

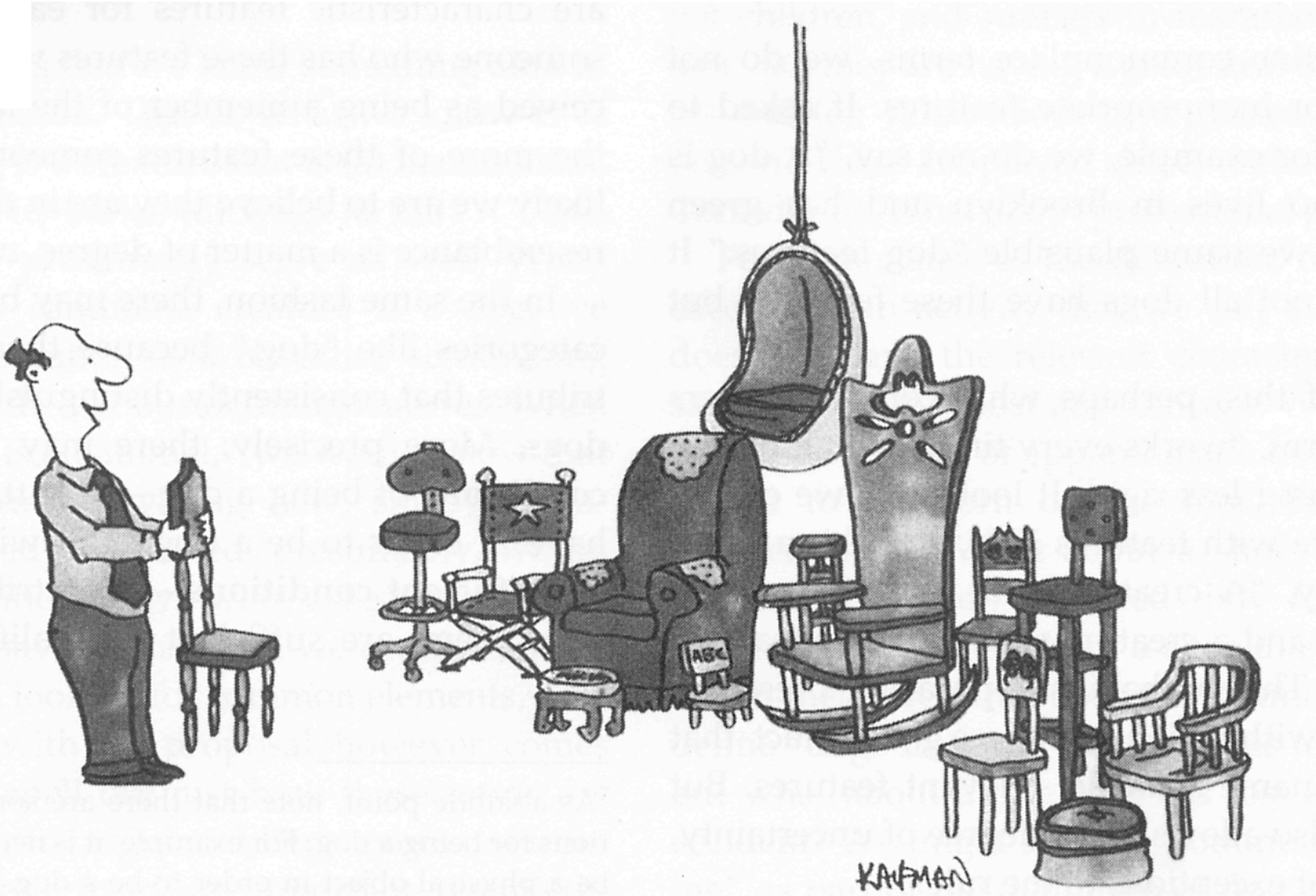
Prototype Theory (Rosch, 1971)

- A Concept is represented by a prototypical item = central tendency
- Prototypes include characteristic features that are usually present, not only necessary or sufficient features
- Unclear cases handled
  - An object may be equally close to two categories' prototypes
- Typicality handled
  - The typicality of an item is based on its proximity to the prototype
- Family resemblance
  - The members of a category are overall similar, but there may not be anything that they all have in common

Prototype Theory



Family Resemblance



"Attention, everyone! I'd like to introduce the newest member of our family."

An objective measure of typicality

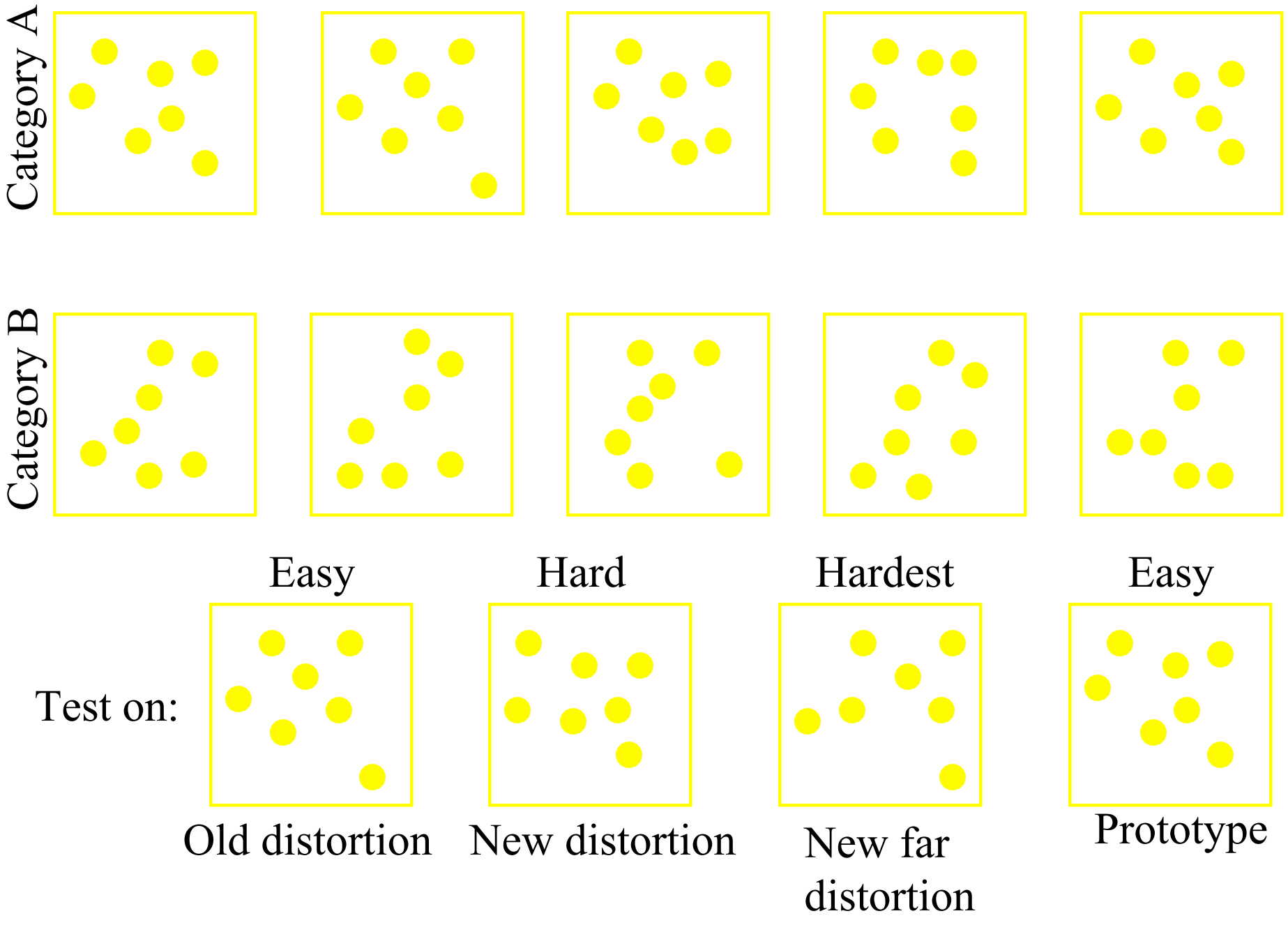
	Bluejay	Robin	sandpiper	Eagle	Penguin
Flies	✓	✓	✓	✓	✗
Nests in trees	✓	✓	✗	✓	✗
Lays eggs	✓	✓	✓	✓	✓
Is small	✓	✓	✓	✗	✗
Eats insects	✓	✓	✓	✗	✗
Properties in common with other birds	13	13	12	11	7

What does typicality predict?

- Typicality ratings
- Order of listing members of a category
  - "Bluejay" listed before "Emu" for Bird category
- Response time to verify "An X is a C"
  - "Yes" to "Are eagles birds?" slower than "Yes" to "Are sparrows birds?"
- Inferences
  - Generalization from typical item to category is stronger than from atypical item to category
  - "All chickens/sparrows on a certain island have a certain bacteria in their gut. How likely is it that all birds do?
  - Higher probability estimates with sparrows than chickens

Random Dot Pattern Experiment (Posner & Keele, 1968)

- Four random dot patterns serve as category prototypes
- Participants see 12 distortions of each prototype
- Learn to categorize patterns with feedback
- Test categorization accuracy for
  - Old distortions of prototype
  - New distortions of prototype
  - New distortions, further removed from prototype
  - The hitherto unseen prototypes themselves
- Results
  - Prototypes are categorized as well as old distortions
  - Both are categorized better than new distortions
  - The new, far-removed distortions are least well categorized
  - With 2 week delay, the prototype is categorized most accurately
- Prototypes are explicitly extracted from examples, and serve as representation for category.


Category A
Category B
Easy
Hard
Hardest
Easy
Test on:
Old distortion
New distortion
New far distortion
Prototype

Sources of fuzzy categories

- Context-dependent categories (Labov, 1973)
  - What counts as a bowl/cup depends on situation
- Multiple models (Lakoff, 1986)
  - Different models of a concept may provide different categorizations.
  - Typicality increases as more models agree with a categorization
  - Mother as female who gives birth, female provider of genes, female who raises you, female married to your father, etc.
  - Lying: not true, trying to mislead, know true answer
  - Climbing: upward component, clambering motion

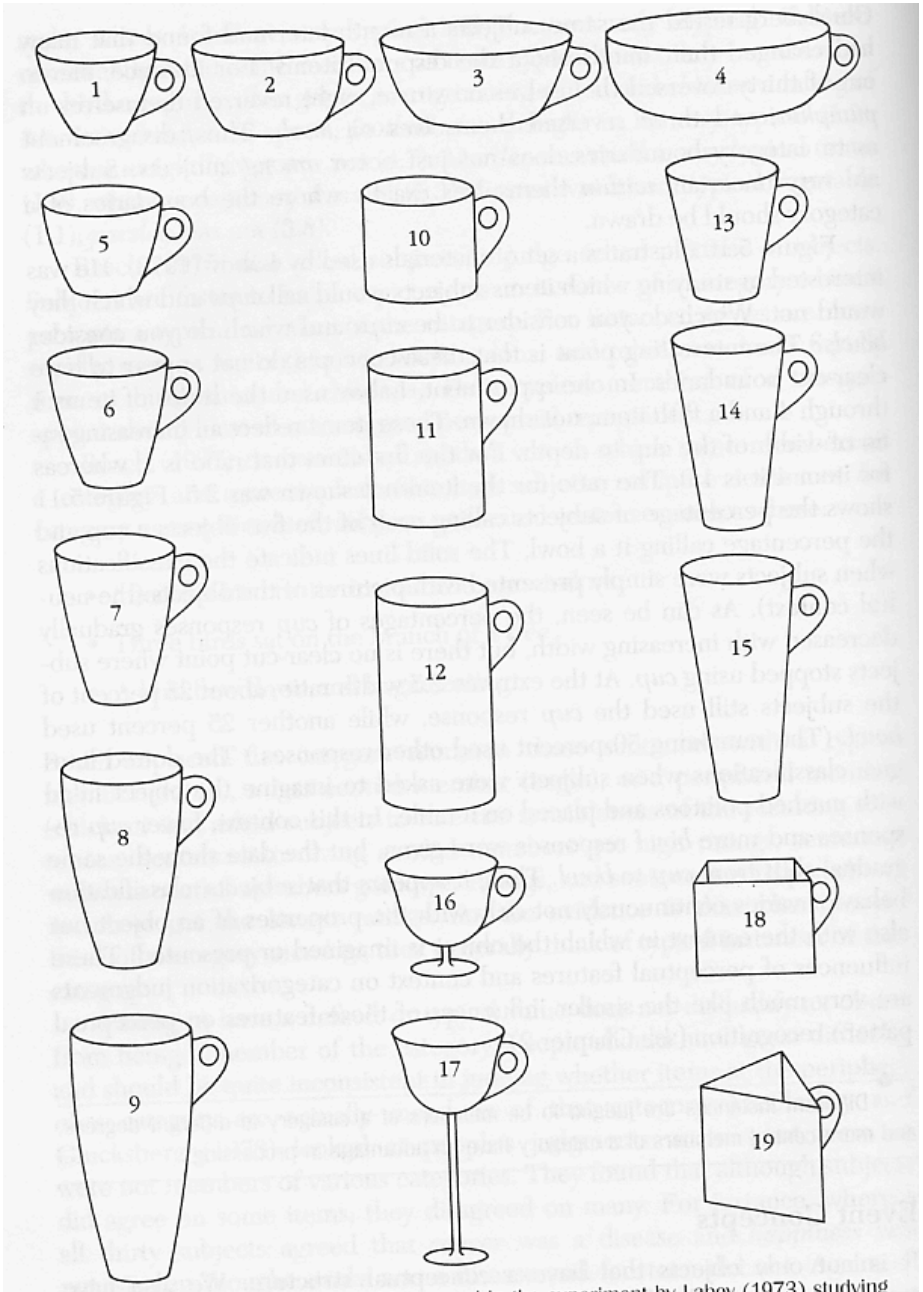
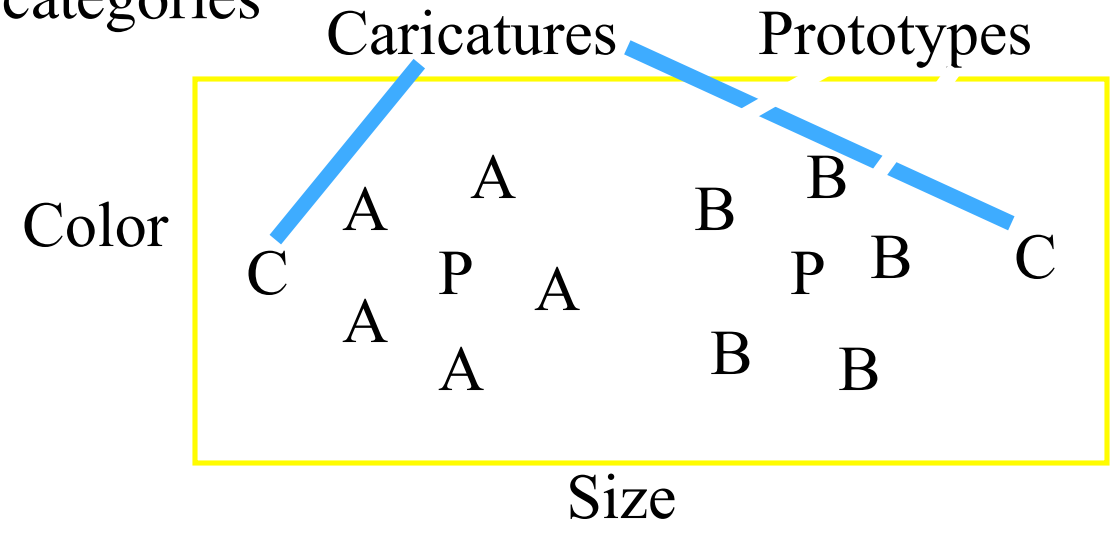


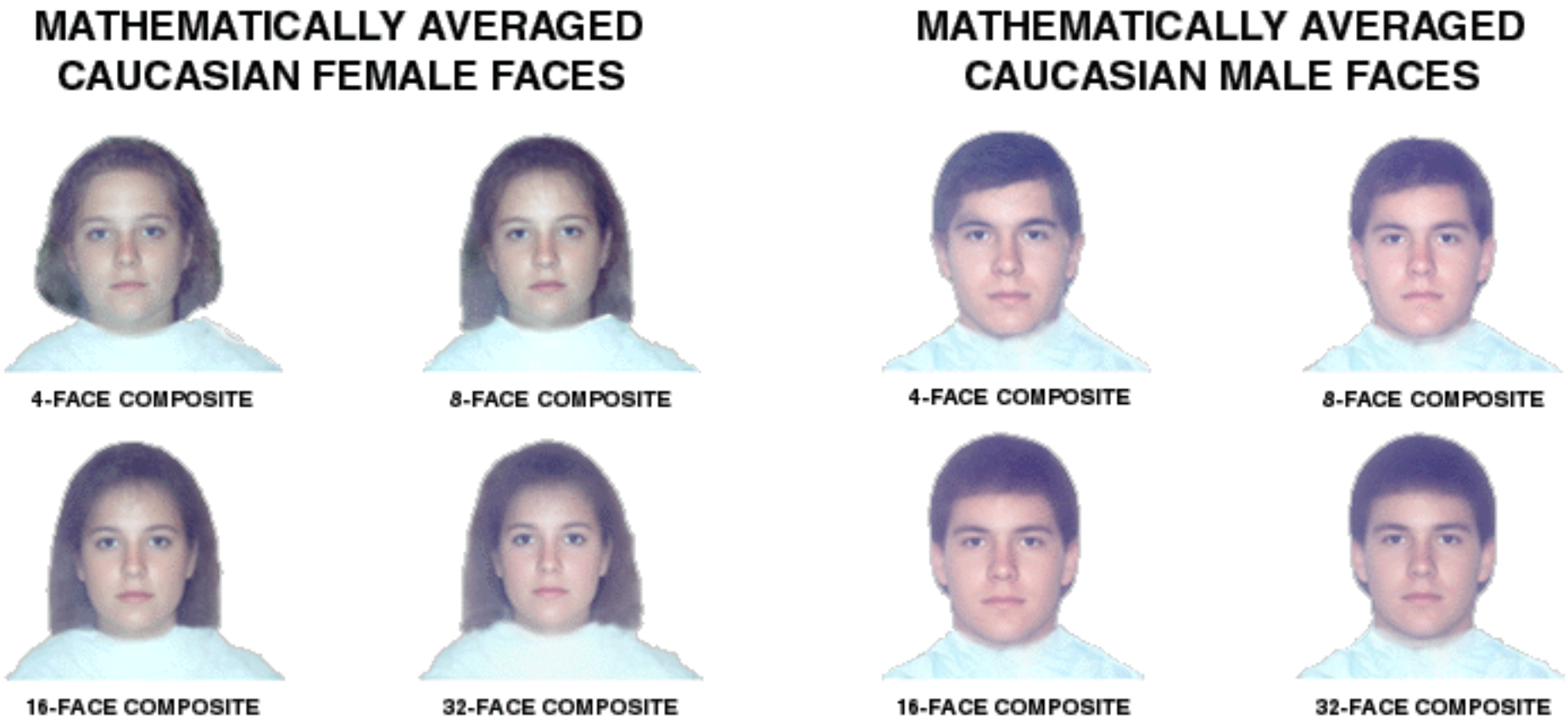
Figure 5.10 The various cuplike objects used in the experiment by Labov (1973) studying the boundaries of the cup category. (Reprinted with permission from W. Labov, "The boundaries of words and their meanings." In New ways of analyzing variations in English, edited by C.-J. N. Bailey and R. W. Shuy. Washington, DC: Georgetown University Press, page 354. Copyright © 1973 by Georgetown University Press.)

Prototypes and Caricatures

- In general, making a face more similar to a prototypical face makes it more attractive
- Caricatures - exaggerate distinctive features of an object
  - Caricatures are more readily recognized than actual pictures
  - You can get more attractive than average
    - The caricature of a set of attractive faces is more attractive than either the prototypical face or the attractive faces themselves
  - Categories are often times represented by caricatures, rather than prototypes, because caricatures better discriminate between categories



Attractive faces are only average



Combining more faces together increases attractiveness

Box 8.1 Computer didn't miss in selecting Miss Mississippi

SUN-SENTINEL WIRE SERVICES

SEATTLE—A retired statistics professor said Sunday he never doubted Susan Akin of Mississippi would walk down the runway as Miss America.

"No one in all my eight years of forecasting Miss America has ever come so close as to the composite Miss America," George Miller said. "She deviated the least."

Akins' only possible drawbacks to winning the crown were her blue eyes, which over the years have been less popular than green or brown, said Miller, who taught statistics and forecasting at Northern Illinois University before moving to the Northwest where last year he taught at Seattle University.

Miller, 62, has correctly picked the winner ahead of the judges four times out of seven—beginning with the 1979 pageant when he chose another Miss Mississippi. He also accurately forecast the 1980 and 1983 winners.

Miller doesn't compute hair color or the contestants' overall appearance into his statistical study. What he uses are facts and figures that can be correlated—such as talent, weight, height, education level and major, and physical measurements.

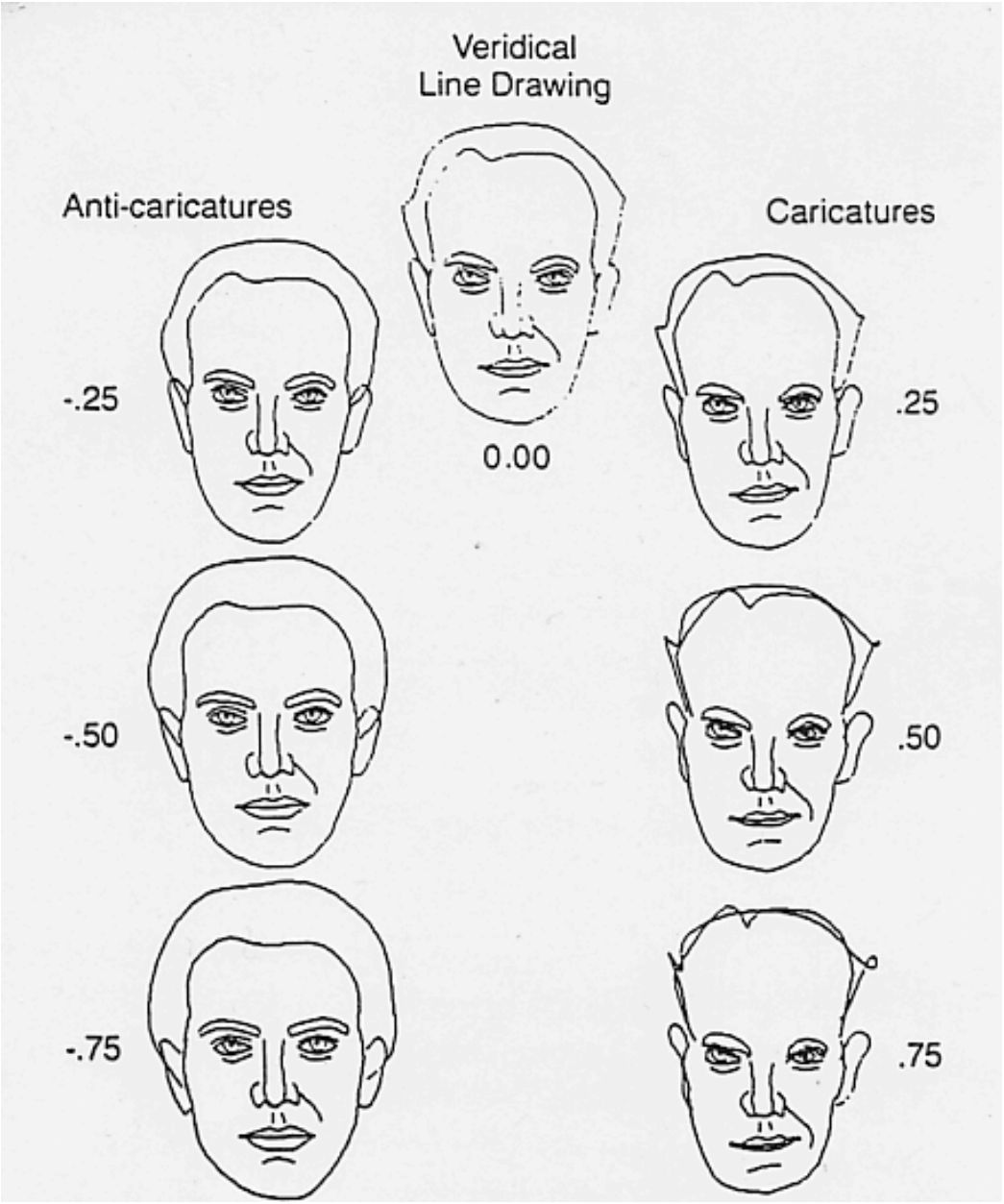
"I don't consider hair color because one-third of the contestants are blonds and one-third of the winners over the years have been blond," he said. "And I don't look at their pictures because a photographer can pose them or doctor the photos."

Miller said the "ideal Miss America" would be 5 feet 7 inches tall, weigh 115 pounds, have measurements of 35-23-35, be 21 years old, have green eyes, be a college junior majoring in communications, and sing classical music.

From the *Sun-Sentinel*, Fort Lauderdale, September 16, 1985.

Automatic Caricature Creation

Prototypes



Automatic Caricature Creation

Veridical

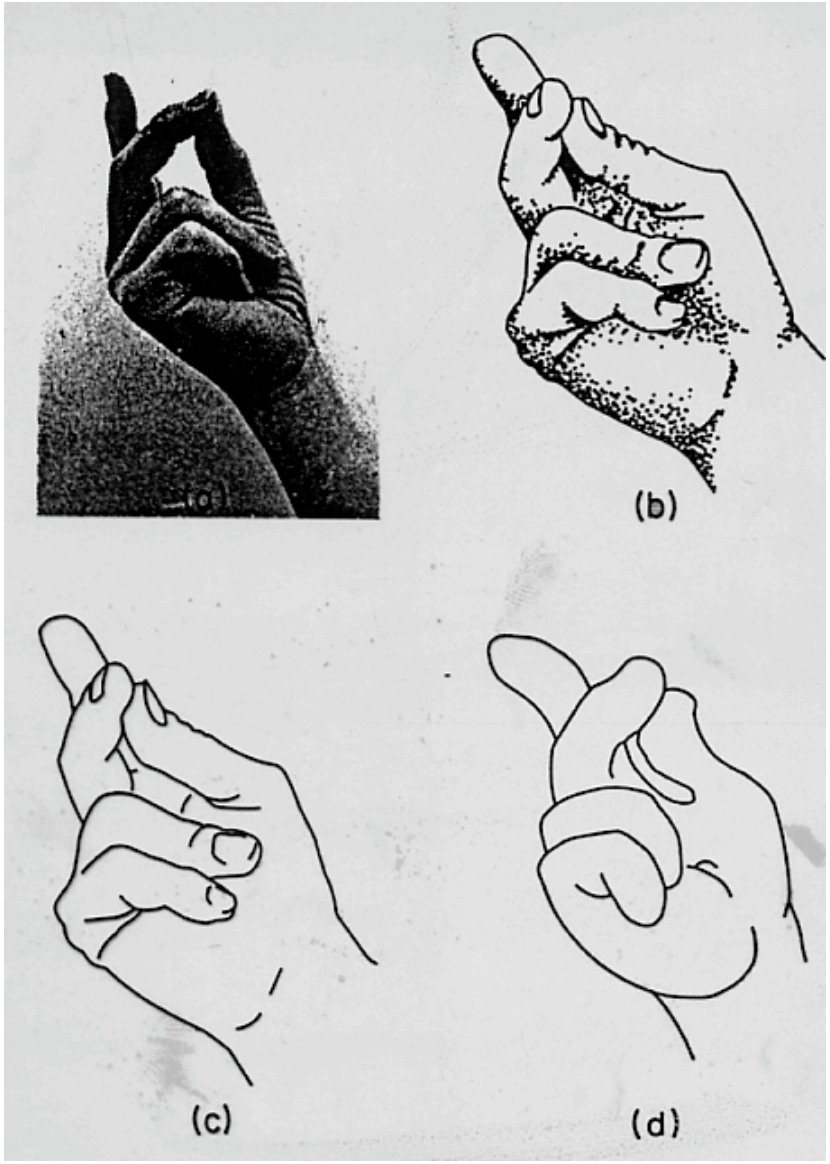
line drawing

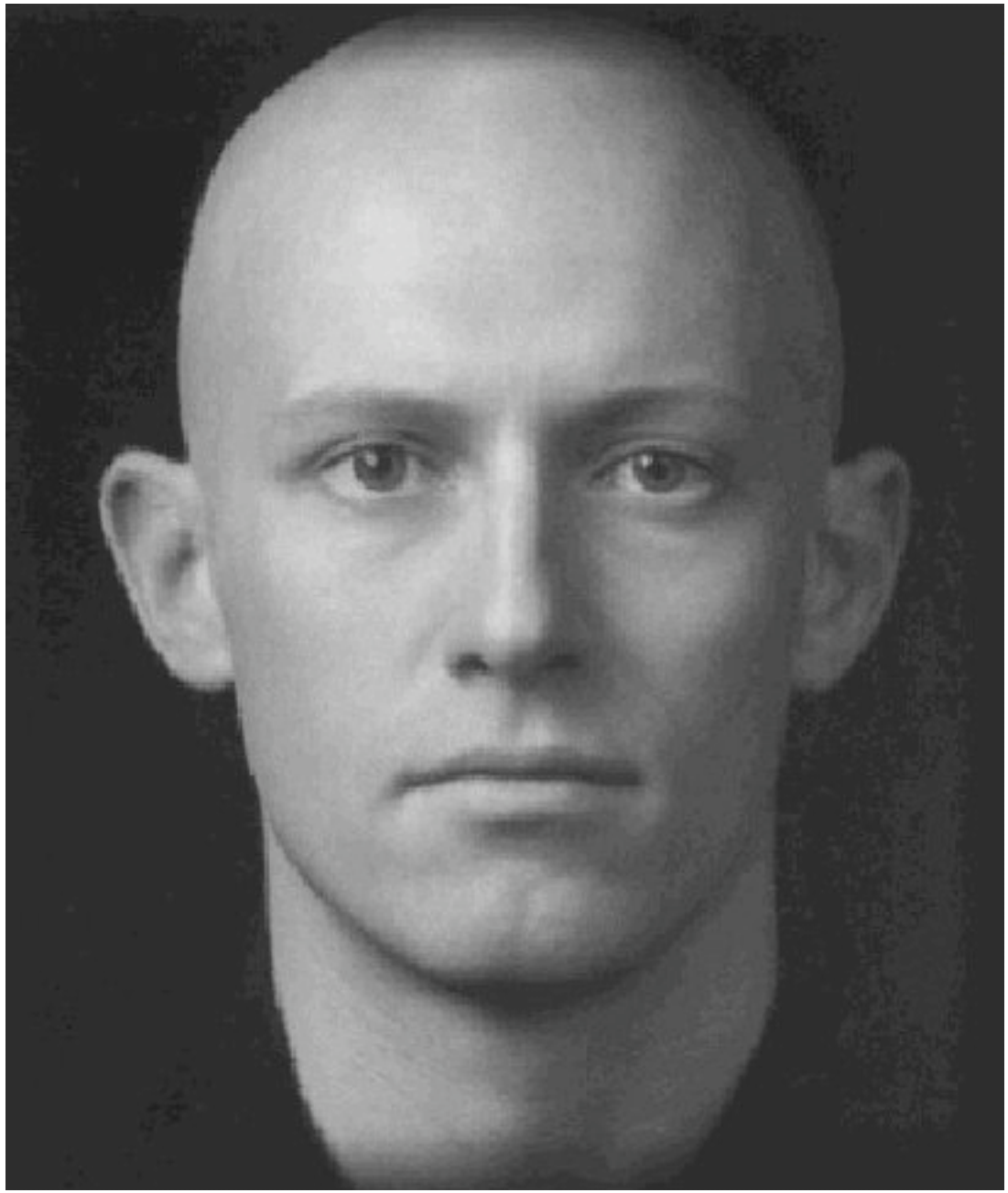
Caricature

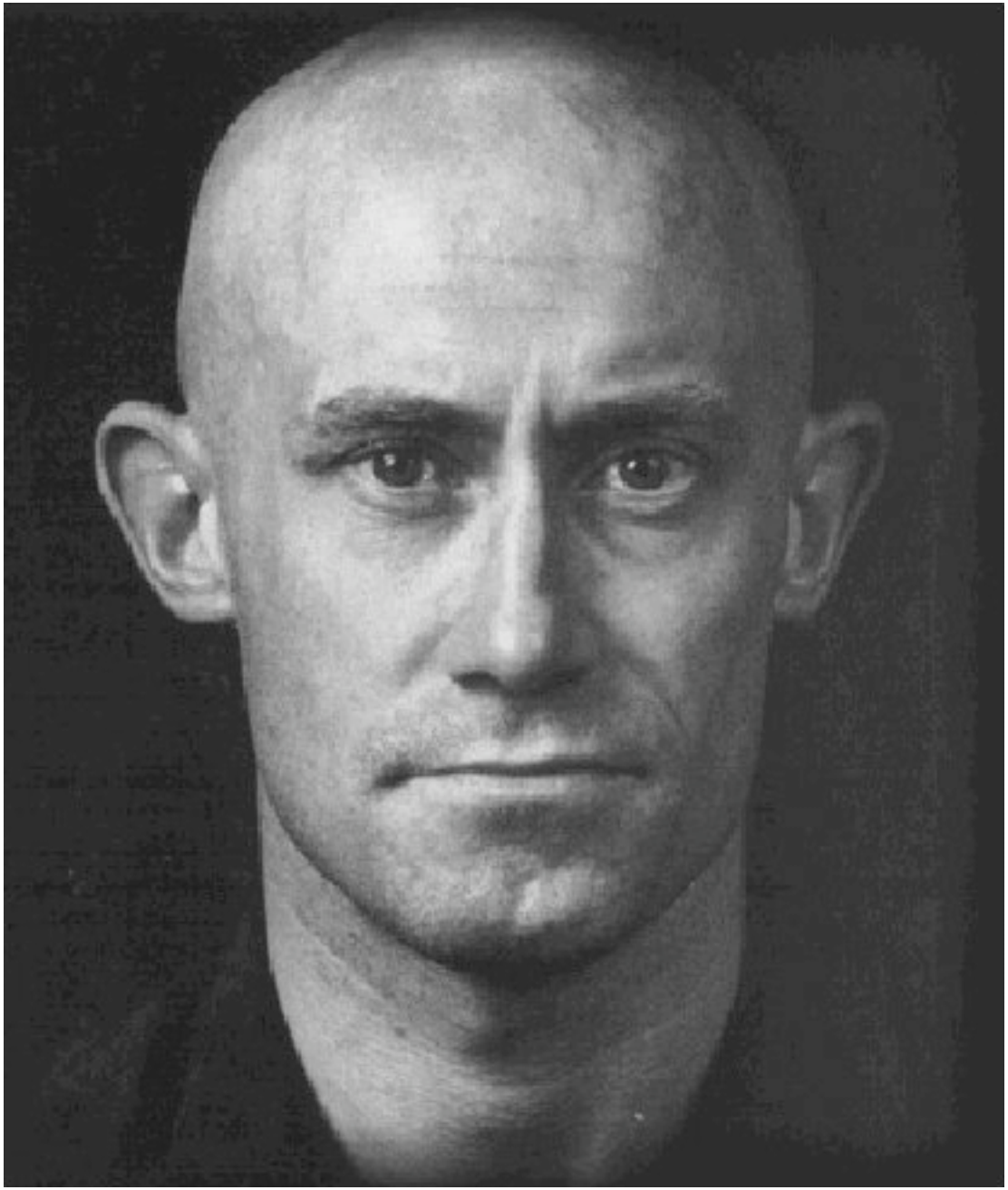
Extreme caricature

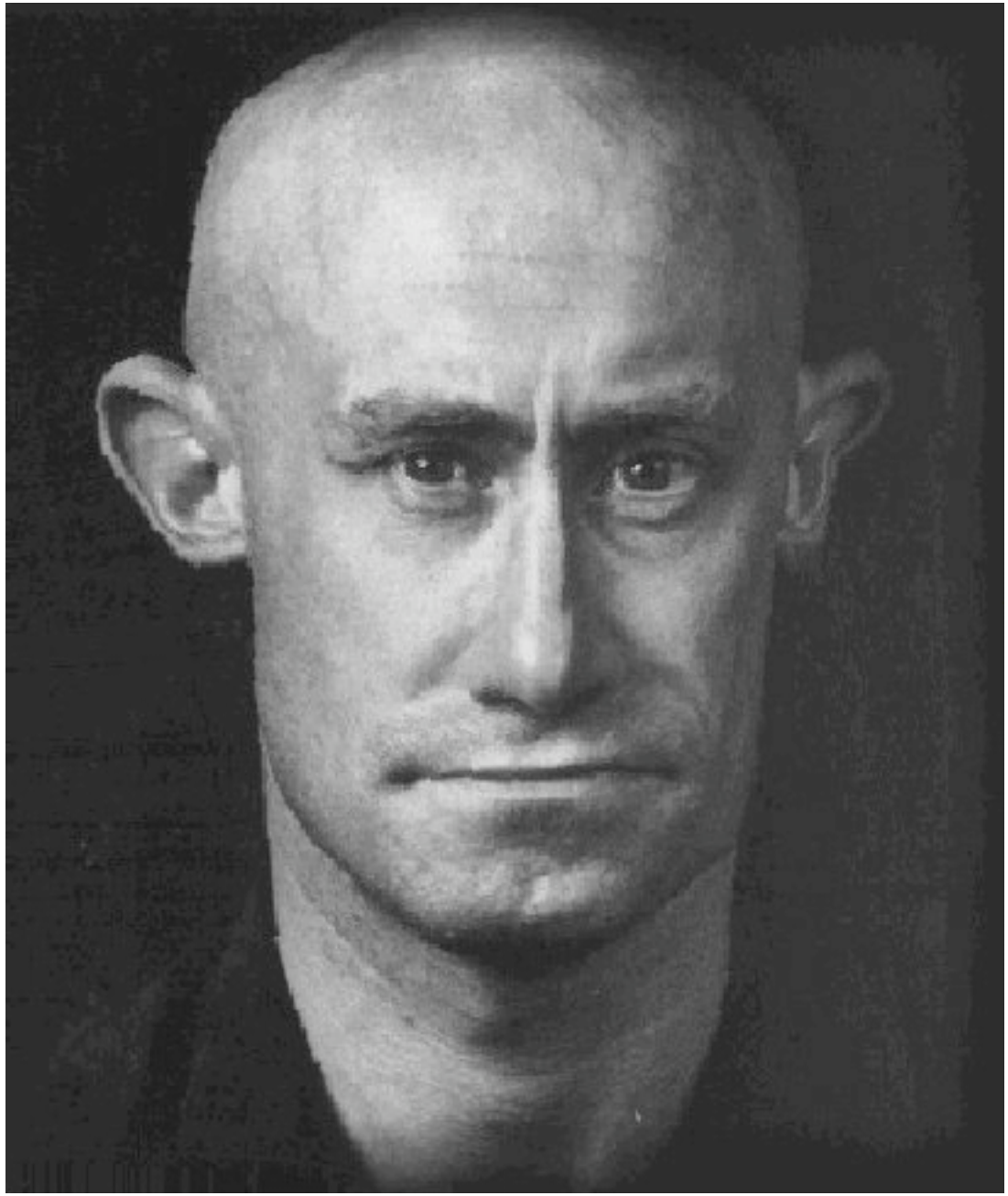
Caricatures are recognized faster than actual line drawing

Caricatures are well perceived because they exaggerate distinctive elements









Prototype

Prototype of attractive subset of faces

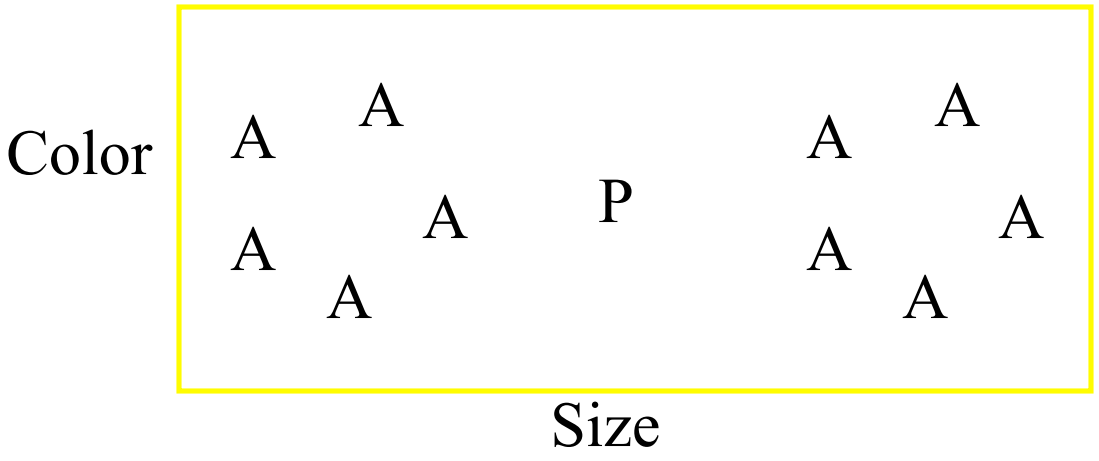
Caricature of attractive subset of faces

Preferred 90%

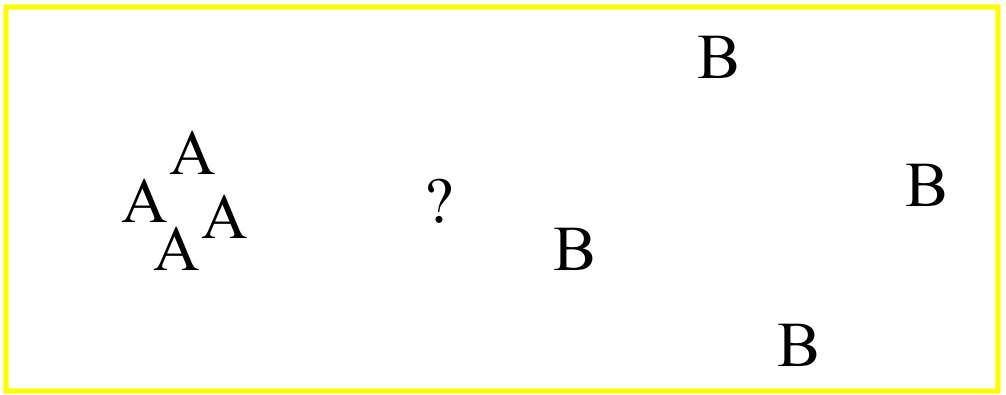
Preferred 70%

Problems with prototypes

- Central tendency is inappropriate sometimes



- Category variability information is important

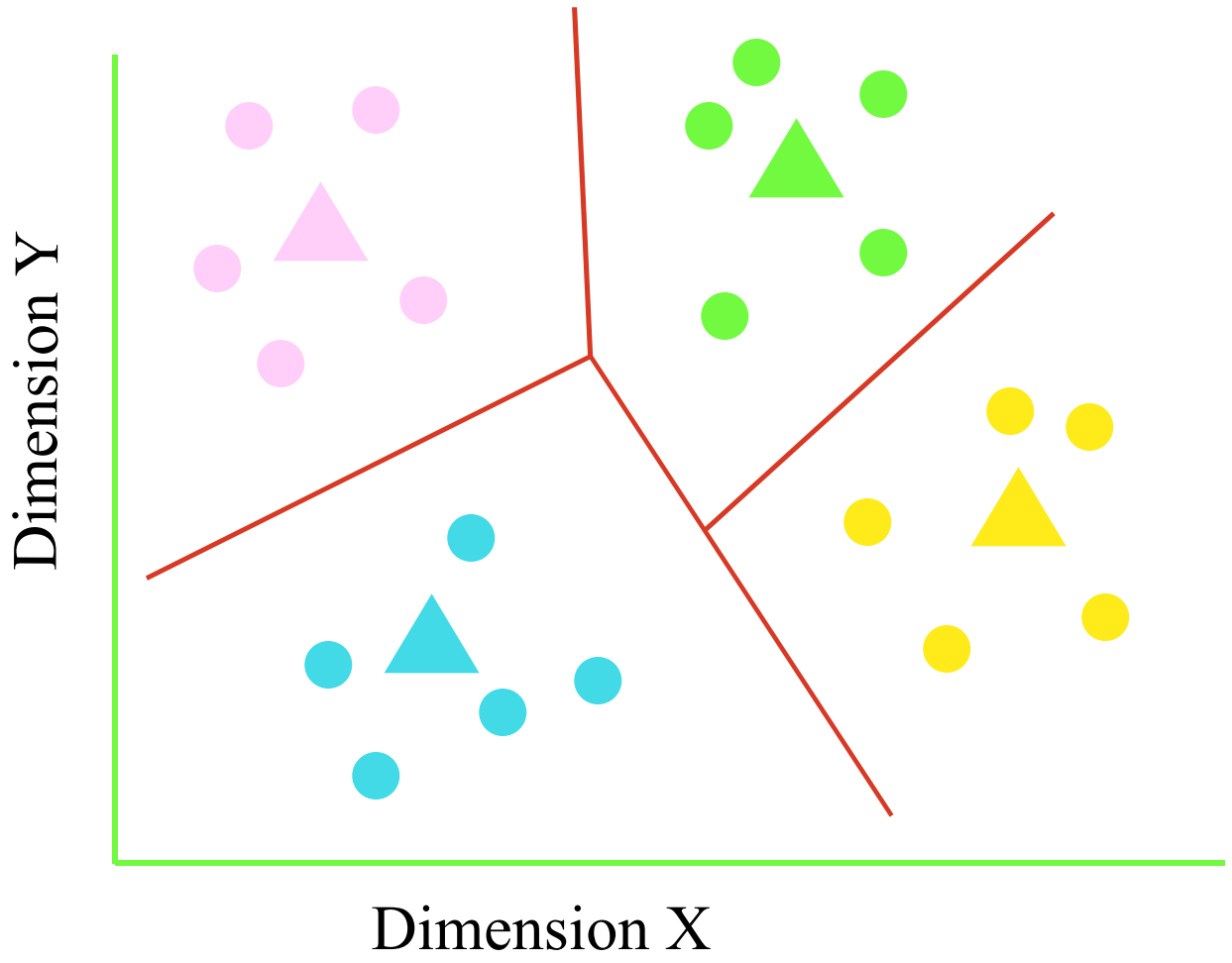


- Prototype loses information about specific instances

Exemplar theory

- A Concept is simply represented by all of the members (exemplars) that are in the concept
  - Classical view: Bird = “Flying animal with beak that lays eggs”
  - Prototype: Bird = sparrow-like thing
  - Exemplar: Bird= {sparrow, emu, chicken, bluejay, eagle}….
  - Does not throw out instance information as does prototype theory
- Uses the total similarity of an object to all members of the category to determine if the object belongs in the category

Prototype, Exemplar, and Boundary Representations



Exemplars

Prototypes

Boundaries

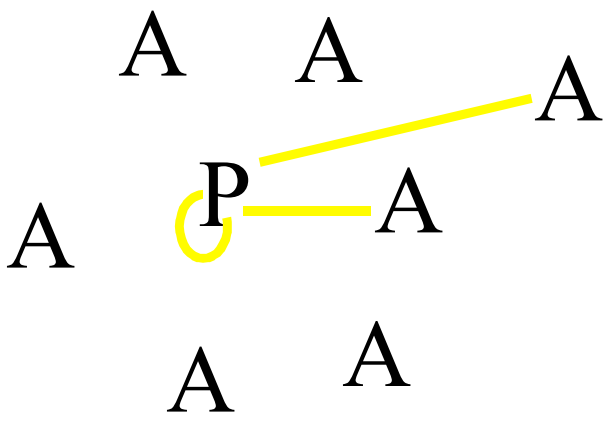
Exemplar and prototype theories can both account for the random dot pattern experiment

Result (Posner & Keele)

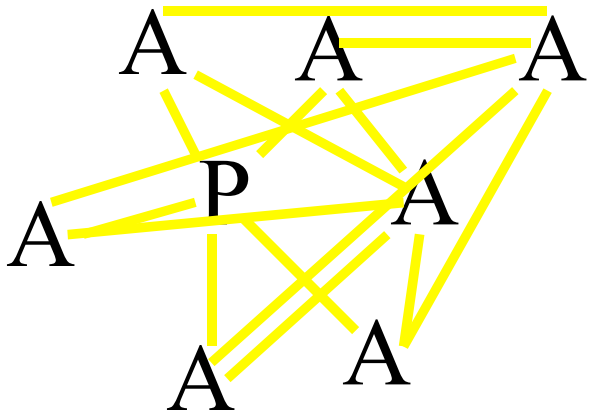
Prototype is better categorized than new distortions, even though prototype was never seen during training.

Categorization accuracy decreases as item moves further away from prototype.

Prototype Theory



Exemplar Theory



Group 1

Group 2

XREMENT

Correct answers

2

1

2

2

1

1

2

1

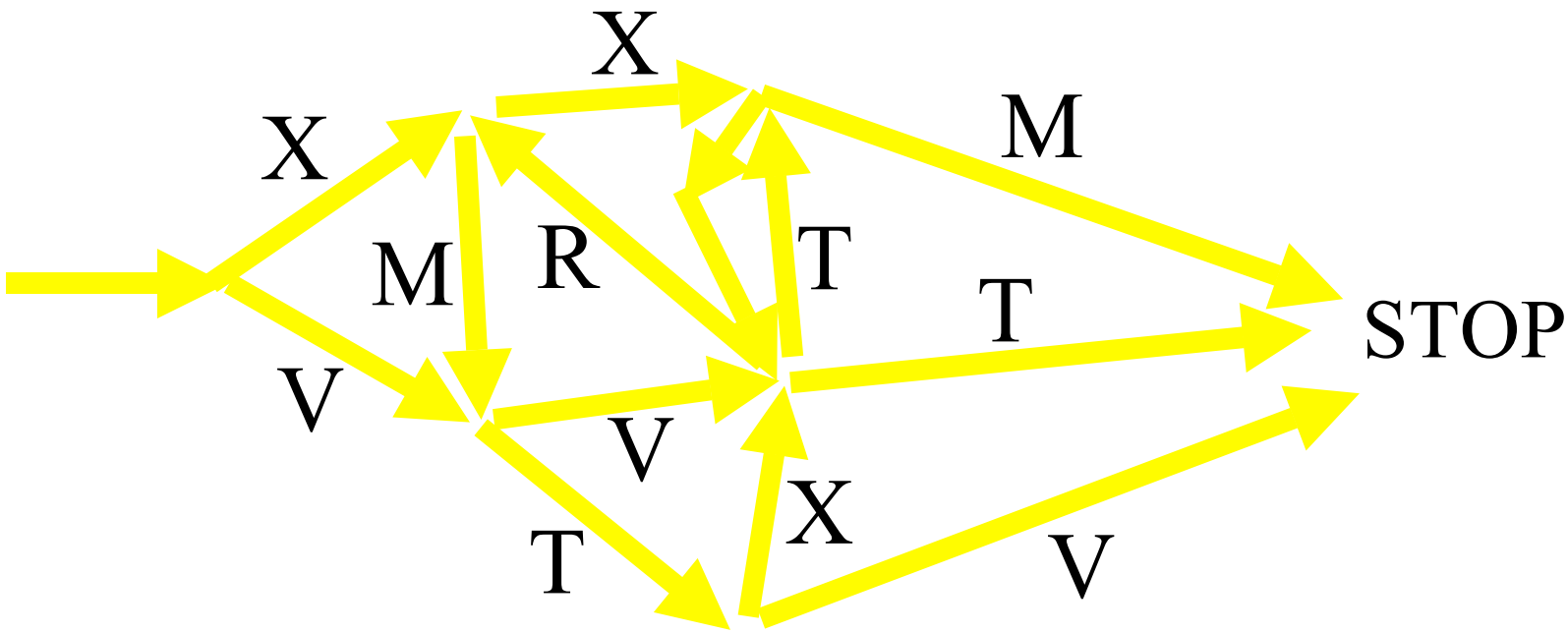
2

1

1

2

Group 1	Group 2
VTXTM	VRMXT
VTV	XTMVV
XMVTTRXM	VXMTRM
VVTM	XRV
XXRMVT	VTXXM
VVRMVTM	XTVMTMRX
XMTV	VVXRTM
XMVTM	VTM
VVT	VXTRM
VVRMVRMTV	XRVMTRMV
XMTXT	XXMXTMM
VVRXTM	VVMRXTTV



Group 1 = Legal sequences

VTV

XMVTTRXM

Group 2: Illegal sequences

VMV

XMVTXM

People categorize new items with some accuracy even if they don't know the rule, by putting a new item in the category with the most similar exemplars to it.

Hierarchical organization of concepts

- Subordinate - most specific - German Shepard
- Basic level - Dog
- Superordinate - Mammal
- Psychologically privileged role for basic level concepts
  - Level people use to identify an object
  - Most general category where items have the same shape
  - Shortest name
  - The most new features are introduced
- But, superordinate level may be more primitive/fundamental
  - Developmental evidence: 18 month old shows sensitivity to superordinate concepts before basic concepts
  - Neurophysiological evidence: agnosics retain superordinate recognition
  - Experts: dog experts can categorize at subordinate as well as basic level
  - So, the more knowledge you have, the more specific (subordinate) your preferred level of categorization will be

Table 8.2 *Examples of subordinate, basic, and superordinate categories*

Superordinate	Basic Level	Subordinates	
Musical instruments	Guitar	Folk guitar	Classical guitar
	Piano	Grand piano	Upright piano
	Drum	Kettle drum	Bass drum
Fruit	Apple	Delicious apple	Mackintosh apple
	Peach	Freestone peach	Cling peach
	Grapes	Concord grapes	Green seedless grapes
Tools	Hammer	Ball-peen hammer	Claw hammer
	Saw	Hack handsaw	Cross-cutting handsaw
	Screwdriver	Phillips screwdriver	Regular screwdriver
Clothing	Pants	Levi's	Double-knit pants
	Socks	Knee socks	Ankle socks
	Shirt	Dress shirt	Knit shirt
Furniture	Table	Kitchen table	Dining-room table
	Lamp	Floor lamp	Desk lamp
	Chair	Kitchen chair	Living-room chair
Vehicles	Car	Sports car	Four-door sedan car
	Bus	City bus	Cross-country bus
	Truck	Pickup truck	Tractor-trailor truck

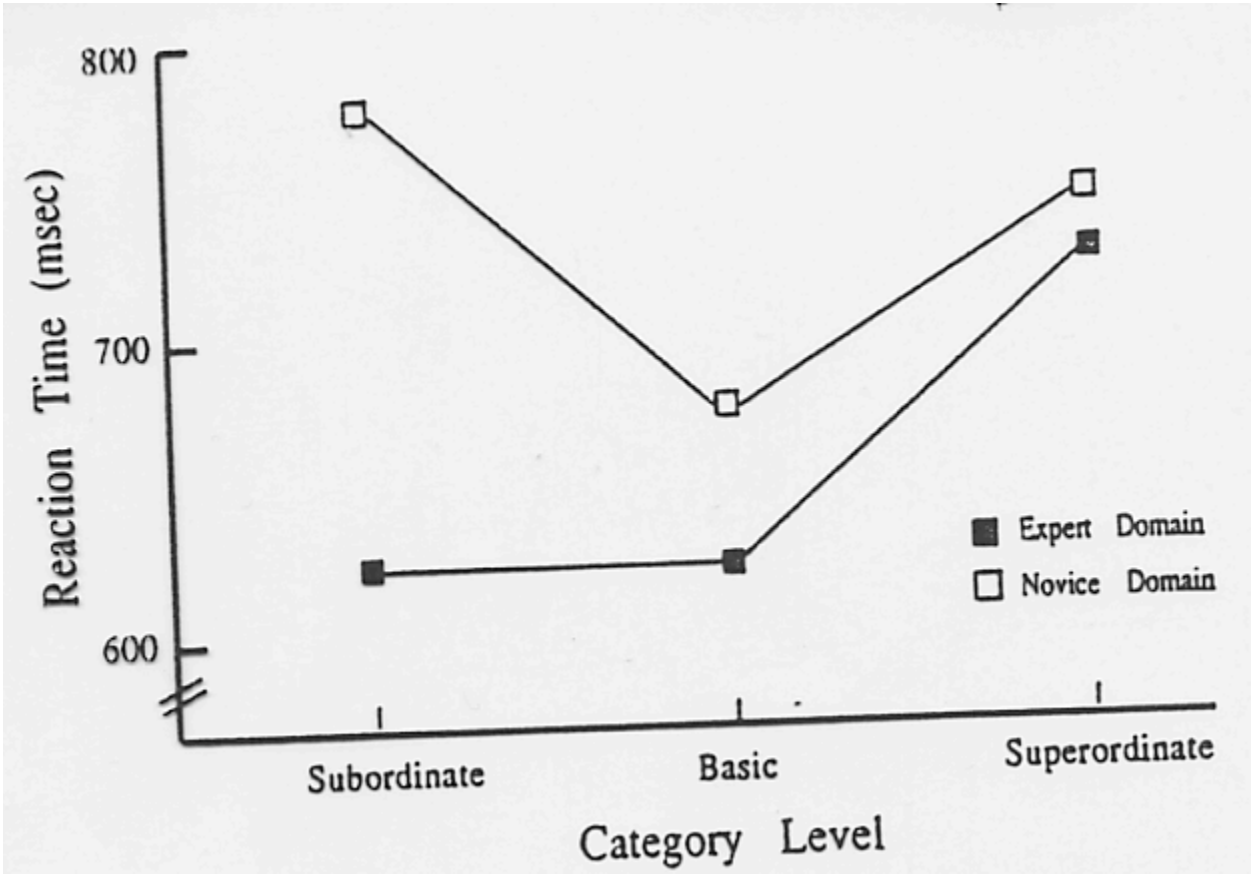
SOURCE: From "Basic objects in natural categories," by E. Rosch, C. B. Mervis, W. D. Gray, D. M. Johnsen, and P. Boyes-Braem, 1976, *Cognitive Psychology, 8*, 382–440. Copyright © 1976 by Academic Press, Inc. Reprinted by permission.

Table 8.3 *Number of attributes in common at each hierarchical level*

Category	Raw Tallies			Judge-Amended Tallies			
	Super-ordinate	Basic Level	Sub-ordinate	Super-ordinate		Basic Level	Sub-ordinate
Musical instruments	1	6.0	8.5	1		8.3	8.7
Fruit	7	12.3	14.7	3		8.3	9.5
Tools	3	8.3	9.7	3		8.7	9.2
Clothing	3	10.0	12.0	2	<	8.3	9.7
Furniture	3	9.0	10.3	0		7.0	7.8
Vehicles	4	8.7	11.2	1		11.7	16.8

Many more features listed for Basic than Superordinate concepts

Not many more features listed for Subordinate than Basic concepts



Dog and bird experts identifying dogs and birds at different levels

Experts make subordinate as quickly as basic categorizations

Figure 1.

The average female face shape (blue line) differs from the face shape of the most attractive 25% of the population sampled (red line). (The overlap of blue and red is white.)