

## Lec 3: Cognitive Artifacts & Epistemic Practice

Kirsh (1995, 2006) suggests two types of practice make tasks easier:

- "Pragmatic Acts" change the world in a way that makes a task **physically easier** (reduce energetic costs)
- "Epistemic Acts" changing the world in a way that makes a task **cognitively easier**
  - Actions that **re-present the problem** in such a way as to help make the solution more obvious
  - These acts involve **manipulating information** such that perceptual or computational processes are easier
  - Some informational problems involve Perception (see last lecture)
  - Cognitive solutions often involve reducing the degrees of freedom = fewer options at each choice point
- e.g. *TETRIS* - arcade game, manipulate block-objects ("Zoids") to fit them together, cover max area
  - As Zoids appear, use Rotate, Translate, Drop-Into-Place, to position them optimally w/others
  - Experts especially will rotate Zoid just to see if it will fit better - an Epistemic Act
  - That is, the cognitive task of determining a fit is easier when Zoid is oriented the way it will be used
- "Epistemic" = "Of or relating to knowledge"
  - e.g. "Epistemic Status" (Expert vs. Novice); (More on these to come!)
  - e.g. "Epistemic Stance" (I act like I know, or don't know);
  - e.g. "Epistemic Engine" (Diff between interlocutors' epistemic status drives conversation, e.g. Ask/Answer)

Today's focus:

- e.g. "Epistemic Advantage" (An environmental change simplifies a cognitive problem);
- e.g. "Epistemic Action" (Action that can provide an epistemic advantage);
- Altho note, sometimes the same act can have BOTH effects!
  - e.g. Paths: Pragmatic advantages: Afford walking by eliminating obstacles
  - Epistemic advantages: Simplifies perception - makes where to walk **salient**

### Costs & Benefits of Doing Cognition

What makes a problem "cognitively easier"?

- Especially when working "under pressure" - e.g. Time constraints, Cognitive load, Unexpected opportunity, etc.,
- Problem can be arranged to improve: Time - Quicker is better - Effort - Less is better - Errors - Fewer is better
  - So, any practices that can accomplish these are Epistemic Acts
- **Speed**: e.g. Mental rotation of TETRIS zoid takes 700-1500 msec; In game, rotation only takes 150 msec
  - So, in-game rotation not only makes problem easier, but is also more efficient
- **Accuracy**: e.g. Look up words in a dictionary; Use easy-to-recall mnemonics to help remember material
- **Precision**: e.g. Use ruler, measuring tape, with standardized markings for precise, conventional assessments of length
- **Simplicity**: e.g. Iteration of simple process easier than multi-step, variable-move, multi-factor process
  - e.g. "Automatic" processes easier than "deliberate" (effortful, planned, "conscious", etc)
- **Cognitive Artifacts** – Any object/practice (such as e.g.s above) used to provide Epistemic advantages
  - *Hutchins (2005)*: Cog Artifacts are "shared transformers of cognitive systems", reconfigure cognitive activity
    - How you restructure (transform) a math problem alters how easy it is to solve
    - Each is a cultural "crystallization of partial solutions to common problems" - such as calculator
  - Include the Objects themselves - Structure constrains pertinent practices, via physical & cultural affordances
  - And Practices - e.g. Tap number, then function, then next number; Plus learn, adapt to Google version, etc
    - These include ephemeral artifacts like words, gestures, & other socio-cultural practices
    - When any of the above are used to make meaning, we call them "Semiotic Resources"
  - But many are "**Material anchors**" (*Hutchins 2005*): durable, constraining
    - From simple tools, to images, to complex technology
    - Their physical presence & features offer advantageous affordances
  - Stable & Shareable
    - Writing, sketch, highlighting, etc. outlast verbalizing or imagining
    - Multiple agents can modify (e.g. preserving record of changes) for future agents' use
    - "Independent" (*Kirsh 2009*) of (possibly absent) creator's point of view
  - Can be physically manipulated
    - Facilitates "**Juxtaposition**"; Alter proximity, configuration; A common problem solving strategy
      - e.g. Much easier to determine if puzzle pieces fit, if you can actually handle them

Task Dependent

Regardless of a tool's design, its epistemic value is always **Task-Dependent**

- e.g. Measuring tape typically affords accurate, consistent measurement
  - But it also affords being used a ribbon to wrap a gift of diet candy
  - This juxtaposition promotes a very different "meaning"!

**So, ANYTHING** can be a cognitive artifact – depends on how the thing is treated!

- e.g. This rock, integrated w/other semiotic resources: assigned names, pointed to, moved in space, etc
  - Note requires cultural practices - deictics, naming, eye contact, etc - to make rock's meaning intelligible
- e.g. How hold, manipulate hammer >> to pound, or to yank, or to measure spans of "about a foot"
  - Note, how hold hammer is a semiotic resource, provides iconicity to help ID activity

**Cognitive Biases** – Facilitate and constrain problem solving

- e.g. Use Space – to simplify choice, organize task, mark out important items, etc. (see last lecture!)
- e.g. Transformations easier via vision than via visualization (e.g. Tetris); Recognition easier than recall
- e.g. Larger size salient, occupy more visual field - e.g. Loom object for infant, Large advertisement or store display
- e.g. We are better at judging length than area, so putting items in a line better for est # than in pile
- e.g. We organize perception per Gestalt relations (Proximity, Similarity, Good Continuation, Common Fate)
- e.g. Iconic representations, that bear a resemblance to their referent, easier to interpret than arbitrary symbolic reps
- e.g. **Functional Fixedness** a common error - previous configuration biases read against new affordances
  - Can help if dismantle previous configuration to "notice" new possibilities -
    - e.g. Candle & Tack Box Problem: Attach a lit candle to a corkboard wall such that it does not drip
    - Minority who solved problem handled the box immediately before their "Aha!" moment

**- Design**

- Human cultural practices shape, and are shaped by, changes in their material (and social) environments
  - **Norman (1994)** - *"Things That Make Us Smart"*
- Design of everyday things provides affordances for our engaging with them & using as them as cognitive resources
  - e.g. Doorknobs: right size, at right height, for grasping
- The best designs exploit our biases, and are sensitive to task demands (see Norman 1994 reading)
  - Iconicity e.g. Map of US pop easier to interpret if greater saturation (vs. arbitrary colors) = greater population
  - e.g. Map that uses 3<sup>rd</sup> dimension to show "size" of population vs. distortion of sizes of states
- What "works" also depends on demands of task
  - e.g. Matrix can be better than a list for searching for what to do next
  - e.g. Best mathematical symbols to use depends on which computational task
    - Tally marks - To rapidly count & compare # objects; Simple cumulative (visual) hatch-object correspondence
    - e.g. vs. Arabic numerals, where need to write new numeral for each increase, via recount or addition
    - Roman Numerals - Easier to add than Arabic - e.g. CVI (106) + CXVII (117) = CCXVIII (223); no need for ZERO
    - Arabic numerals - Easier for other calculations, such as arithmetic algorithms for multiplication & division
  - e.g. Effectiveness of a map can be greatly influenced by its orientation
    - Always easier if oriented from perceiver's current point of view

In this week's lab, you will DESIGN a SPACE  
to provide Epistemic and Pragmatic advantages  
for one of two different tasks. . .