

Psychology 354
Week12: The Cognitive Penetrability Criterion

The Cognitive Penetrability Criterion
An Example From Mental Imagery
An Example From Apparent Motion

Architecture Is Important

- Functional theories of the type proposed by classical cognitive science must be grounded in an architecture



- To exit Ryle's regress
- To establish strong equivalence
- Can the architecture be identified in the absence of biological evidence?

Cognitive Penetrability Criterion

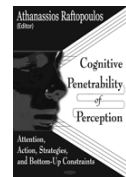
- Pylyshyn has proposed a methodology that cognitive psychologists can use to test whether a proposed function is primitive
- This methodology is called the cognitive penetrability criterion



Zenon Pylyshyn

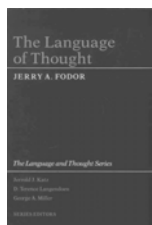
Cognitive Impenetrability

- The cognitive impenetrability criterion takes advantage of the view that the architecture must be fairly static
- If a function is part of the architecture, it must be "wired" into the brain
- So, changes in beliefs/content should not change the function
- This suggests one approach to experimentally determining if a function is primitive

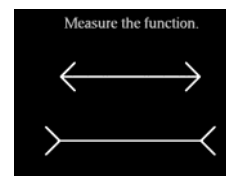


Penetrability Paradigm

- Pretest
 - measure the function
- Manipulation
 - change a belief relevant to the function
- Posttest
 - did the function change in a way rationally related to the change in belief?
 - If yes, then it was penetrated
 - If no, then it was not -- and may be part of the architecture!



Example: Pretest



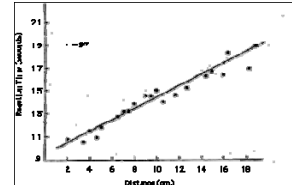
Map Scanning

“Imagine the map, attending to the beach. Scan from the beach to the tree, and press ‘Yes’ as soon as it is reached”



Basic Result

- The basic result in this study is “straight line data”
- The longer the distance between two points in the image, the longer it takes to scan from one to the other



Depictive View

- Supports the notion of images as having spatial extent
- Images are scanned at a constant rate
- It takes time to scan through the (primitive) spatial extent of the mental image



Propositional View

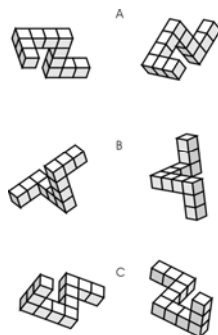
- Map scanning is cognitively penetrable
- Tacit knowledge gives straight line data
- Bannon demonstrated that straight line data disappears under different instructions
- How do subjects know where to scan without already being there?



Liam Bannon

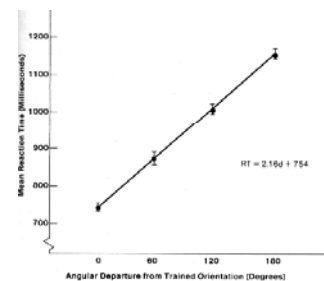
Mental Rotation

“As quickly as you can, tell me whether the two objects in a pair are the same or not”



Typical Results

- Again, straight line data is found
- There is a linear relationship between time to make the decision, and the angular difference between the two stimuli



Depictive View

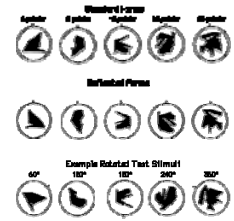
- Consistent with the view that images are primitive
- Images are rotated at a constant rate
- Images, because of spatial extent, must pass through all intermediate stages as they are rotated from one appearance to another
- This takes time!



Roger Shepard

Propositional View

- Mental rotation is cognitively penetrable
- Rotation is affected by image complexity
- But image complexity reflects properties of content, not of the medium
- So, content affects rotation rate -- which therefore can't be primitive!



Imagery Debate Redux

- The imagery debate faded from view in the 1980s
- Recently, it has resurged – as evident in the readings for this lecture
- The debate has been revitalized by the methodology of cognitive neuroscience

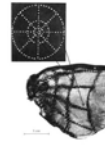


Brain Imagery

- Modern evidence indicates that there is a topographic mapping from visual reception to visual processing in the brain
- Hubel used tracing techniques to show how a target presented to a monkey's eye was "drawn" on its visual cortex
- Are mental images literally pictures on the brain?

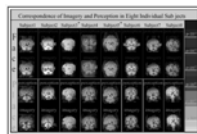


David Hubel



Perception and Imagery

- A variety of brain scanning technologies have shown that seeing and imagining use similar brain areas
- The image on the left is fMRI data from O'Craven & Kanwisher (2000):
 - "These findings strengthen evidence that imagery and perception share common processing mechanisms, and demonstrate that the specific brain regions activated during mental imagery depend on the content of the visual image"



Neural Depiction

- Depictive researchers now argue that such results indicate how mental images are represented visually or spatially in the brain
- According to the Harvard University Gazette, 1999, "researchers have proved that visual memories are re-created in the brain as mental pictures. Stored images are played, like videotapes, on a screenlike sheet of tissue at the back of the head"



Stephen Kosslyn points to the "mind's eye" at the back of the brain where visual memories are replayed into consciousness.

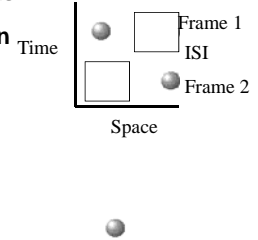
Propositional Response

- Pylyshyn's response to the neural re-imagining of imagery is that this evidence is mute with respect to format
- The scope problem: is space a property of the image, or of the imagined content?
- Furthermore, many spatial representations in the brain – such as the “cognitive map” in the hippocampus – do not appear to be strictly spatial in nature



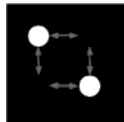
Apparent Motion

- The cognitive penetrability criterion has also been used in the study of apparent motion
- Two static views of an element in different positions will give the illusion of apparent motion
- This is responsible for many different “movement artifacts” – TV, movies, etc.



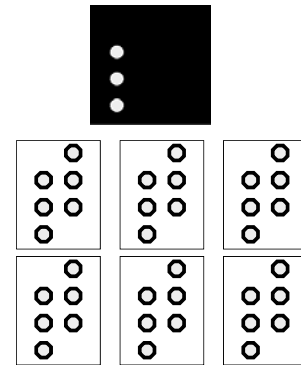
Apparent Motion Ambiguity

- Ambiguous apparent motion. The two spots move either vertically or horizontally. Can you control the direction by willpower?
- “What went where” is underdetermined!
- This is one problem that the visual system must solve



Motion Correspondence

- The problem of “what went where” is called the motion correspondence problem
- With N elements in Frame 1 and Frame 2, there are N! possible interpretations.
- However, only one of these will be correct



Motion Quality

- The quality of motion that is filled in is also something that must be computed
- In some instances, we have a sense of motion, but not of the shape of the moving thing (phi motion)
- In other instances, illusory motion can not be distinguished from real motion – beta motion
- There is reason to believe that filling in motion is computed separately from the computations that solve the correspondence problem



Phi Motion



Beta Motion



Stuart Anstis

Beliefs And Motion

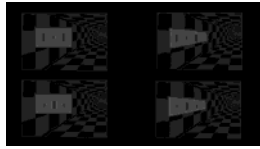
- To what extent do beliefs affect apparent motion?
- To what extent is it cognitively penetrable?
- Wright and Dawson argued that the answer to this question requires segregating correspondence processes from others



Richard Wright

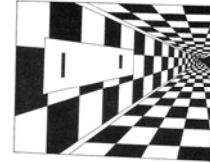
Competition Displays

- Wright and Dawson studied the effect of manipulating “believed depth” on competition displays
- Such displays are used to measure motion correspondence processing
- This processing is cognitive impenetrable



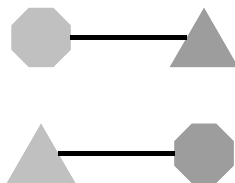
Quality Displays

- Wright and Dawson studied the effect of manipulating “believed depth” on motion quality
- The quality of motion – how it was filled in – was affected by these manipulations
- This type of processing is cognitively penetrable

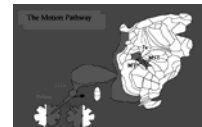


No Image Matching

- When motion correspondence matches are computed, the visual system does not image match
- This too is consistent with correspondence processes being impenetrable

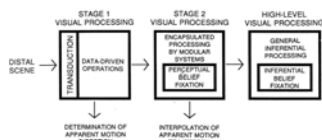


The Motion Pathway



- Dawson has argued that motion correspondence matches are assigned by Area 7a in parietal cortex
- These assignments are based on motion measurements made in areas MT and MST
- The impenetrability results are consistent with this story

Functional Theory



- Wright and Dawson have used such results to integrate their theory of apparent motion into extant theories of visual cognition
- Early stages of such theories required the operation of primitive transducers, some of which perform correspondence processing