A simple story....

Mary heard the ice-cream man coming.

She remembered her pocket money.

She rushed into the house.

Questions

- *What is an "ice-cream man" and why does he make noise?*
- *Why does she think of money?*
- *Why does she go into the house?*
- *Why does she rush?*
- *How old is she?*

Can constraint satisfaction support structured thought?

Useful properties

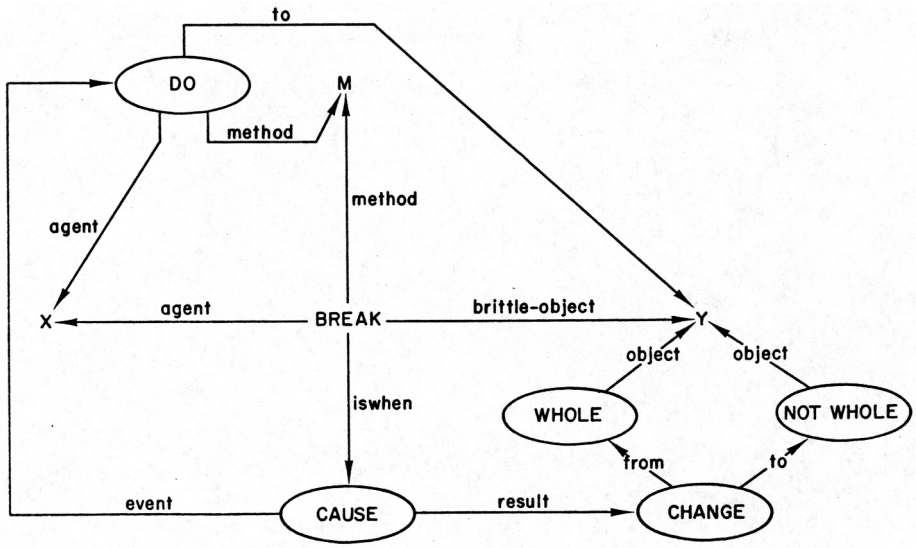
- content addressibility (by name and by partial content)
- default assignments
- graceful degredation (noisy cues, removal of weights)
- spontaneous generalization

Can relationships and constraints among different types of information really be reduced to pairwise interactions among simple features/descriptors?

Schemas: data structures for representing generic concepts in memory

- objects, situations, events, actions, sequences of events/actions...

To break


to
DO
M
method
agent
method
X
agent
BREAK
brittle-object
Y
object
object
iswhen
WHOLE
NOT WHOLE
from
to
event
CAUSE
result
CHANGE

Schemas: Essential properties

Schemas have *variables*

- Slots have restrictions (e.g., AGENT must be animate)
- Default values (values in absence of more specific information)
  - But must be context-sensitive (agent in breaking window vs. bubble)

Schemas can *embed*

- BREAK contains DO and CAUSE
- Not always simpler (e.g., room with picture of room)

Schemas range across levels of abstraction

- Original focus on lexical level (like GIVE, BREAK)
- Also indended to span larger "events" (e.g., restaurant "script")

Schemas represent knowledge rather than definitions

- Not "definitional" but what is "normal"

Challenges for traditional theories of schemas

- How to select relevant schemas (best-match problem)
- How to integrate multiple schemas (birthday party in restaurant)
- How to create new schemas
  - Specialize/generalize existing ones? Hybrids?
  - Transition from single instance to "general" knowledge
  - Proliferation makes selection problem more difficult

Schemas in constraint satisfaction networks

- Situations composed of primitive "features"
- A schema consists of knowledge about what features go with other features (i.e. **constraints** between features)
- Certain subpatterns tend to act in concert
  - Support each other and inhibit same sets of other units ("stable coalitions")
- Good interpretations are **goodness maxima / energy minima**
- **No structure corresponds to a schema**
  - more like a description of structured/systematic behavior of system
  - No *selection*: use **all knowledge all the time**

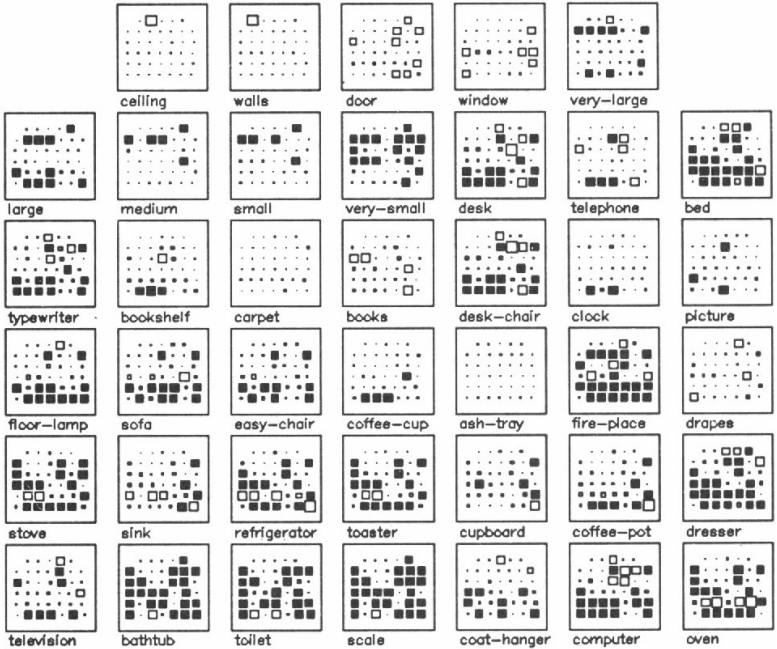
Schema model (Rumelhart et al., 1986)

- Two subjects each imagined 8 different versions of 5 room types
  - kitchen, office, bathroom, bedroom, living room
- For each imagined room, subject decided which of 40 **descriptors** applied to it
  - Network has 40 **units** (one per descriptor); fully connected
- **Weights** set based on the likelihoods, across rooms, that the two descriptors agreed (both on or both off)
- **Biases** set based on likelihoods that each single descriptor was included in a room
- Five room types are **only implicit** in pattern of weights and biases (nothing explicit)

ceiling	walls	door	windows	very-large
large	medium	small	very-small	desk
telephone	bed	typewriter	bookshelf	carpet
books	desk-chair	clock	picture	floor-lamp
sofa	easy-chair	coffee-cup	ashtray	fireplace
drapes	stove	coffeepot	refrigerator	toaster
cupboard	sink	dresser	television	bathtub
toilet	scale	oven	computer	clothes-hanger

$$w_{ij} = -\ln \frac{p(x_i = 0 \;\&\; x_j = 1)p(x_i = 1 \;\&\; x_j = 0)}{p(x_i = 1 \;\&\; x_j = 1)p(x_i = 0 \;\&\; x_j = 0)}$$

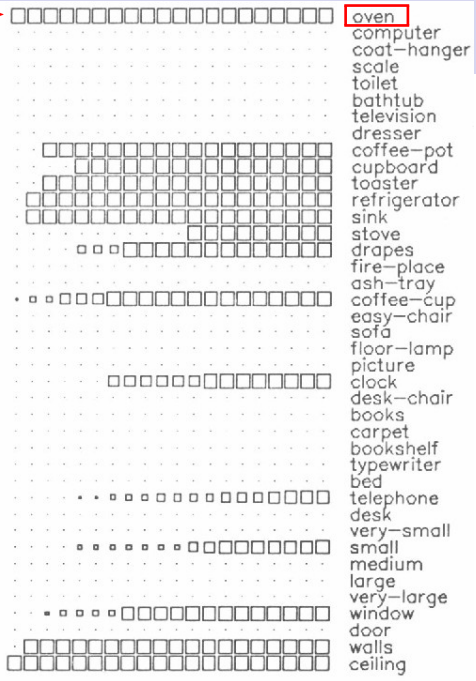
$$bias_i = -\ln \frac{p(x_i = 0)}{p(x_i = 1)}$$



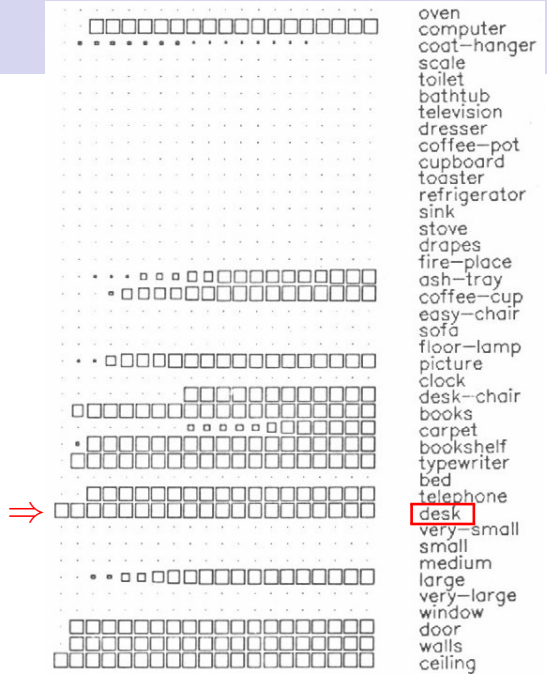
- Each large square is a unit whose incoming weights (white = positive; black = negative) are displayed inside it
- Internal position of each incoming weight corresponds to the sending unit's position in large display

Kitchen

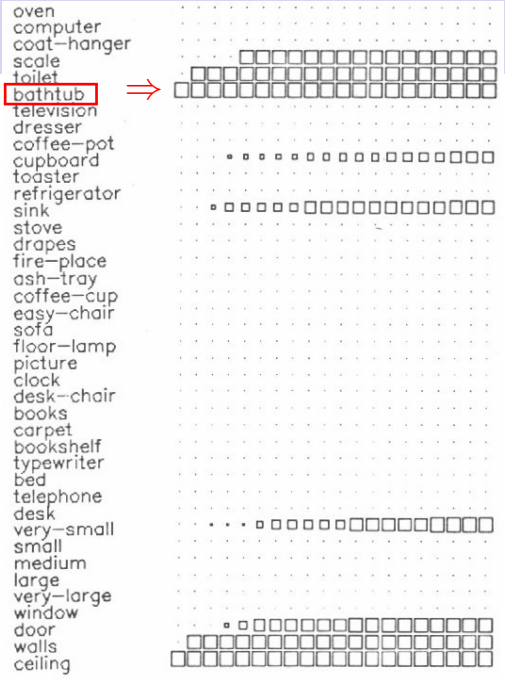
- Clamp on “oven” unit, run network (“Imagine a room with an oven; what else is in it?”)
- Final pattern called “kitchen” prototype (although nothing explicit about a kitchen per se was involved)



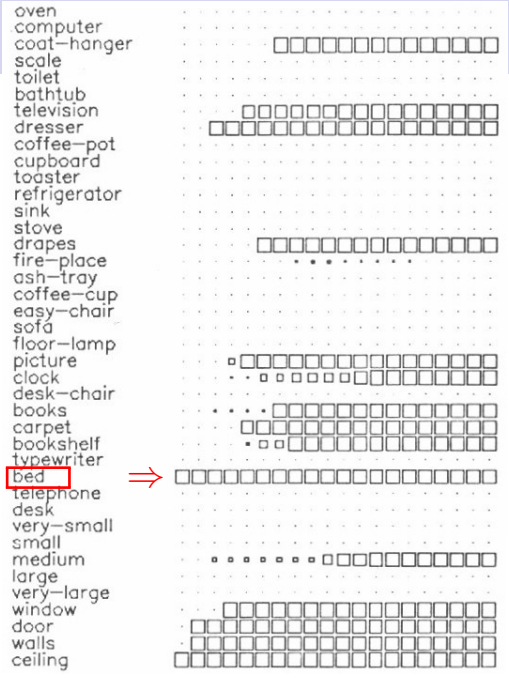
Office


oven
computer
coat–hanger
scale
toilet
bathtub
television
dresser
coffee–pot
cupboard
toaster
refrigerator
sink
stove
drapes
fire–place
ash–tray
coffee–cup
easy–chair
sofa
floor–lamp
picture
clock
desk–chair
books
carpet
bookshelf
typewriter
bed
telephone
desk
very–small
small
medium
large
very–large
window
door
walls
ceiling

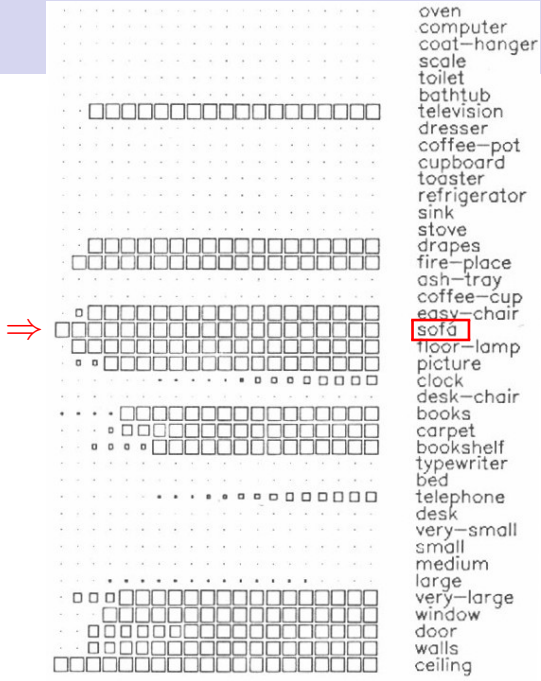
Bathroom


oven
computer
coat–hanger
scale
toilet
bathtub
television
dresser
coffee–pot
cupboard
toaster
refrigerator
sink
stove
drapes
fire–place
ash–tray
coffee–cup
easy–chair
sofa
floor–lamp
picture
clock
desk–chair
books
carpet
bookshelf
typewriter
bed
telephone
desk
very–small
small
medium
large
very–large
window
door
walls
ceiling

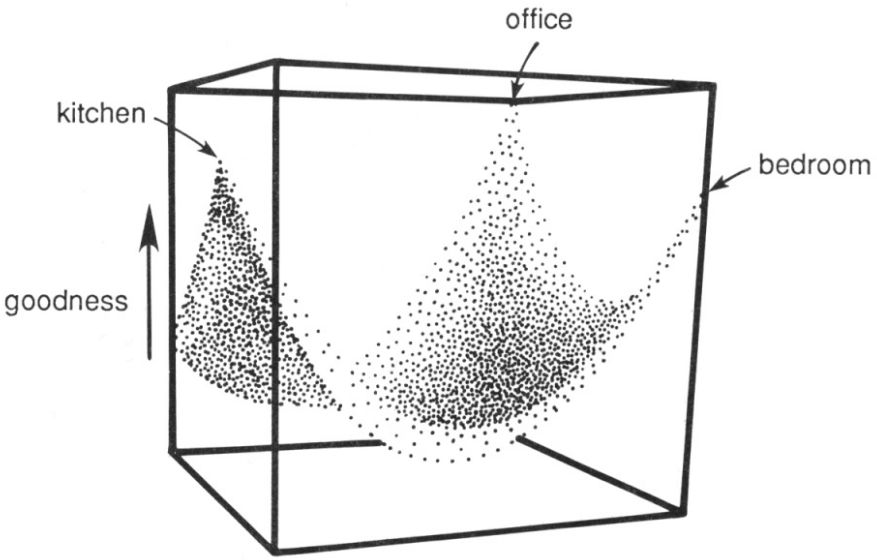
Bedroom


oven
computer
coat–hanger
scale
toilet
bathtub
television
dresser
coffee–pot
cupboard
toaster
refrigerator
sink
stove
drapes
fire–place
ash–tray
coffee–cup
easy–chair
sofa
floor–lamp
picture
clock
desk–chair
books
carpet
bookshelf
typewriter
bed
telephone
desk
very–small
small
medium
large
very–large
window
door
walls
ceiling

Living room

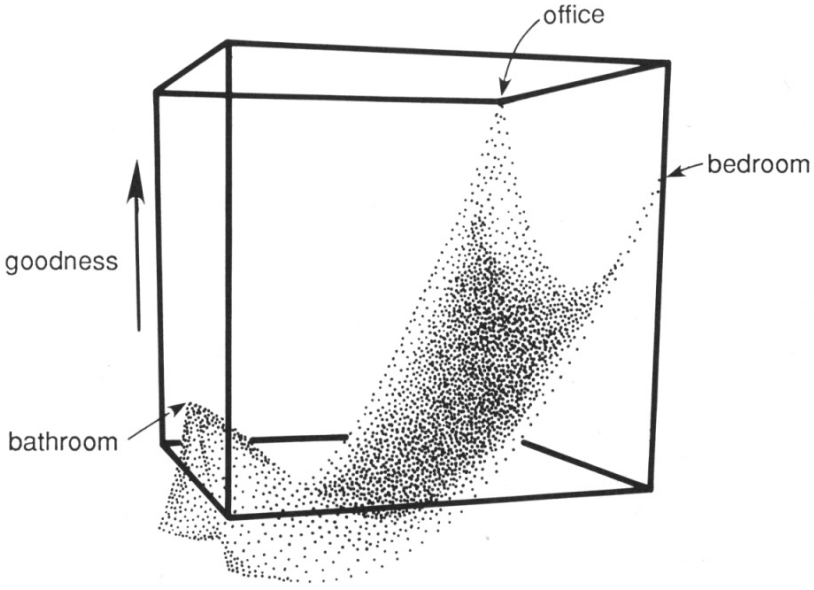

oven
computer
coat–hanger
scale
toilet
bathtub
television
dresser
coffee–pot
cupboard
toaster
refrigerator
sink
stove
drapes
fire–place
ash–tray
coffee–cup
easy–chair
sofa
floor–lamp
picture
clock
desk–chair
books
carpet
bookshelf
typewriter
bed
telephone
desk
very–small
small
medium
large
very–large
window
door
walls
ceiling

Goodness surface: Kitchen, Office, Bedroom

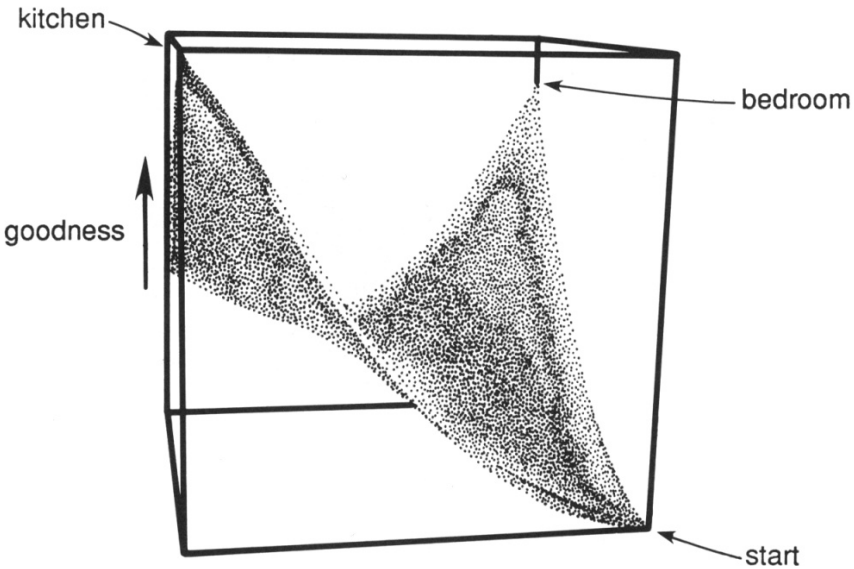


- State space (bottom of cube) is interpolation within the unique plane determined by three points (kitchen, office, and bedroom prototypes)
- Goodness surface is plotted over this subset of state space

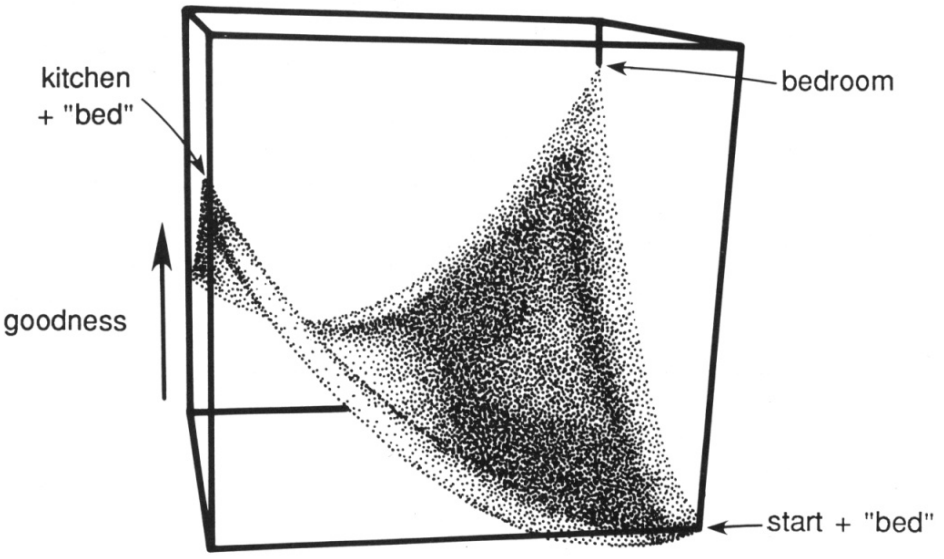
Goodness surface: Bathroom, Office, Bedroom



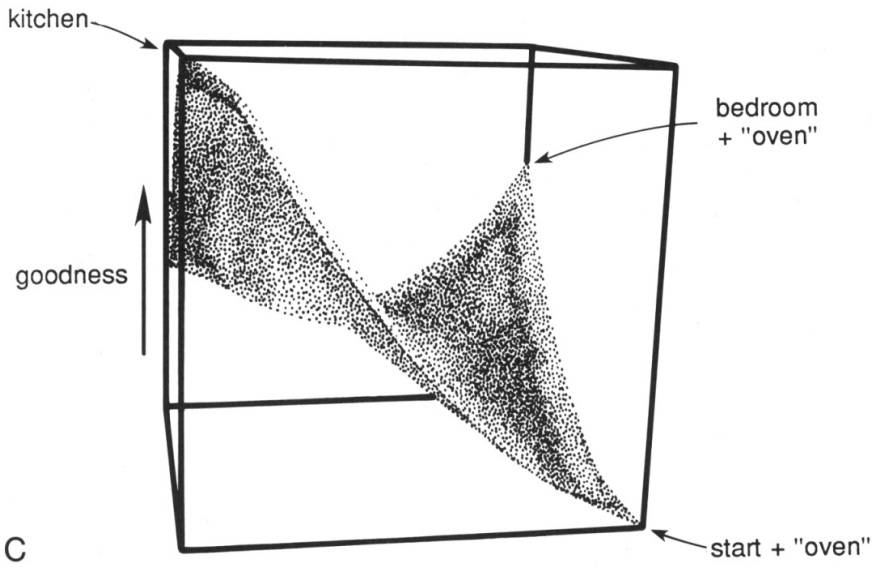
Goodness surface: Kitchen, Bedroom, (start)



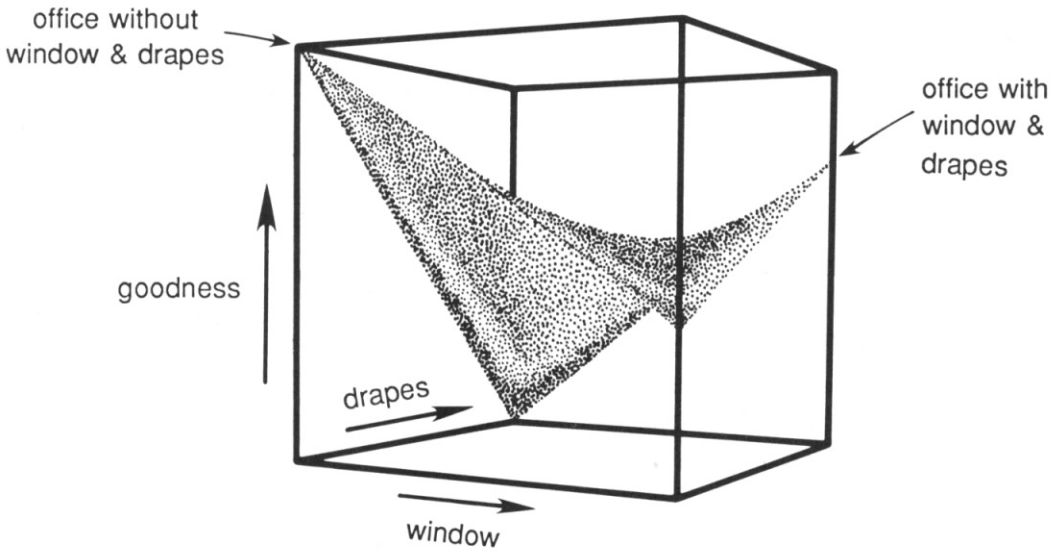
Goodness surface: Kitchen+"bed", Bedroom



Goodness surface: Kitchen, Bedroom+ “oven”



Schema embedding



Schemas: Essential properties

Schemas have *variables*

- Slots have restrictions (e.g., AGENT must be animate)
- Default values (values in absence of more specific information)
  - But must be context-sensitive (agent in breaking window vs. bubble)

Schemas can *embed*

- BREAK contains DO and CAUSE
- Not always simpler (e.g., room with picture of room)

Schemas range across levels of abstraction

- Original focus on lexical level (like GIVE, BREAK)
- Also indended to span larger "events" (e.g., restaurant "script")

Schemas represent knowledge rather than definitions

- Not "definitional" but what is "normal"

Challenges for traditional theories of schemas

- How to select relevant schemas (best-match problem)
- How to integrate multiple schemas (birthday party in restaurant)
- How to create new schemas
  - Specialize/generalize existing ones? Hybrids?
  - Transition from single instance to "general" knowledge
  - Proliferation makes selection problem more difficult