Lec 2

Using Space

Cogs 102A * Distributed Cognition

Ecological Perception

- A systems model that asks:
  How does the human/world system accomplish perception?
- Assumes evolved perceptual systems enable perceivers to navigate through, and manipulate, their environments.
- Operation of systems generate "**Invariants**" = regularities that emerge whenever a human engages its visible space
- Since natural function is of primary concern, both theory & method aim to maximize "**Ecological Validity**" of research
  - The world is a cluttered, dynamic place and perceivers often move themselves, so this is what we should study

Ecological Perception

J.J. Gibson: "Ecological Perception"

Perception as the interaction

between an

active perceiver

and its environment

Ecological Perception

Gibson commissioned to research how to design realistic simulators to train WWII Navy pilots

Contemporary research done in complex, real-world environments, w/subjects solving real-world problems

- PROBLEM:
- How does an observer get from here to there?
- How does it perceive its speed and direction of movement?

- SOLUTION:
- Focus on destination point and move such that the

Optic Flow pattern symmetrically expands from that point.

Optic Flow =

when observer moves, environment streams to or from "Focus of Expansion" (FOE)

- Only FOE (subject's focal point in env, towards which it is moving) is stationary
- Rest of visual environment expands as you move forward (toward FOE)
- Similarly, visual environment contracts as you move backward (from FOE)

FIGURE 8.49 The flow of the environment as seen from a car speeding across a bridge toward point A. The flow, shown by the arrows, is more rapid closer to the car (as indicated by the increased blur) but occurs everywhere except A, the focus of expansion, toward which the car is moving. (Also see Figure 8.48a)

Optic Flow =

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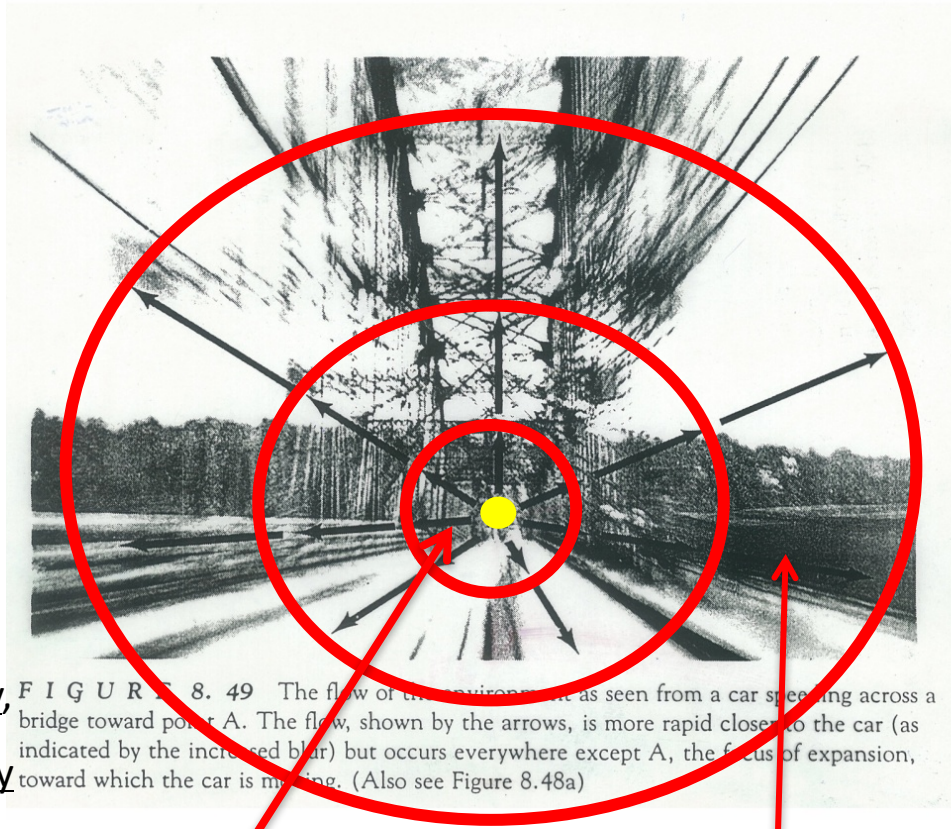
- Only FOE (subject's focal point in env, towards which it is moving) is stationary
- Rest of visual environment expands as you move forward (toward FOE)
- Similarly, visual environment contracts as you move backward (from FOE)
- The **acceleration** of expansion/contraction is directly dependent on mover's velocity
  - Points closer to FOE will move more slowly,
  - Points farther from FOE move more quickly



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These points move slowly

These points move quickly

So, it is these regularities of relationship between rate of expansion/contraction and direction & velocity of movement that are the **invariants** in this activity.

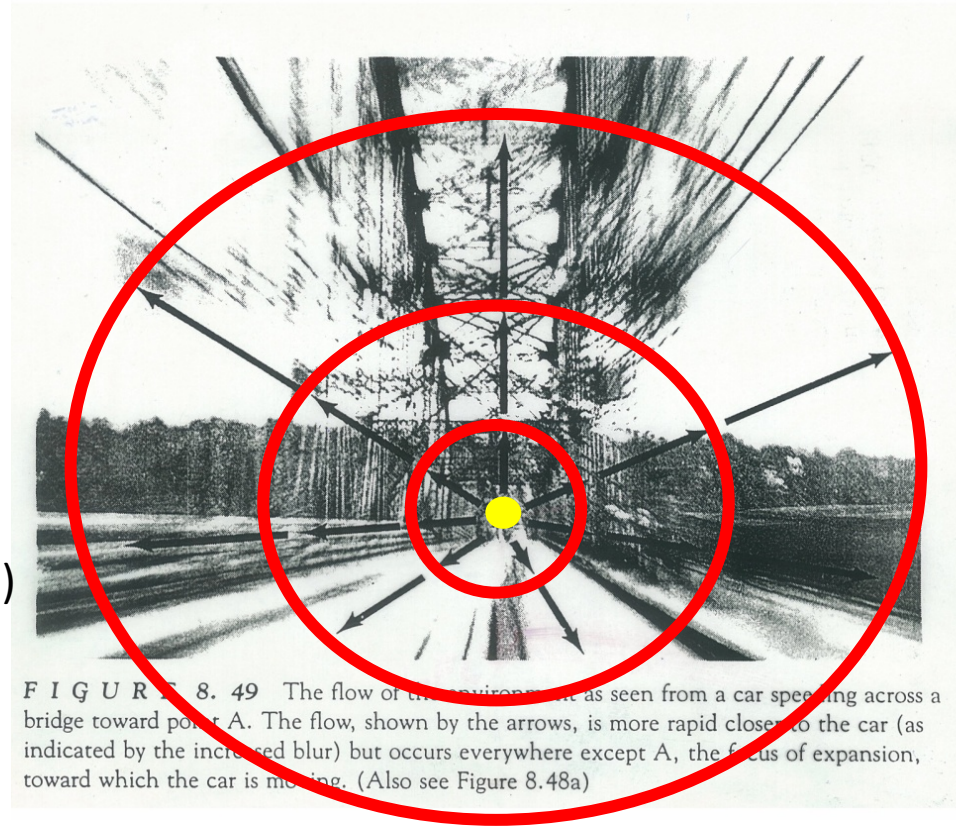
Optic Flow Function

- Thus, if focus on destination (FOE) & move so that Optic Flow <u>symmetrically</u> expands . . .

- 1) Works to get you there

- 2) Enables you to perceive your relative distance from all points (based on their relative rates of expansion)

- 3) Enables you to perceive your own velocity (since expansion rates are a function of this)



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- PROBLEM:
- How do you keep from running into things?
- How do you catch or dodge something coming at you?

- SOLUTION:
- Adjust trajectory (or reach/grasp) according to the

Rate of Angular Expansion (“Tau”) of the object.

Rate of Angular Expansion

When an object moves directly at you, or you directly toward it, at a given velocity, its rate of change is an **Invariant**

Rate of Angular Expansion

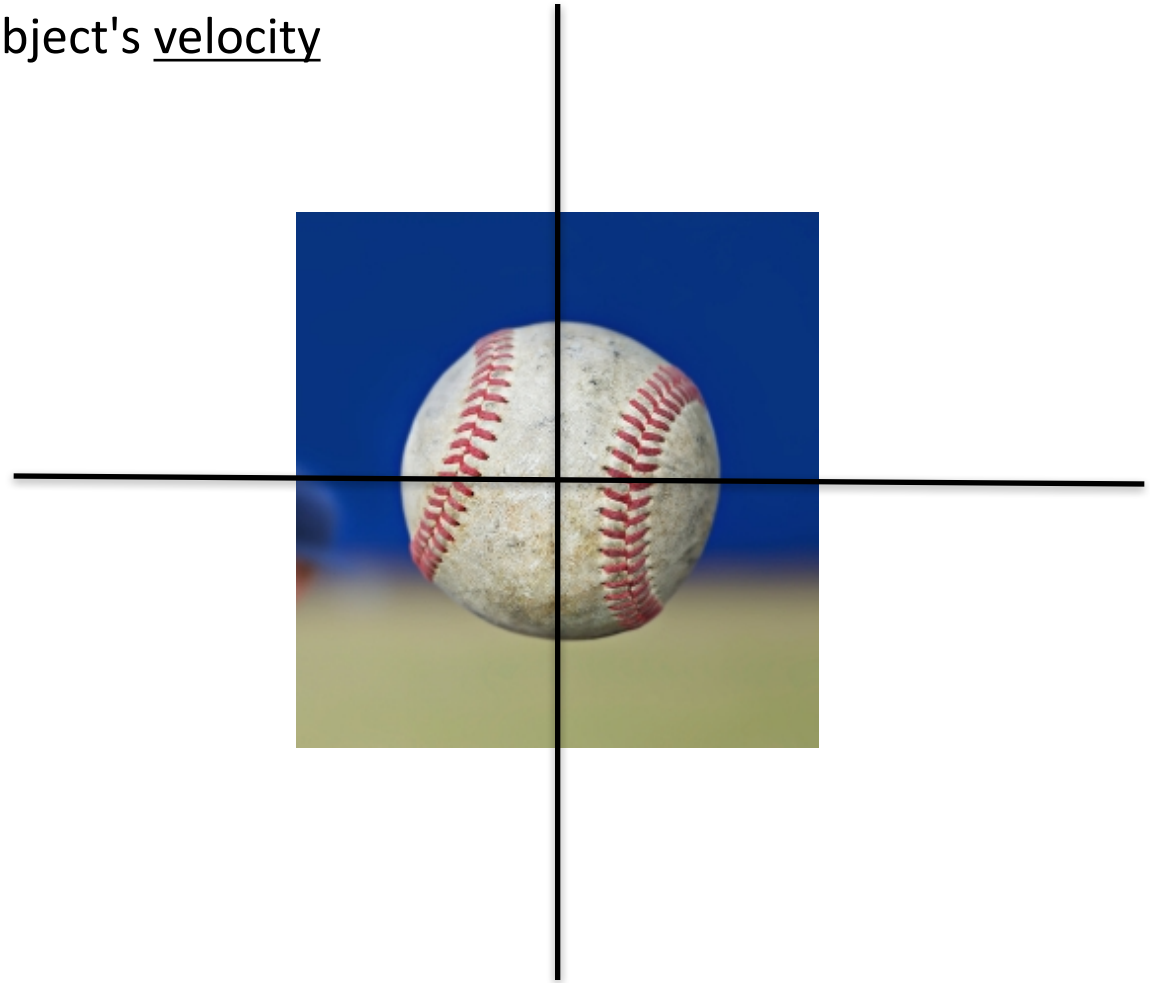
Object expands at an accelerating rate at it approaches you

Rate of Angular Expansion

Object expands at an accelerating rate at it approaches you, contracts at a decelerated rate as it moves away

Angular Expansion – "Tau"

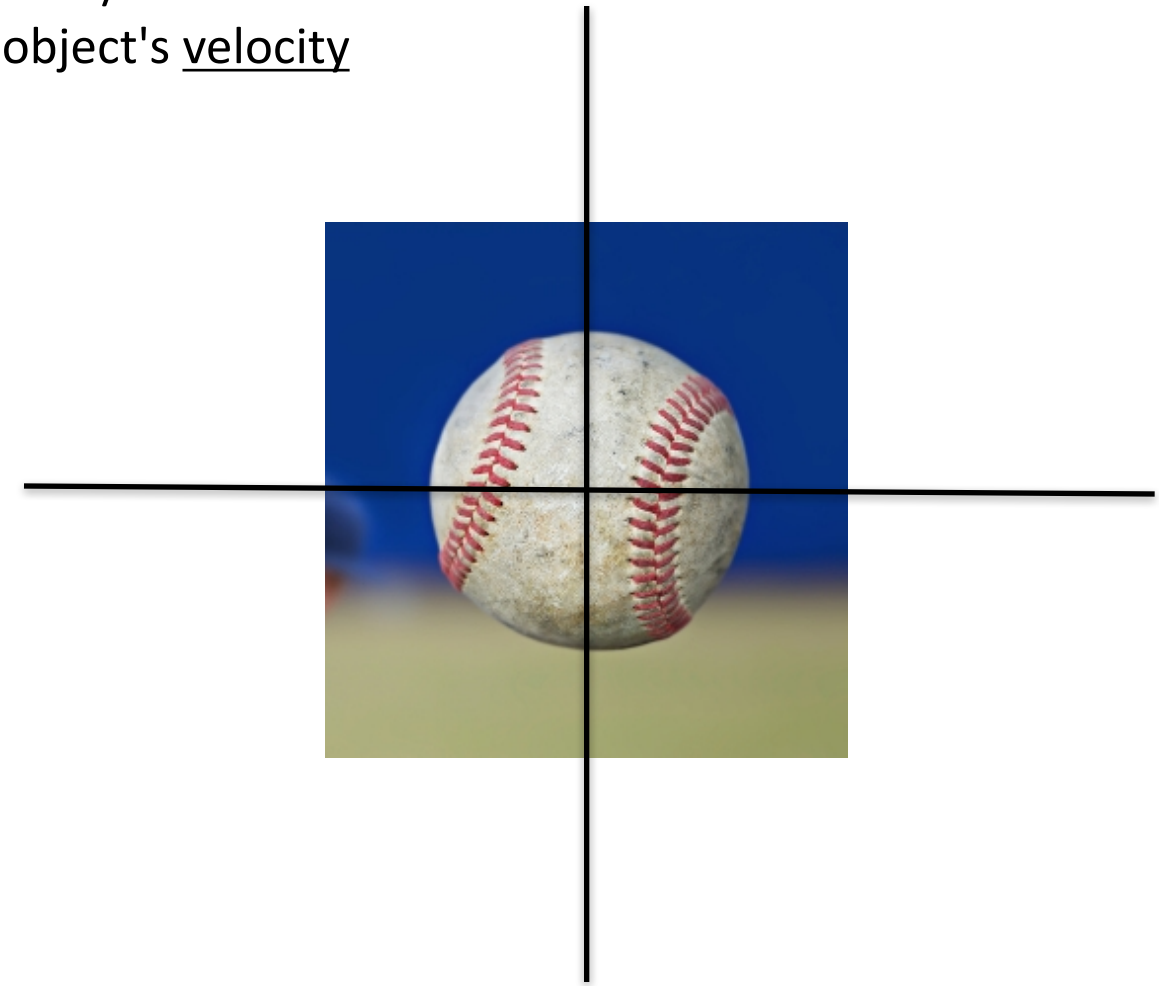
Rate of expansion/contraction
depends on object's velocity



Plus, if object is moving directly to/from you,
its apparent expansion/contraction will be symmetrical

Angular Expansion – "Tau"

Rate of expansion/contraction
depends on object's velocity



But, if object is NOT moving directly to/from you,
its apparent expansion/contraction will be asymmetrical

- PROBLEM:
- How do you determine the relative location
  (to you, to each other) of 2 objects
  as you (or they) move?

- SOLUTION:
- Observe invariant patterns in **“Kinetic Occlusion”**
  (AKA “Accretion/Deletion”)

Kinetic Occlusion

(AKA "Accretion/Deletion")

Object that deletes (occludes) another is moving in front of it,
OR is positioned between you and it as *you* move

Object that shows accretion (becomes more and more visible as other moves)
is revealed as behind other

Kinetic Occlusion

(AKA "Accretion/Deletion")

At a given velocity,
objects closer together change in deletion/accretion more slowly
than objects farther apart

- PROBLEM:
- How determine the relative size and location of 2 objects when all you can move are your eyes?

- SOLUTION:
- Observe relative frequency of the **"Texture Gradient"** on the substrate that they occlude (hide).

Texture Gradients

All substrates, natural or man-made, are perceived as
a repeating pattern that increases in frequency as it recedes

Man-made

Natural

Texture Gradient

"Frequency" = # of CYCLES of texture per degree of Visual Arc

Man-made

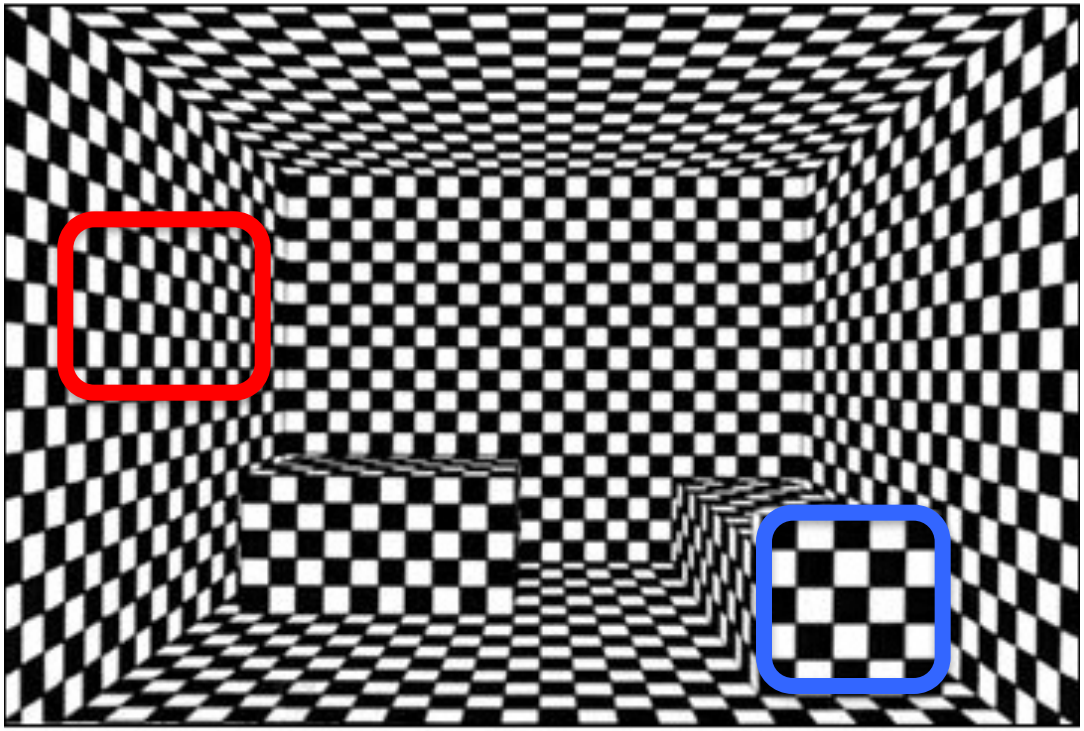
Natural

Invariant: Gradients become higher in frequency
as observer's focus moves farther away (lower freq as moves closer)

Texture Gradient

This invariant allows us to judge distance & size

Change in Frequency = Change in Distance

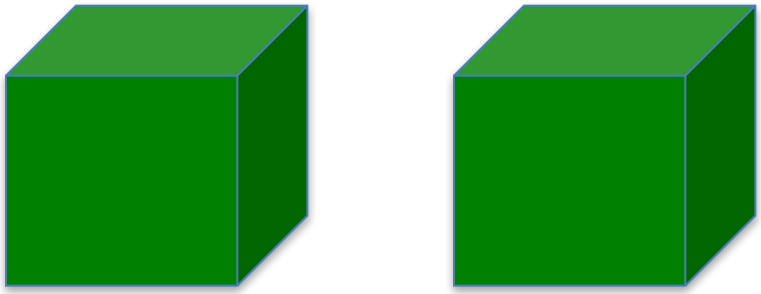


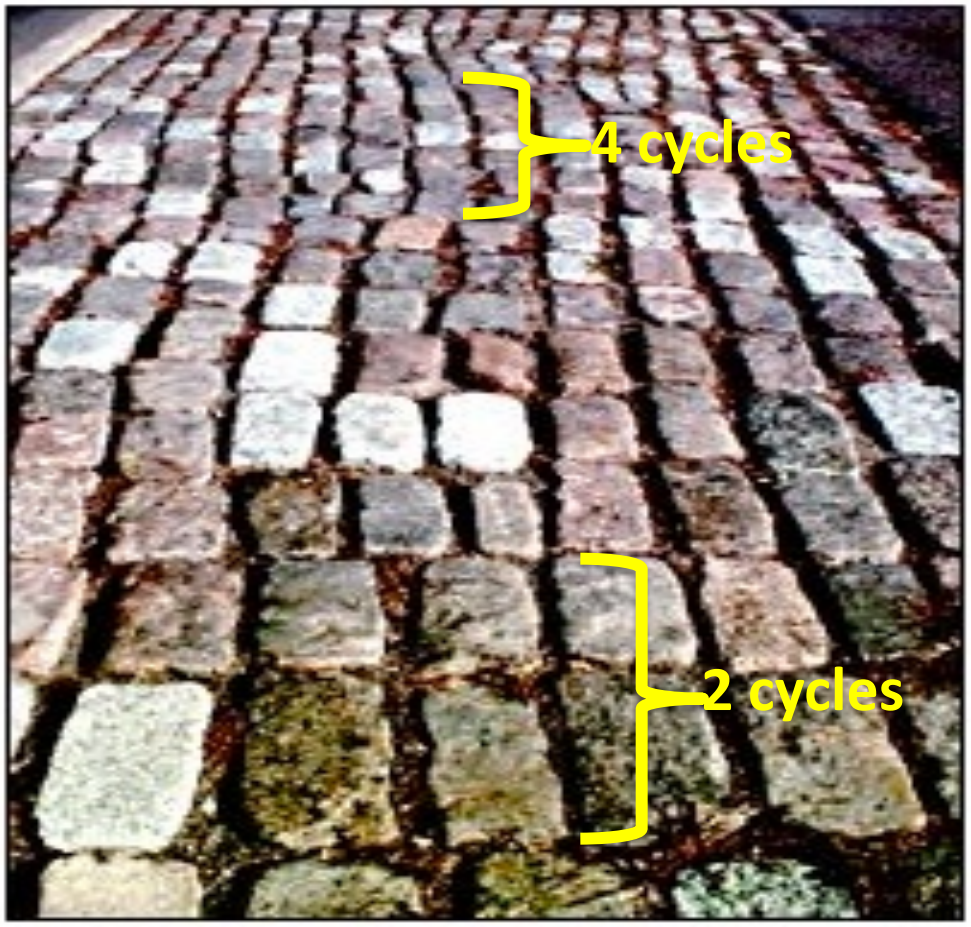
No Change in Frequency = No Change in Distance

Invariant: Gradients become higher in frequency as observer's focus moves farther away (lower freq as moves closer)

Texture Gradient

If objects A and B are the same size, if A occludes a higher freq gradient than object B does, object A must be farther away than object B





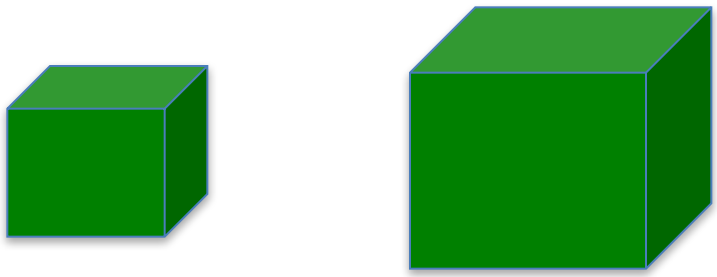
Texture Gradient

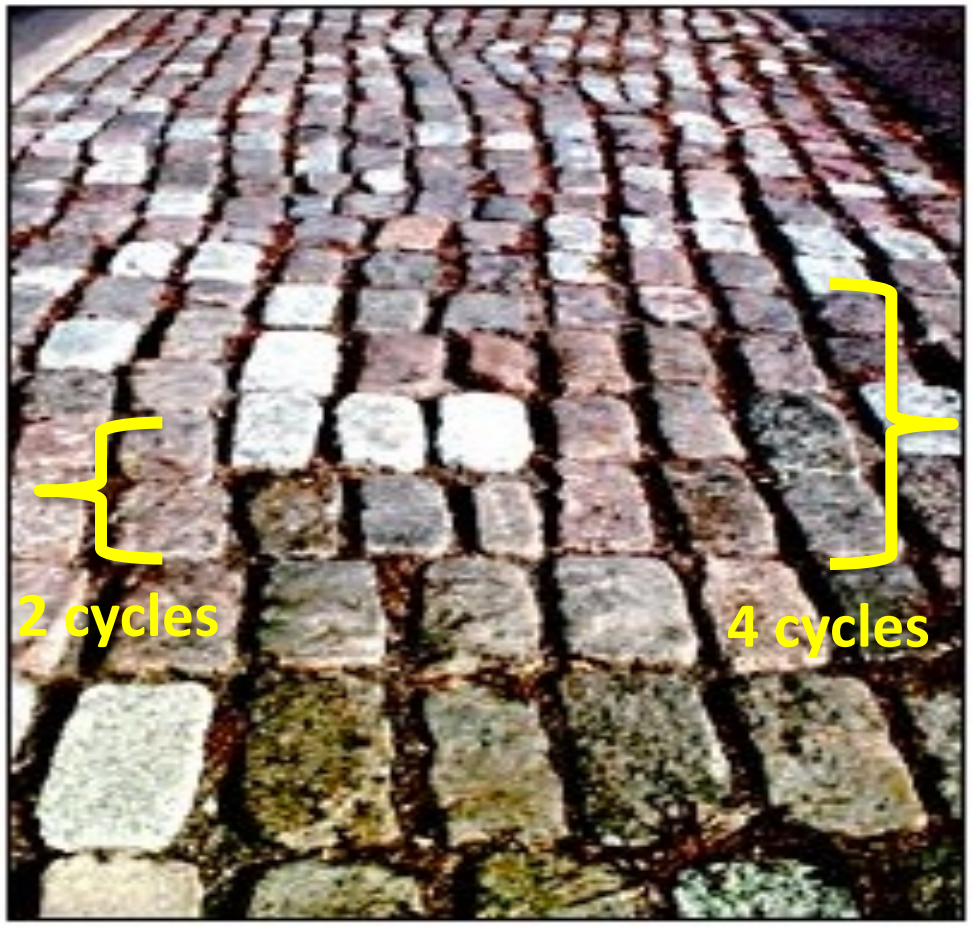
If objects differ in size,

at the same distance,

the one that occludes

more cycles will be perceived as larger





Texture Gradient

- Note: Typically, large/close objects LOOM = take up more of visual field, but above factors can take priority (see LAB 2!)

- So, size and distance are **co-constraining factors** in this system
  - (e.g. As you may know, see... *Emmert's Law* Sp=Sr X Dp)

Texture Gradient

We can be *fooled* into seeing space that isn't there, misjudging size, etc. by artists who exploit these invariants

Texture Gradient

We can be *fooled* into seeing space that isn't there, misjudging size, etc. by artists who exploit these invariants

Plus

Motion Parallax

Invariants = Regularities in how objects in env move relative to one another given perceiver's position, movement & focus

See LAB 2!

Given how fundamental

– i.e. predisposed, well-practiced, vital to accomplishment –

spatial cognition is,

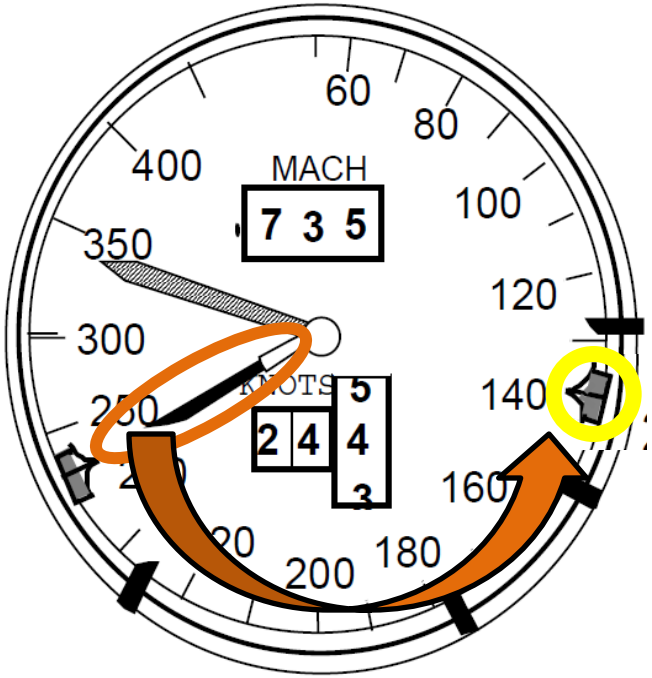
it is not surprising how often we exploit it's regularities to

make other cognitive tasks easier…

Spatial vs. Symbolic Processing

Shift from symbolic to spatial processing

- e.g. See Speed Bug from Lecture 1
  - Pilots shift from using numbers to judging spatial distance from needle on dial to “Speed Bug” marker

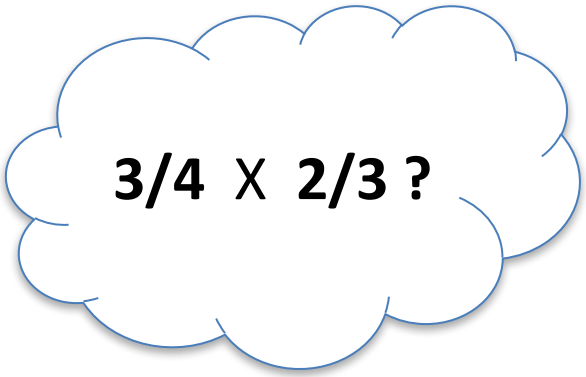


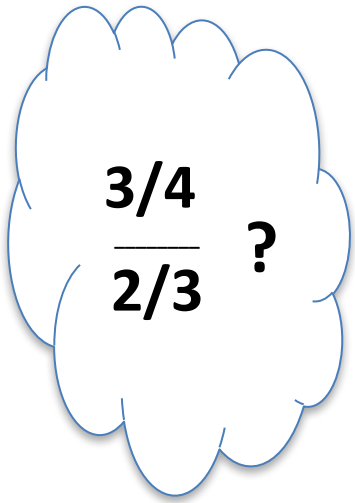
Track spatial juxtaposition of needle and “bug”

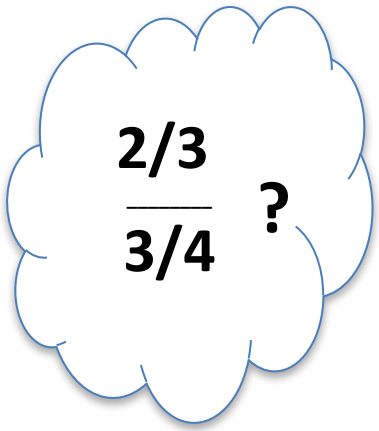
Spatial vs. Symbolic Processing

Avoiding abstract, symbolic procedures

- e.g. Lave 1994
  - Asked to provide "3/4 of normal daily allowance of 2/3 cup of cottage cheese"
  - Cook first mumbles about having taken "calculus in college"...

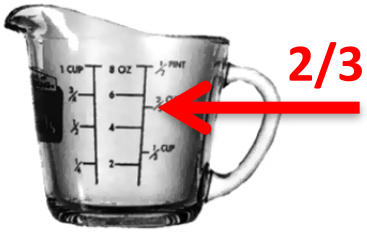


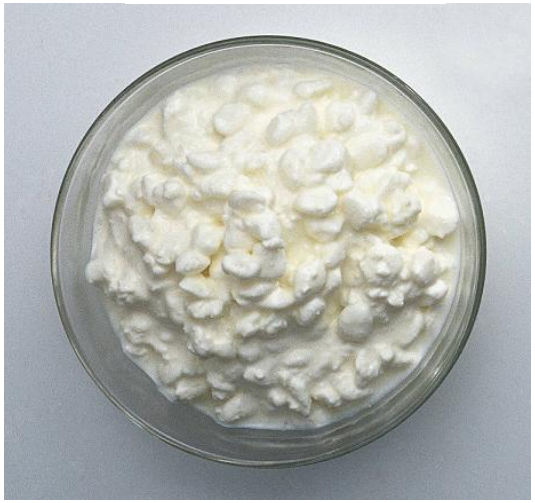




Spatial vs. Symbolic Processing

How much is 3/4 of daily allotment of 2/3 cup?



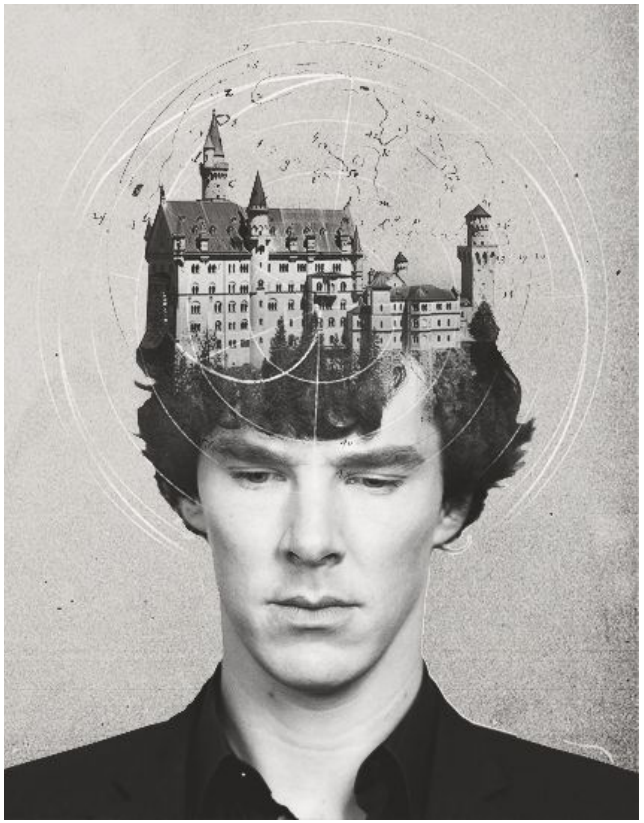


Voila!

Spatial Associations

Memory Palace

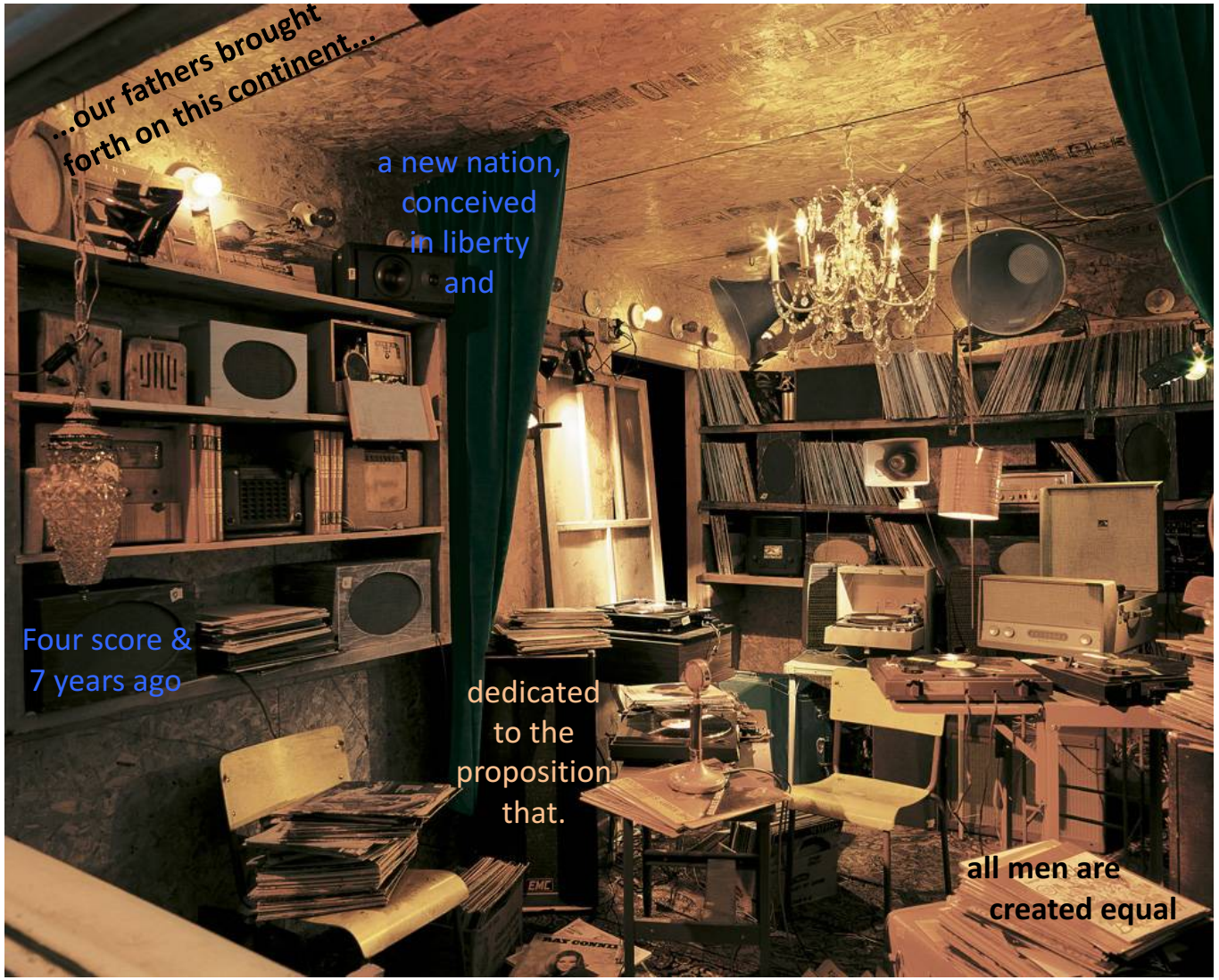
- Use spatial simulation of a "Memory Palace" as mnemonic device
  - Easier to remember items associated with distinct, known locations



- "Method of Loci" – First described by Greek philosophers, 500 BC

Spatial Associations

Memory Palace



Spatial Associations

Chunking

- Group subsets > fewer items to remember

CIAFBINCISDOD

vs.

CIA FBI NCIS DOD

Spatial Associations

Cache - Put things “in their place”

- e.g. Dishes, towels in different cupboards
- Especially with similar things
- Easier to find when needed

- Organization then shapes behavior
  - Go to “right” place to get

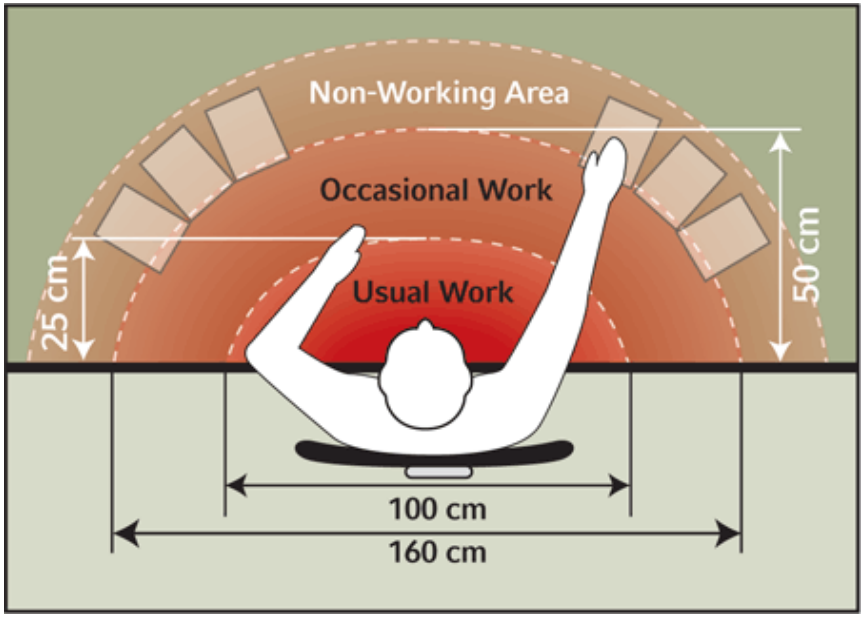
Spatial Associations

Co-Locate with associated structure

- e.g. Clean dishes in drying rack,
  dirty stacked on counter or in sink

Task-Dependent Organization

- Hand-Eye Coordination
  - We learn to diverge and coordinate our modalities of attention
  - See upcoming lecture on TRIADIC DEVELOPMENT



- Primacy of "Praxic Space"
  - Time-lapse reveals area (ventral, medial, head to lap) of most hand activity

Task-Dependent Organization

ACCESS

Within reach

- e.g. Cook brings all ingredients and tools to Workspace ("**Praxic**" space)
  - Allows easy, efficient access, in sometimes time-sensitive procedures

Task-Dependent Organization

ACCESS

Re-Orient for better (safer) access

- e.g. Turn handles of cooking pots toward (cooler) edges of stove so won't get too hot to handle

Task-Dependent Organization

ACCESS

Locate tools <u>where activity occurs</u> for ease of access

- e.g. Keys near door, since need when leaving house

Task-Dependent Organization

ACCESS

Locate objects where activity occurs for ease of access

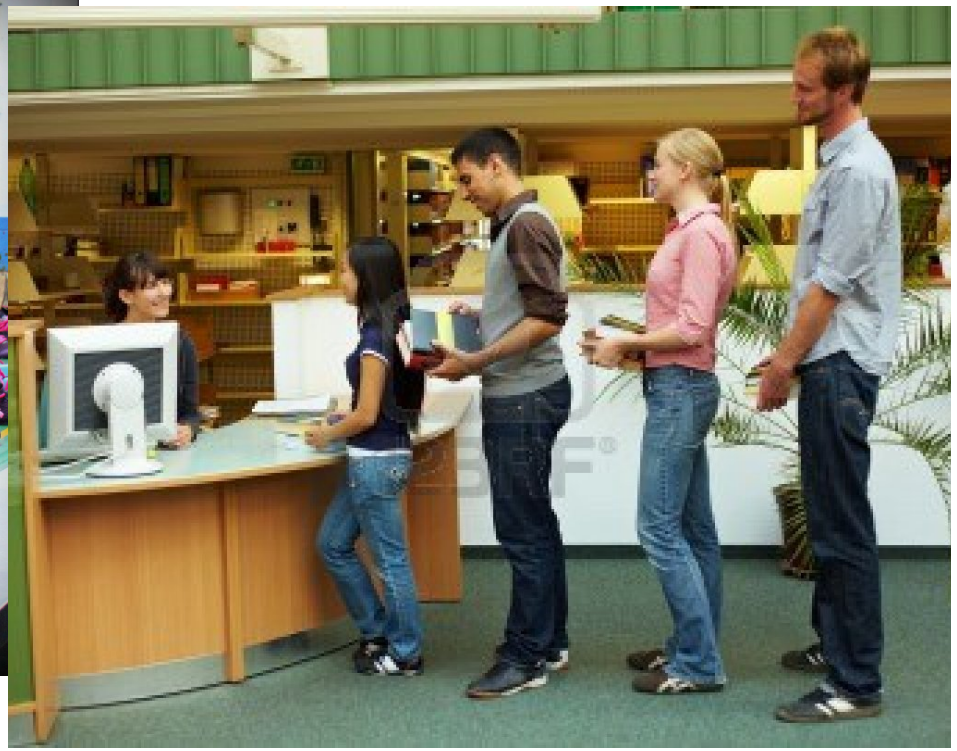
- e.g. Production line w/bins of parts

Task-Dependent Organization

ORDER

Arrange access based on ORDER elements will be used

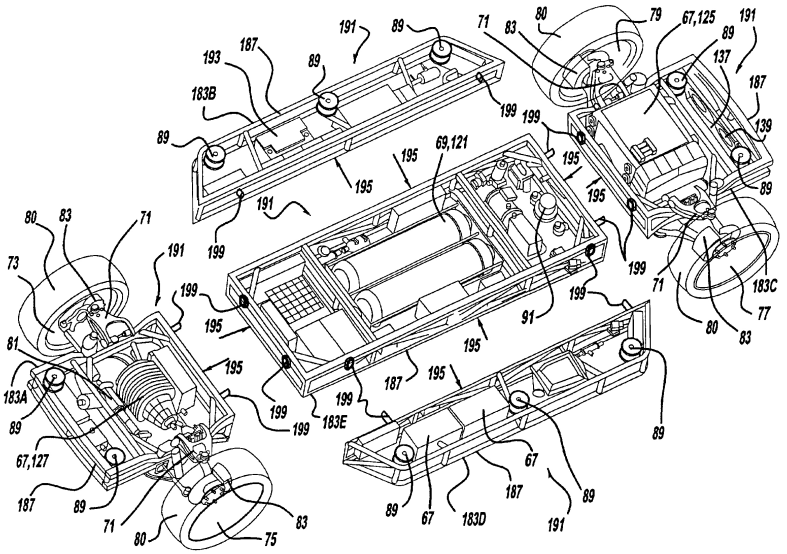
- e.g. Put objects **in a line**, in the **order** they are needed
  - Next is easiest to reach, Looms as approach



Task-Dependent Organization
ORDER

- Note tradeoff during <u>assembly</u>
  - Can lay out <u>in order</u> **or** for <u>location used</u>, but not both…

...unless additional info provided



Task-Dependent Organization

ORDER

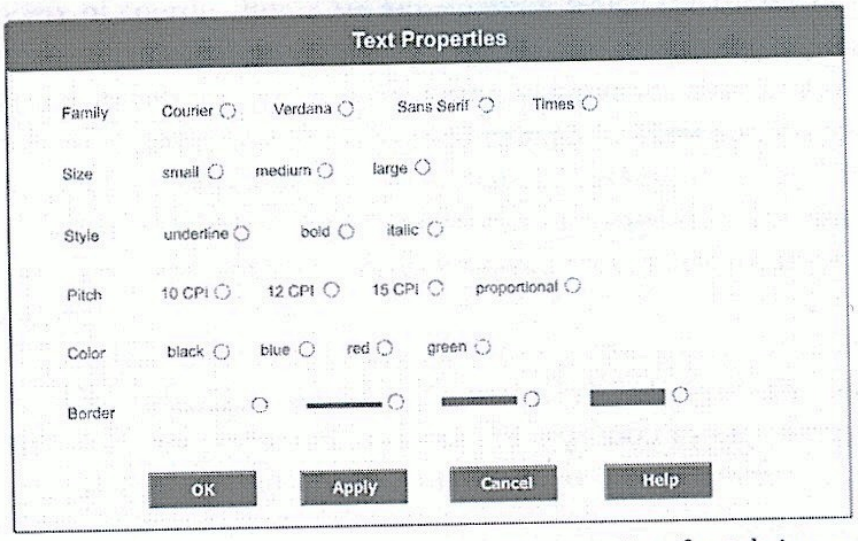
Co-Locate with associated structure

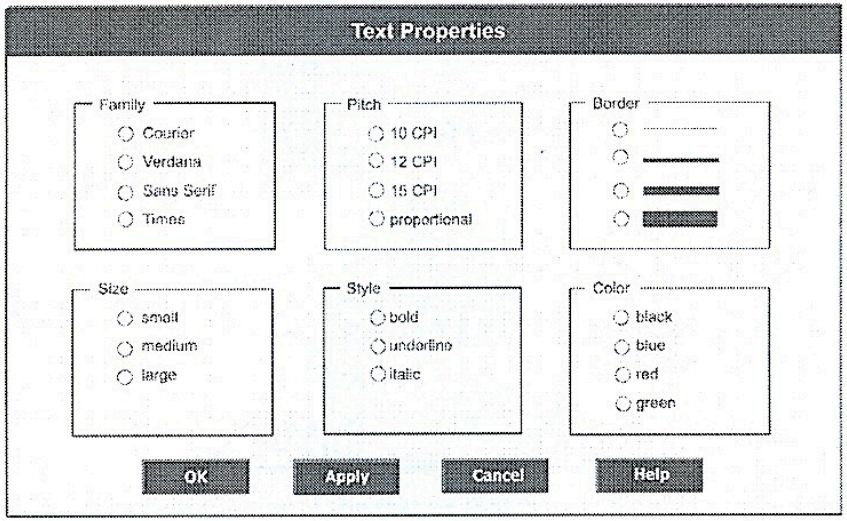
- e.g. Bagger separates items by size, weight, fragility to organize effective bagging

Task-Dependent Organization

ORDER

- e.g. **Hierarchical sorting** allows search to be…
  - Limited to one level at a time
  - Directed to relevant details



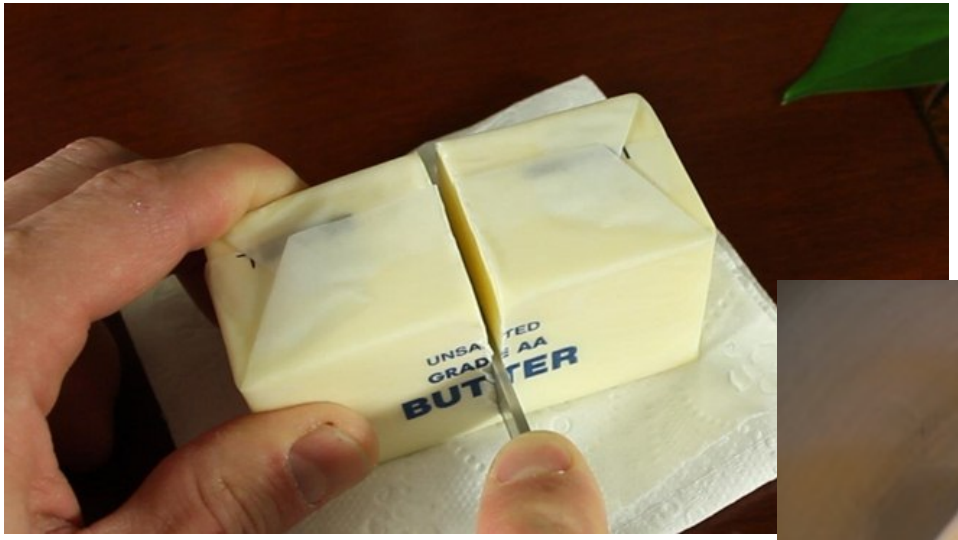


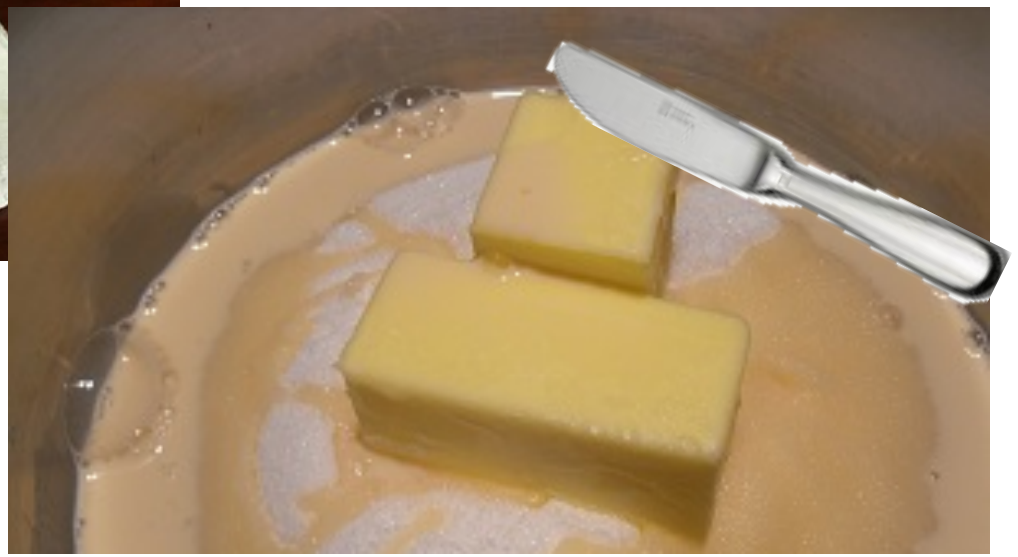
Task-Dependent Organization

MARKING

Co-Locate with associated structure to inform

- e.g. Once measure & cut butter, lay knife on cut section to ID, later, which was measured part





Task-Dependent Organization

MARKING

Can also use space to mark <u>what NOT to do</u>

- e.g. At a set table, do not do homework
- e.g. Workers lay rag across hot handles: *Beware!*

Spatial Associations

*Un*usual placement

- e.g. Pill bottle on keyboard
- Especially in commonly engaged location
- *Surprise* marks as “special”, noteworthy
  - Increases ”**Salience**"
  - Likeliness of being noticed

To the trees!