Concept learning in the 1960s

Boolean algebra
aka Propositional Calculus

Propositions are statements that assert a fact (true or false), e.g.

- The sky is blue
- Cats like catnip
- All ducks are green

The law of the excluded middle: Every proposition is either true or false. (Debatable?)

Propositional calculus (aka Boolean algebra) is a system for assembling complex propositions from simple ones using connectives, such as AND ($\wedge$), OR ($\vee$), or NOT ($\sim$).

Boolean connectives

truth tables

A \ B	T	F
T	T	F
F	F	F

$A \wedge B$

"and"

conjunction

A \ B	T	F
T	T	T
F	T	F

$A \vee B$

"or"

"inclusive or"

disjunction

A	
T	F
F	T

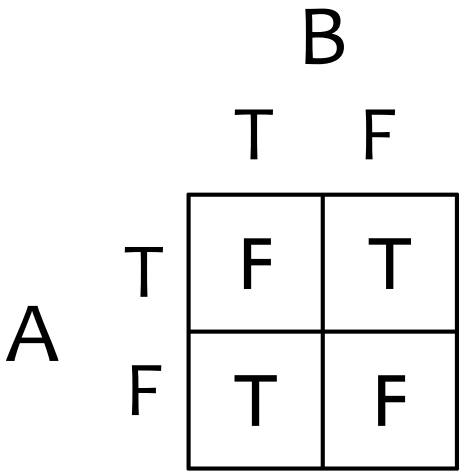
$\sim A$

"not"

negation

The all-star team of logical connectives
but not the only possible team!

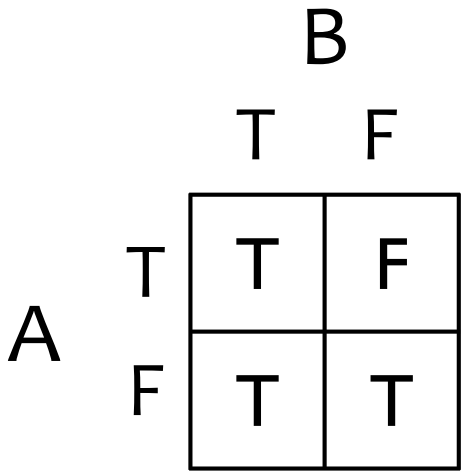
New connectives; same as the old connectives?



$A \oplus B$

"exclusive or"

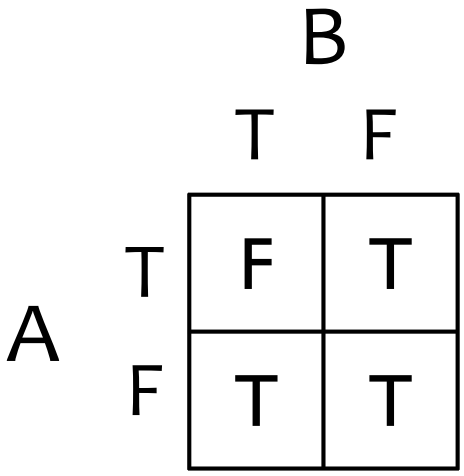
$(A \wedge \sim B) \vee (\sim A \wedge B)$



$A \rightarrow B$

"implication"
"conditional"

$\sim A \vee B$



$A \uparrow B$

"not-and"

$\sim(A \wedge B)$

NAND is sufficient by itself to create all the connectives!

Classical concept learning experiments (1960s)

- Experimenter teaches a "concept" to a subject, giving new positive and negative examples (with feedback) until subject learns successfully
- Dependent measure is number of trials (examples) required for successful learning
- Independent measure is the type of concept

Examples

Concept

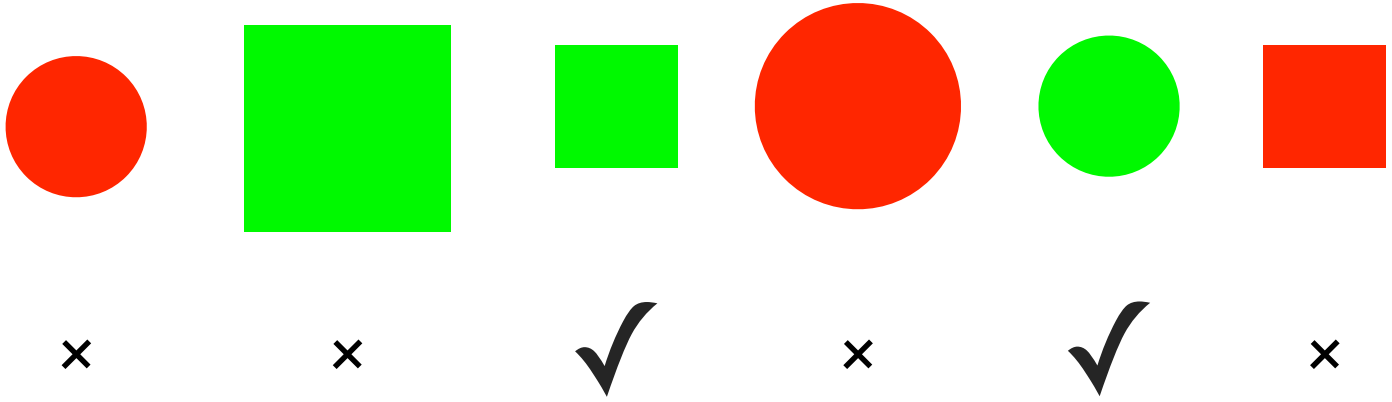
square

× ✓ ✓ × ✓ ×

affirmation

Examples

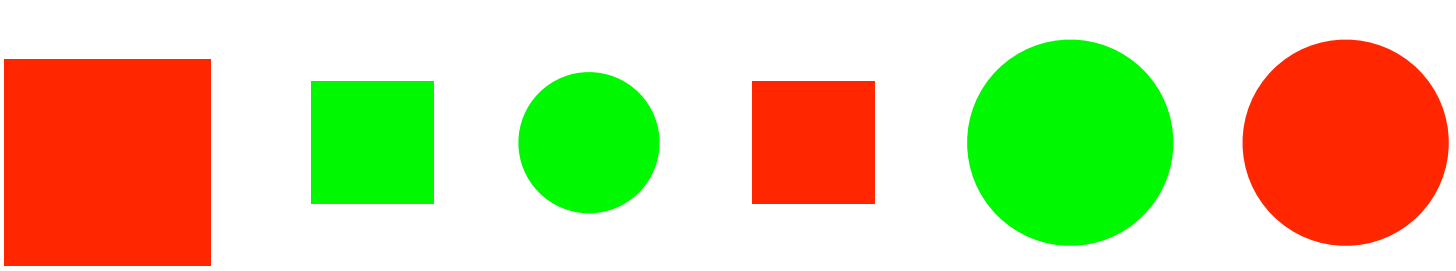
Concept



× × ✓ × ✓ ×

small ∧ green

conjunctive



✓ ✓ × ✓ × ✓

square ∨ red

disjunctive

Experimental conclusions

- Affirmation < Conjunction < Disjunction (inclusive) < Disjunction (exclusive)

  - especially: Conjunction < Disjunction

- This was seen as a very basic conclusion about learning
- But: it assumed that "concepts" were defined logically.

Classical vs. modern views of categories

- In the classical view, categories have definitions

  A bachelor is an unmarried adult male person

  A triangle is a 3-sided geometric figure

- A definition lists necessary and sufficient features

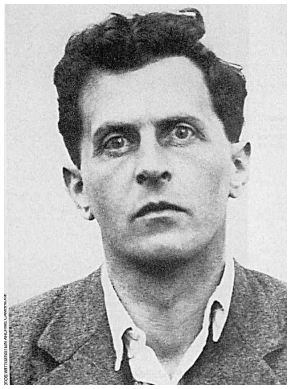
  Being unmarried is necessary, but not sufficient

  All 4 features are jointly sufficient.

- Classical categories have clear-cut boundaries

  Objects are either members or non-members of the category

Fuzziness and family resemblance



Ludwig Wittgenstein

- Most mental categories have “fuzzy” boundaries

  Objects within them have a family resemblance but no clear definition

- Examples:

  game

  furniture

  bachelor (?)

  even number (?)

Prototypes

- Posner & Keele (1968) taught subjects artificial categories by providing examples with various degrees of distortion.

  - Subjects induce a "prototype"—a characteristic "normal" form

  - … even when highly typical examples were withheld (called prototypification).

- Eleanor Rosch (1973) studied color concepts in Dani people in Indonesia and concluded that concepts have "natural" central tendencies

  - Subjects had more trouble remembering atypical examples

The prototype view

- The "prototype" (aka fuzzy, aka family-resemblance) view of human concepts:

  Mental concepts exhibit degrees of membership, called typicality

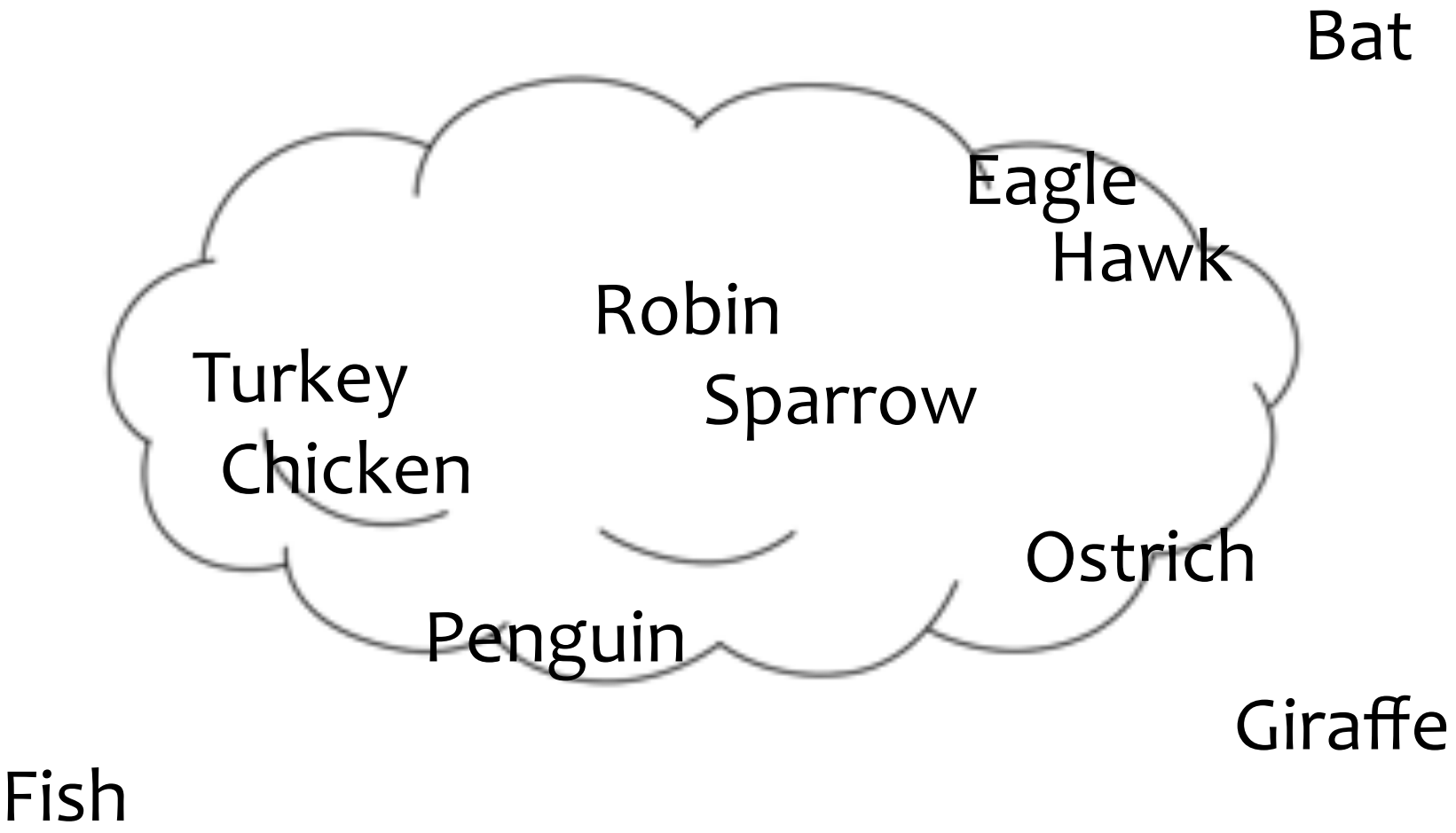
  ... and are defined by their central tendencies, called prototypes.

- e.g. Birds usually have feathers, fly, lay eggs, sing, make nests, live in trees, ...

  but none of these features are necessary or sufficient

- Category membership is determined by similarity to the prototype

Example: the bird category



Even definitional categories act fuzzy

- Armstrong, Gleitman & Gleitman (1983) tested very "definitional" categories like *odd number*, *female*, *grandmother*

  - Measured typicality ratings, RT to classify

- They found that even these concepts behave like fuzzy categories
- They argue however that definitions must be part of the meaning of certain concepts
- Instead they propose distinguishing between core meaning and identification procedures

Prototype

small furry
animal
long bushy tail,
eats nuts,...

Similarity comparison