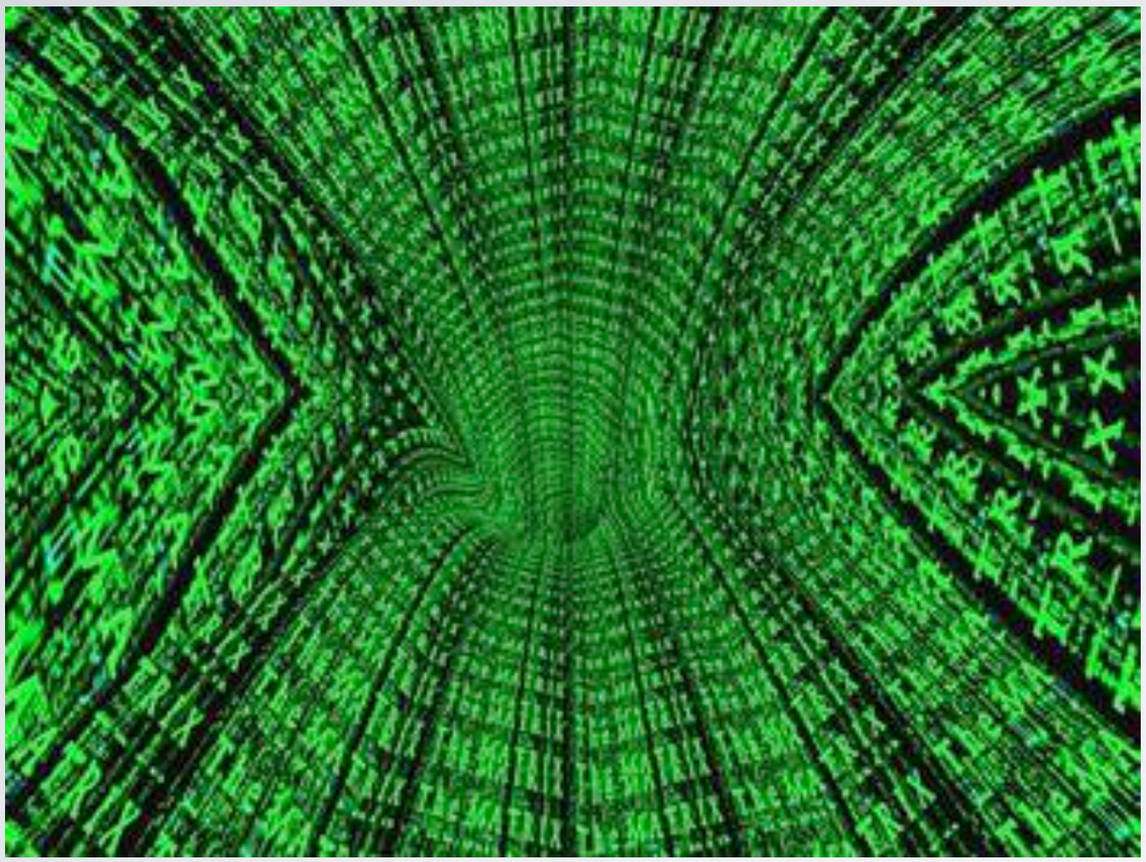
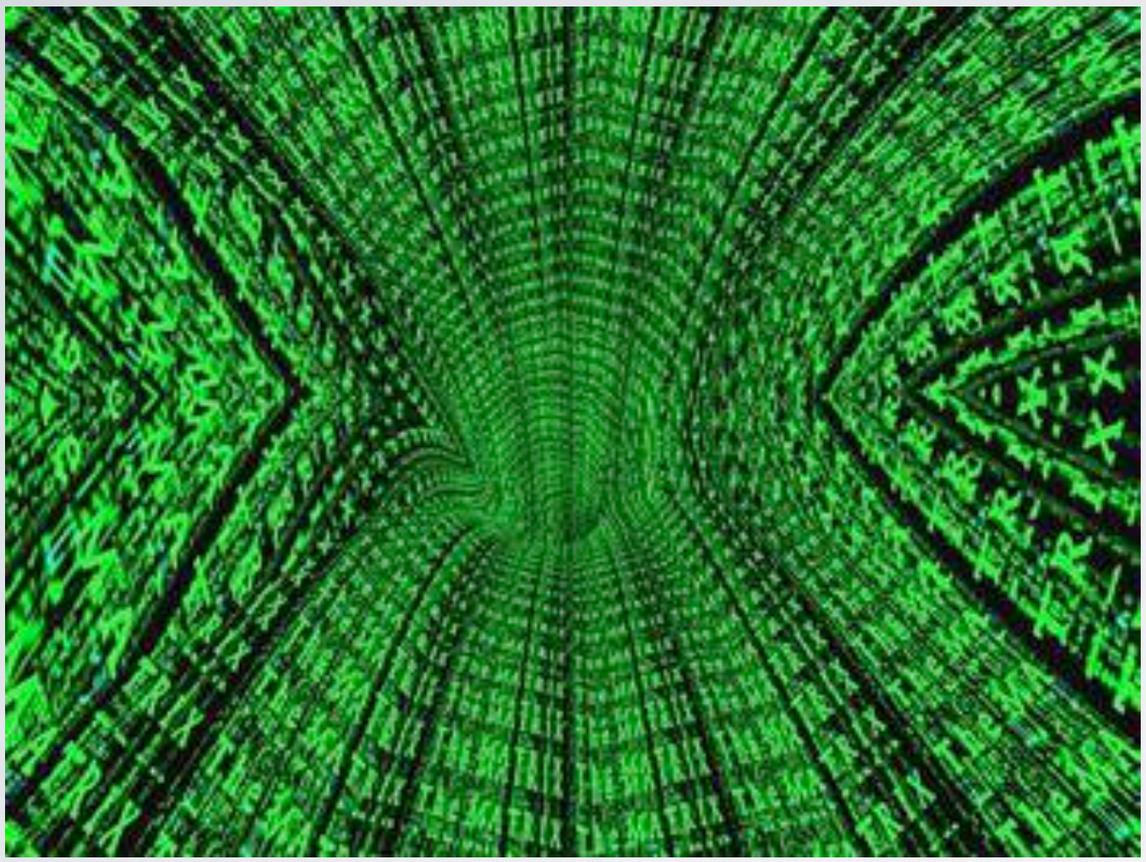
FORM, PERCEPTION AND COGNITION: EMBODIED COGNITION AND MODULE RECAP

Dr Brian Bridges
BD.Bridges@ulster.ac.uk
brian.randomtwist.com



ECOLOGICAL PERCEPTION: ENVIRONMENT AS ‘CONTEXT-SENSITIVE’ INFORMATION



RE-EXAMINATION OF THE ROLE OF THE ENVIRONMENT IN PERCEPTION...

DOES THE ENVIRONMENT DO SOME OF THE 'WORK' FOR US WHEN IT COMES TO PERCEIVING ITS FEATURES?

AFFORDANCES: THE WORLD 'SPEAKS' TO US

Sculpture or seat?

Tree-trunk or seat?

Pavement or ????

SIT
UPRIGHT

COGNITIVE MODELS AND PROCESSES

Computationalism is DIGITAL

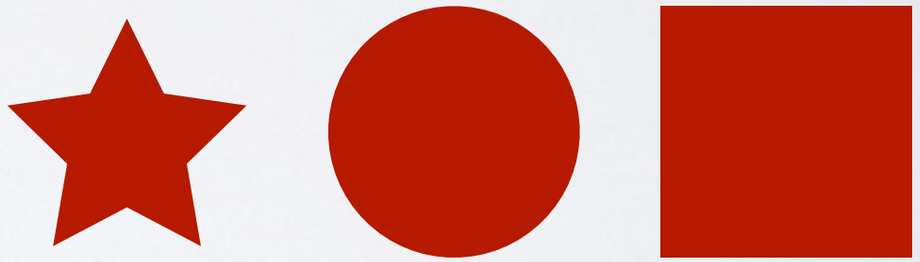
A B C

1 2 3

symbol manipulation

logic

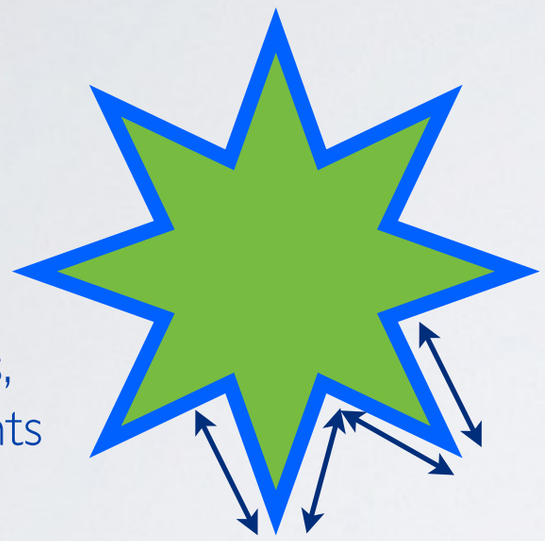
Ecological/Embodied approach is ANALOGUE



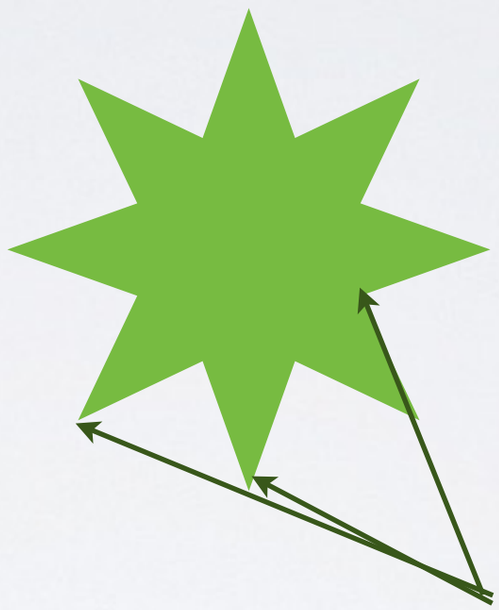
physical manipulation affordances and embodied schemas

COMPUTATIONAL MODELS AND PROCESSES

model:
distances,
no. of points



Extensive computational model
(procedure for drawing a star combined with cognition of attributes of overall structure)
DECONSTRUCT and ABSTRACT relevant details

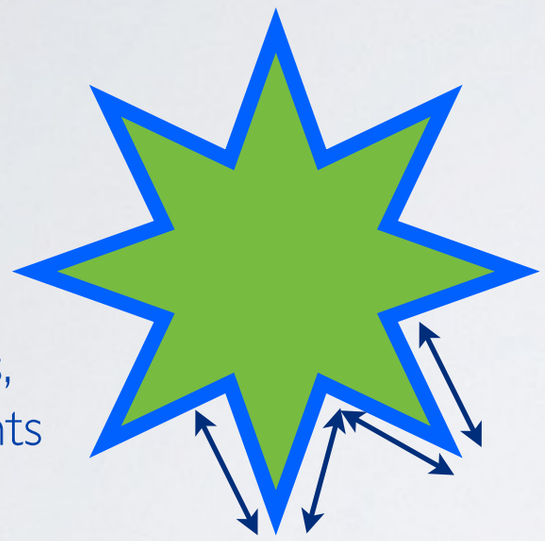


Gibsonian/ecological perspective: examine from different angles to find relative positions of points in relation to each other

Gibsonian approach:
Get the interactive 'gist' of the object
=> actively interact with object to judge relative positions to facilitate adaptive behaviour (but don't need to 'exhaustively map' the object)

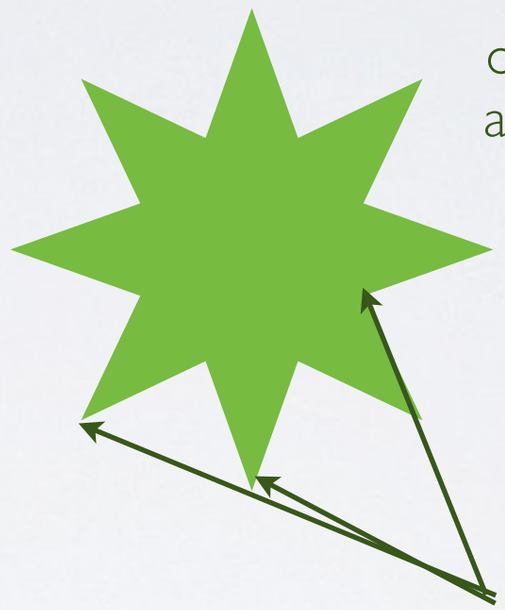
REPRESENTATIONAL AND NON–REPRESENTATIONAL APPROACHES

model:
distances,
no. of points



Representational

top-down



object with
affordances

=> watch out
for sharp edges!

Non-representational

bottom-up

APPLICATIONS AND OUR PERSPECTIVE

- We're going to leave more extensive top–down (representational) perspectives to psychologists and AI (artificial intelligence) researchers

- We're more interested in developing technologies which people find easy to engage with

- So, as mentioned before, the Gibsonian perspective (and, by extension, other non–representational perspectives) is attractive to us when considering interaction: using basic environmental 'principles' when considering interaction design can result in a reduced learning curve and a more attractively 'intuitive' interaction experience

WHERE DOES THIS LEAVE US AS DIGITAL ARTS/CREATIVE TECHNOLOGIES PRACTITIONERS?

- The Gibsonian perspective is clearly useful for design: an approach which is informed by the theory of affordances treats interface components as parts of an environment (and expects us to uncover interaction possibilities on a similar basis)

- This may work for relatively simple cases: however, for more complex interactions, experience (i.e. memory–based processes) are more likely to play a significant role

- => more complex tasks which require abstract reasoning are clearly a part of human activity (e.g. mathematical reasoning or following an coding checklist with understanding)

- Can we enjoy our Gibsonian cake whilst still being able to think about its structure?

EMBODIED COGNITION

- This approach is held by its proponents to be beneficial in terms of combining the more complex abilities entailed by cognitive models with Gibsonian environmental contexts (which may be taken to simplify cognitive processes)

- In other words, thinking/modelling still 'happens', but its structure is dictated by the environmental structures which are familiar to us

- In other words, the structure of cognition is mediated by the environment and its affordances (and, as Andy Clark has put it (Clark, 2001), we're 'good at frisbee and bad at logic')

- Human cognition is influenced by human experience of human environments

EMBODIED COGNITION

- In other words, we combine affordances which we are familiar with and cross–reference (map) them to different domains to help us structure our thinking

- More complex/abstract cognitive structures are facilitated through the employment of structures derived from these affordances

- This may therefore reduce the cognitive load of a particular process...

- The structure of sensorimotor experience (i.e. the experience of our movements—large or small, informed by sensory feedback—within our 'natural' environment) is applied to the structure of cognition

- This sensorimotor experience is 'imported' into more abstract cognition, such as mathematics (Lakoff and Núñez, 2000, p.xii)

SO...

- Big deal, you might say!
- But this means that, from a design point of view, if we have a complex task which we want people to execute, we may make it easier for them if we think about the structure of their thinking
- Certain structures, influenced by our environmental affordances, may be easier to *think* with than others
- Employing these structures may aid the creation of more complex interfaces which are still quite intuitive

IMAGE SCHEMAS

- One embodied cognition approach has applied it to language
- George Lakoff and colleagues (Lakoff and Johnson, 1980, 1999; Johnson, 2008, p.141; Lakoff and Núñez, 2000) have investigated what they term image schemas in a variety of domains (initially language, then mathematics)
- Image schemas are simple models which are abstracted from typical sensorimotor actions in our environment
- These image schemas can be thought of as affordances, but the crucial difference is that they can be mapped from the original domain to another one

IMAGE SCHEMAS

List of basic image schemas: after Johnson (2008, p.21)

(1) UP–DOWN (Verticality)
(2) INTO/OUT OF (Container)
(3) TOWARD/AWAY FROM (Centre/Periphery or Scalar Distance)
(4) STRAIGHT/CURVED (Scalar or Cyclical Distance)
(5) SOURCE–PATH–GOAL

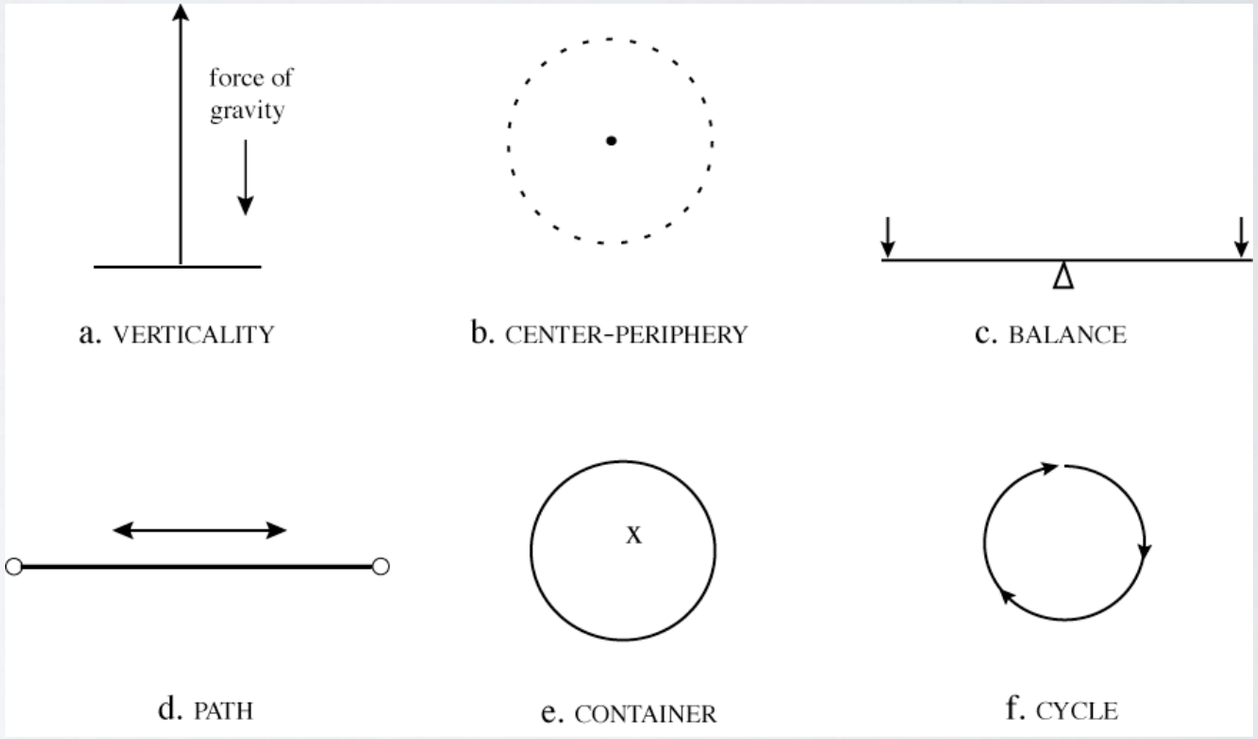


Fig. 9 Embodied image schemas

Graphic representations of various important embodied image schemas (from Brower, 2008)

IMAGE SCHEMAS

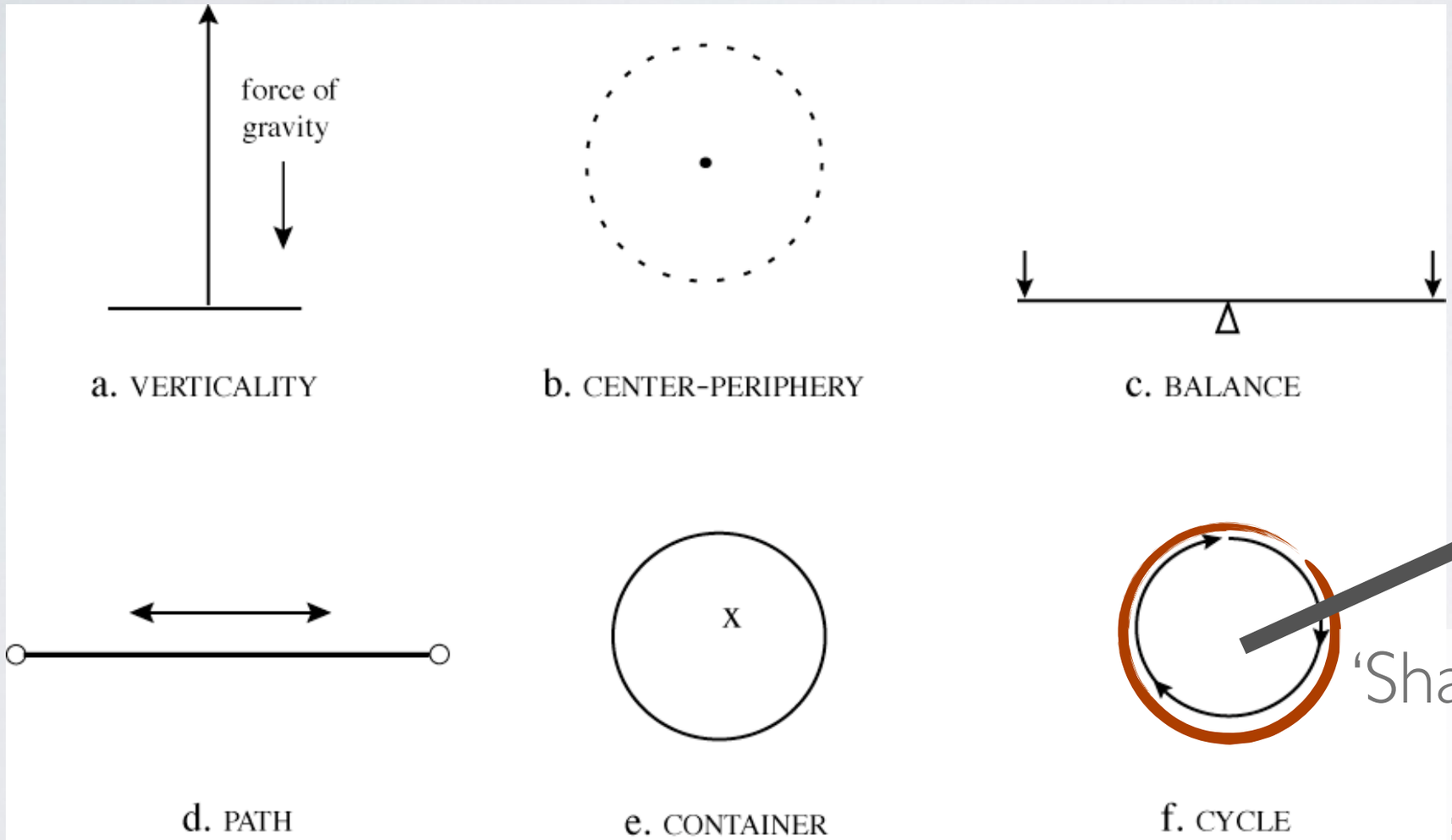
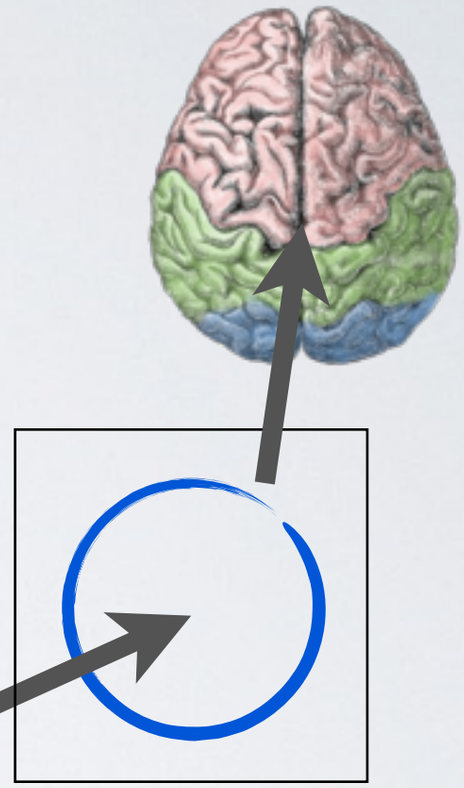


Fig. 9 Embodied image schemas



'Shape' of action maps to mental structure in another domain

IMAGE SCHEMAS

- To use the words of Lakoff and Johnson (1980), image schemas are 'metaphors we live by': they propose many cases of linguistic structures which they assert are influenced by sensorimotor movements

- It follows that using these image schemas ('metaphors') in any domain is a powerful tool to facilitate easier cognition

- (Indeed, sometimes this may facilitate cognition to the point that it may manipulate it: Lakoff has investigated the application of such metaphors to political speech!)

- However, from our perspective, actions/interactions which can be described using these image schemas (or relatively simple combinations of these image schemas) are likely to be easier for humans to learn (if the proponents of embodied cognition are correct)—see Hurtienne and Israel (2007)

- These schemas may have a dynamic component: simplified versions of real–world physics in interfaces may make for richer embodied–schema–based interactions (e.g. iPhone 'physics' of scrolling etc.)— see Jacob et al. (2007)

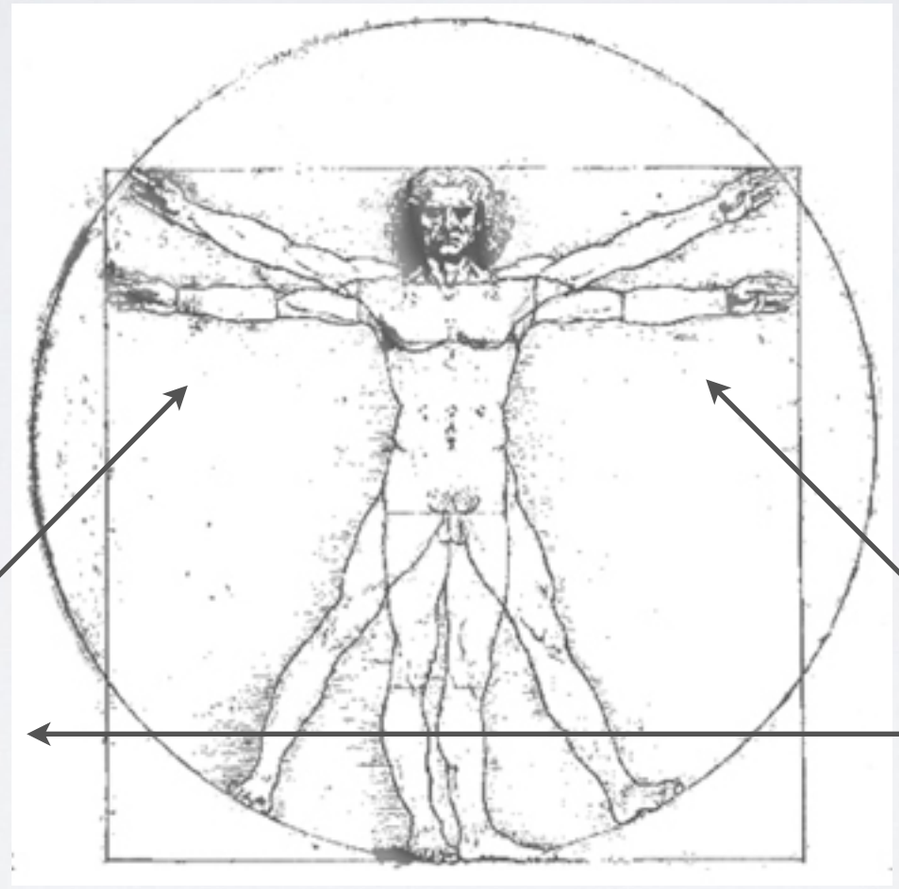
DISTRIBUTED COGNITION

A related idea is distributed cognition: thinking which is distributed between many different locations/nodes

This approach describes human cognition at work in a network which includes our tools and the surrounding environment as cognitive ‘aids’

DISTRIBUTED COGNITION

Smartphone



Sensorimotor actions

Cognitive processes

DISTRIBUTED COGNITION=CYBORGS

But this sort of cyborg?

or...

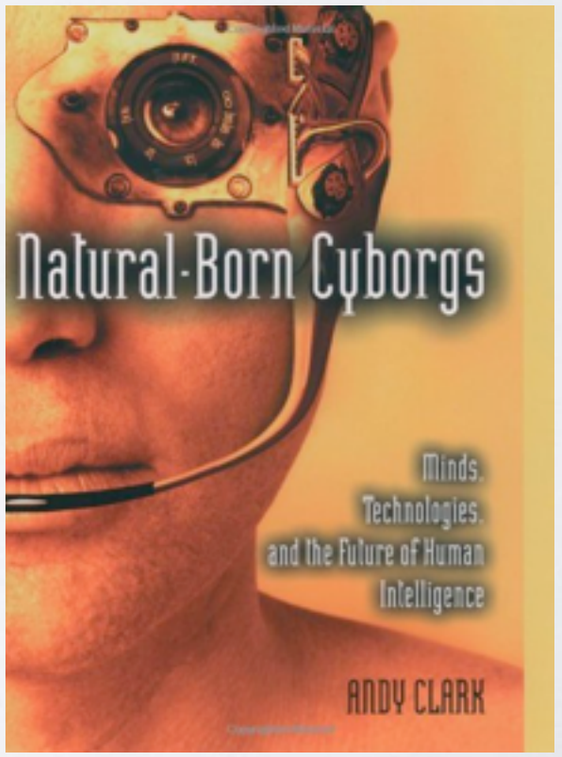
DISTRIBUTED COGNITION=CYBORGS (PHYSICAL AND COGNITIVE EXTENSION)

IMAGE SCHEMAS AS INTERFACE TECHNOLOGY

- Andy Clark's book *Supersizing the Mind* (Clark, 2011) regards image schemas as providing a virtual interface technology to allow for distributing cognition across a range of domains

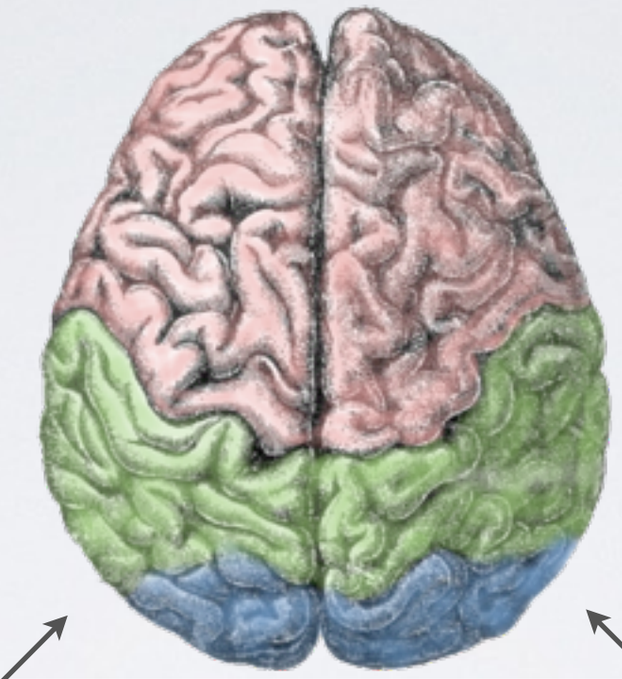
- Clark is a proponent of a strong theory of distributed cognition: when combining human and smartphone cognitive technologies, the locus of the actual thinking is, to him, no longer clear

- It follows from this that careful interface design which takes account of ideas from embodied cognition may facilitate the offsetting of cognitive load to the interface/device from the human 'operator'

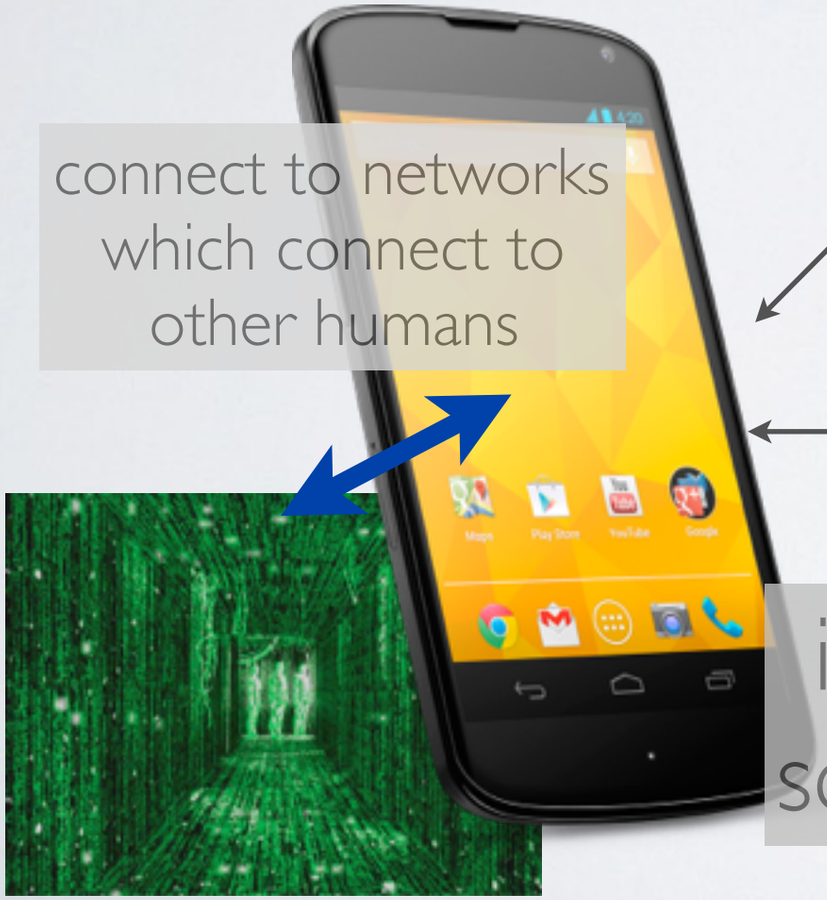


DISTRIBUTED COGNITION: A RANGE OF CONNECTIONS

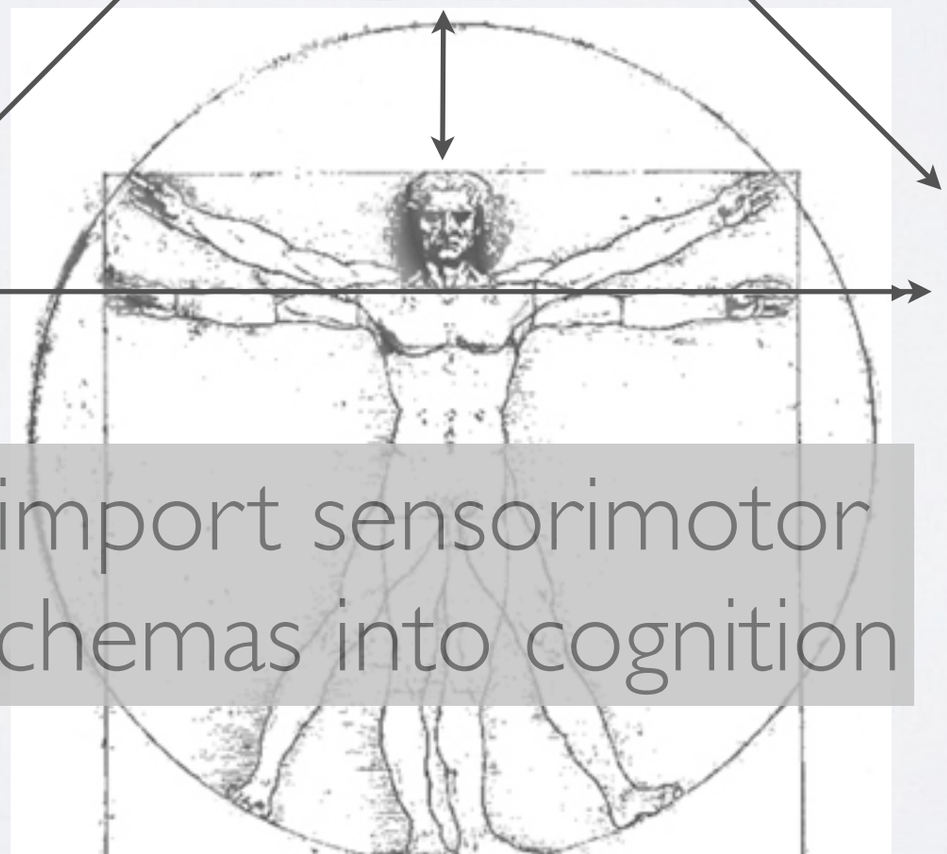
offload cognition to technology



offload cognition to environment



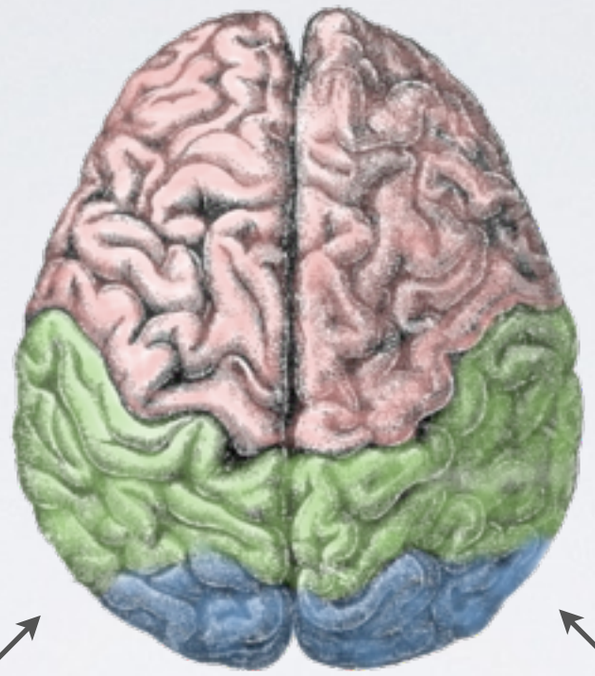
connect to networks which connect to other humans



import sensorimotor schemas into cognition

DISTRIBUTED COGNITION: A RANGE OF CONNECTIONS

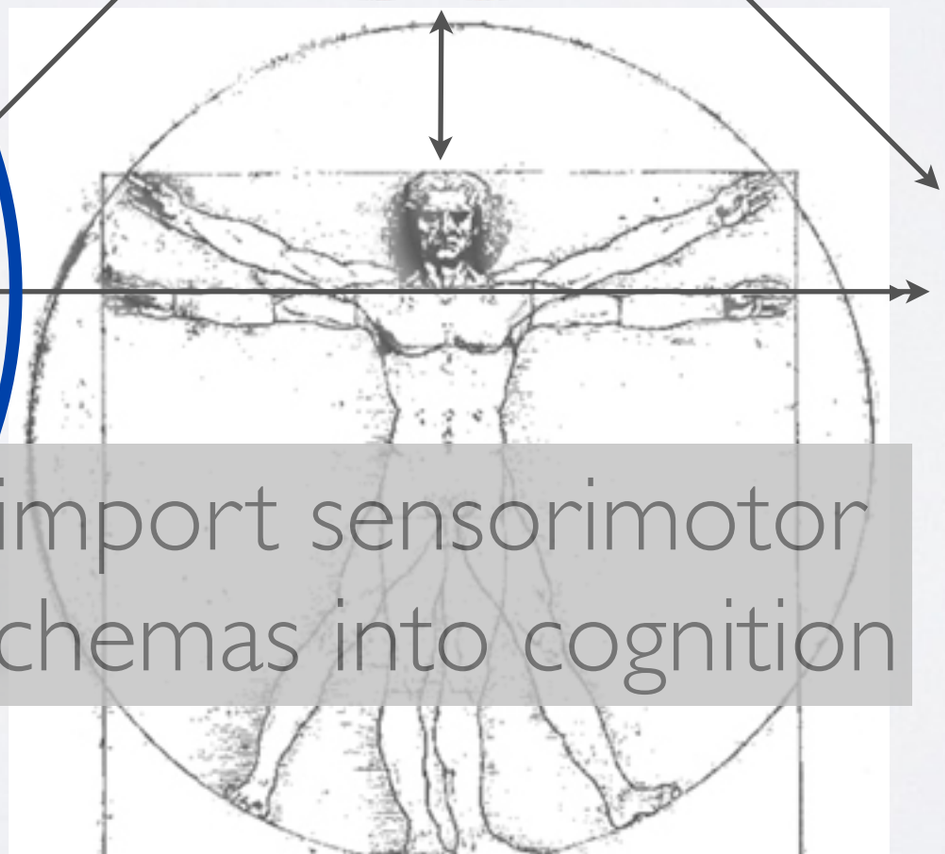
offload cognition to technology



offload cognition to environment

connect to networks which connect to other humans

the crucially significant recent development!



import sensorimotor schemas into cognition

CONCLUSION: MASSIVELY DISTRIBUTED COGNITION IMAGINED?

...OR WILL CONSIDERATION OF EMBODIED FACTORS AT LEAST KEEP MORE HUMAN CONCERNS 'CENTRE STAGE'?

SUGGESTED KEY FURTHER READING

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- Clark,2003. Natural-Born Cyborgs. NewYork:OUP USA.

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- Johnson, M., 2008. The Meaning of the Body: Aesthetics of Human Understanding. Chicago: University of Chicago Press.
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- Lakoff, G. and Núñez, R., 2000. *Where Mathematics Comes From: How the Embodied Mind Brings Mathematics Into Being.* New York: Basic Books.
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PART II

Module recap and conclusion

THE STORY SO FAR...

A long time ago in a galaxy far, far away....

THE STORY SO FAR...

- We found out that when it comes to making 'sense' (form!) out of the world, things are not necessarily as we expect them to be

- It seems that the 'simple' act of perception may be a more complex (and less mechanistic) business than we often think: the relationship between digital 'signal' and perceptual 'event' may not necessarily be straightforward

- Certain configurations of shapes or sounds (or even brain–states) may fool the brain into perceiving impossible objects

A SCANNER DARKLY
AND MENTAL REPRESENTATION

THEMES

- Human perception and failures in the processesing of perceptual data (figure-ground discrimination problems and hallucinations due to brain damage)

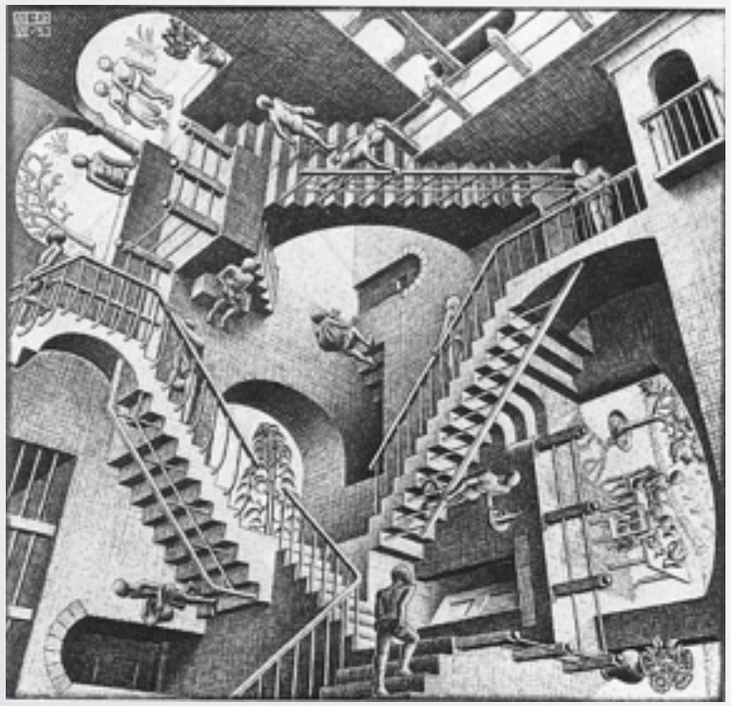
- Somewhat more ecological perspective on the perception of shapes and objects in this clip: more extensive tests revealed to use a wider range of modalities (testing touch as well as vision for objects), although these are still investigated in isolation

- Machine 'perception' and 'cognition': 'What does a scanner see?' Does it see using the same 'rules' as we do? (Philosophical question—will machine capabilities for structured perception always be limited by our strategies for perception? Can machines designed by humans transcend human limitations in perception/cognition?)

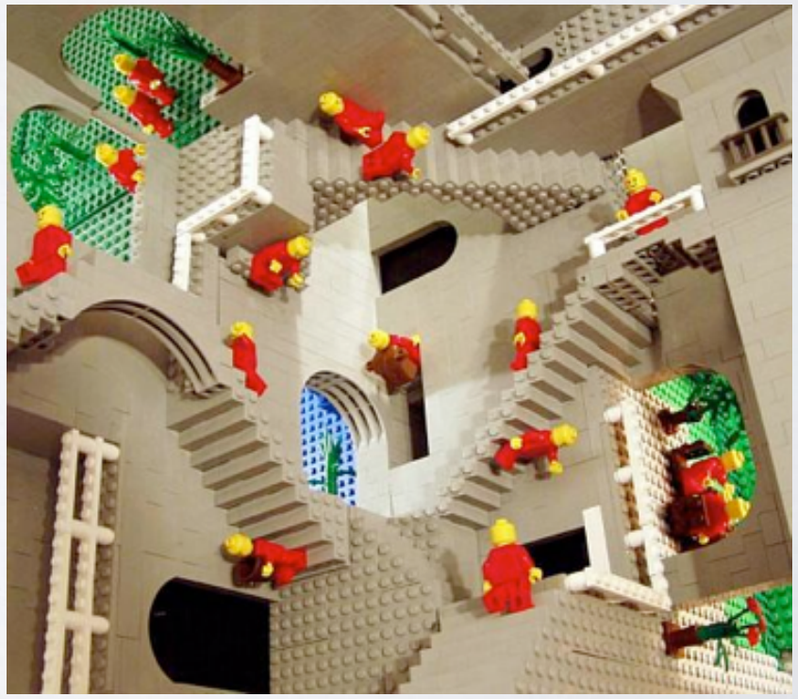
- Significance of focussing on perceptual 'failure' rather than 'perceptual success': Gibson might retort that, when faced with such non-adaptive behaviour as hallucinations, an organism should engage a range of their senses (touching objects) to resolve ambiguities and find invariances that lead to structured perception (work 'harder' at perception)

ECOLOGICAL PERSPECTIVES AND 'IMPOSSIBLE OBJECTS'

- These impossible objects are based on the exploitation of a particular viewpoint, whereby your perceptual 'rule–book' causes certain parts of an image to be joined together into a cohesive, connected virtual object, whereas they are, in fact, disjunct objects/parts of objects
- They appear to possess a singular, cohesive shape, but in fact, on closer examination/interaction, they may reveal themselves as disjunct...



See some interesting lecture notes with commentary here (click on his 'Perception' Powerpoint—if referencing, the person's name is Pálmi Magnússon and the year is 2006, slide 18 relates to these objects)



INTERACTING WITH IMPOSSIBLE OBJECTS

SUMMARY

- At the 'end' of the Penrose stairs: 'paradox' or 'paradox resolved'?

- If such paradoxical perceptual/cognitive experiences occur, do they require more extensive mental maps (a la 'traditional' models of cognition) or do they simply require the application of a basic ecological/Gibsonian 'rulebook' which is abstracted from environmental regularities as we interact with the environment?

- Do we need mental representation (maps) to explain object/shape perception? The Gibsonian perspective is arguably a little extreme, but it does focus our minds on some fundamentally important questions regarding cases which might simplify the mental processes which might be required by perception!

RECAP OF LECTURES AND KEY POINTS

We've introduced a variety of topics in perception from a range of perspectives...

FPC: THE STORY SO FAR...

- **1. First,** we looked at the 'problem' of perception as a 'decoding' problem for finding relevant structures in complex environments. We also decided to confine ourselves to the basic 'how' of perception, rather than questions of emotional response.

- We talked about how our **active perceptual decoding mechanisms** currently mark our perception as different (and more actively engaged) from the simple recording/encoding processes deployed by technology (even smart technologies have problems in decoding relevant from irrelevant details).

- We approached the problem of perception on the basis of trying to understand the **processes/strategies (heuristics)** which we apply to the world, in the hope that we can then develop more informed technological approaches.

- We talked about **illusions** and how these cases of **'perceptual breakdown'** may suggest the nature of our **perceptual 'rules'**.

FPC: THE STORY SO FAR...

- **2&3:** We looked at vision, firstly from the perspective of the **mechanical processes at work in the eye** (and in the light rays that come into the eye), followed by the basic neural processes that 'enhance' the image data and route it in different ways (enhancing edges due to luminance/colour-based processes. We looked at how our colour vision is related to detecting three different wavelength/ frequency ranges of light (red, green, blue).

- We looked at **where this visual data is routed to in the brain**, and discussed how the data appears to be handled by different modular processes in the brain (different visual cortex regions).

- We looked at how the crucial process of binocular vision allows for **3D/depth perception** and we looked at the processes of tracking different **sizes of details in images (spatial resolution/spatial frequency)**.

FPC: THE STORY SO FAR...

- **3. We were looking at the processes of visual perception from the perspective of the biological 'technologies'.** But, to continue to explain perception, we now needed to be free to think about perceptual 'rules' without worrying too much about the particular processes happening in the nervous system and brain.

- So, we considered the **perceptual organisational principles** proposed by the **Gestalt psychologists**, such as grouping and segregation by **proximity, similarity, continuity,** etc., relating to shape segmentation and surface parsing (joining objects up from apparently disjointed fragments)

- We looked at how these processes may be **facilitated by lower-level pre-processing in the nervous system and brain** (contour/edge details being forwarded separately from other visual data)

- Beyond these principles, we looked at how **objects may be mentally represented on the basis of composites of simpler components** (cones/cylinders)

FPC: THE STORY SO FAR...

- **5.** We looked at sound as a **psychophysical phenomenon**: as perceived energy transfer. We focussed initially on the psychophysical equivalence between (physical) **amplitude** and (perceptual) **loudness**.
- We looked at how **this equivalence is based on a log (logarithmic) scale**, constructed **using powers of numbers** (taking the 'raw' amplitude data in perceptually-equal steps of 10, 100, 1000, or 10^1, 10^2, 10^3, resulting in our perceptual scale of 1, 2, 3 from the powers).
- **Although we have a wide range of sensitivities to the energy transfer entailed by a travelling sound pressure wave**——from 10^{-12} to 10^{0} Watts/m^2——**this range can be represented as 10 Bels or 120 deciBels** using such a power–based scale, with 1 deciBel being (generally) taken to describe the smallest change in amplitude level which we can reliably discern.

FPC: THE STORY SO FAR...

- **7. We examined another psychophysical phenomenon: pitch** (corresponding physical attribute: frequency)
- We discussed the relationship between **frequency content** of a sound stimulus and the **more complex perceptual attribute of timbre**
- We discussed ear physiology, and how this might account for two different theories of **pitch perception**, based on the basilar membrane being a physical frequency analyser
- We discussed how ear physiology (the basilar membrane) accounts for some aspects of musical structuring through relative **sensory consonance/dissonance** for musical stimuli (more 'near–miss' overlap of frequency components on the basilar membrane means more dissonance)
- We discussed how ear physiology (the nature of the basilar membrane) means that some loud sounds (or 'parts' of sound, in frequency terms), can perceptually block certain other sounds (**masking**) and how this may mean that

FPC: THE STORY SO FAR...

- **8.** We looked at **how we decode sound location information** from the **temporal behaviour of sound waves** (ITD and ILD)

- We noted the Haas effect, which states that **these sound location cues even work inside rooms with significant reverberation** characteristics (sound bouncing off hard surfaces in large rooms causing delayed 'copies' of the sound to be heard)

- **Haas effect: 'First come, first heard'!**

- We considered how the ITD and ILD localisation 'cues' are relevant for **re-creating sound location impressions in stereo** to fool the listener into hearing the sorts of perspective associated with real sound environments

FPC: THE STORY SO FAR...

- **8. We also looked at Auditory Scene Analysis**
- For some reasons, certain types of sound structure tend to group together in our perception (auditory streaming)
- Bregman (who studied these phenomena) traced a common thread for all of these cases back to the environment; how common environmental cases provide the basis for our structured auditory perception (and music).
- To summarise, sounds which are close together in frequency/pitch, time, timbre and spatial location are more likely to be heard as a unit
- Sounds with simple, harmonic (whole number) frequency relationships are likely to be from the same source
- Many changes that take place in an acoustic event will affect all freq. components

FPC: THE STORY SO FAR...

- **9: We looked at AI**
- Problems of how to explain our own perception and cognition of shapes, objects and data can tell us something about how machine intelligence might work.
- Simulating or mimicking human intelligence with computer processes might tell us something about ourselves. What sort of criteria are used to assess machine intelligence?
- How good/bad are computers at 'human–style problems'?
- Are they any better at 'machine–style' problems?

FPC: THE STORY SO FAR...

- **10.** We looked at the **ecological perception theories of James J. Gibson**, who asserted that **perception is inextricably bound with action** and, in particular, the nature of actions necessitated by environmental structures
- This idea is also termed **direct perception**. Our perception is structured because the environment is! There is no need to make complex mental models, the only 'model' which is truly required is that of the environmental object itself!
- We noted how this is **a radical re-framing of the perception 'problem',** but that it has found favour in the technology field as **a perspective on interaction design**

FPC: THE STORY SO FAR...

- In Gibsonian terms, **illusions/false perceptual judgements could be seen as occuring when you don't work hard enough at perception** (taken an active 'reading' from multiple perspectives). They're not as important as more traditional information–processing–based models of perception would have us believe.
- There are **no particularly mysterious processes for constructing mental representations** (maps) of objects. We don't need lots of complex mental processes to construct objects which are separate from the basic organisational principles of the world and how we interact with it.
- Considered as a part of action, perception isn't therefore actually *that* difficult a problem to describe. We simply follow the organisational principles which are to be found in the world and work from these basic principles to structure our perception.

FPC: THE STORY SO FAR...

- **11.** Following this line, even if we don't buy the Gibsonian argument that there's no extensive **mental mapping** process for objects in the world, we can still apply an ecological perspective to perception and look for some cases which suggest that we perceptually group stimuli in certain ways due to our environment–derived specifications. Ideas from **embodied cognition** suggest that our **mental organisation processes may even be based on environmental structures**.

- Gestalt theories of visual perception are thus examples of **less strident ecologically–based theories**, when considered from this perspective

- Context is key: **we've approached perception from a number of different theoretical perspectives**, rather than one grand, unified, theory

- It depends, to some extent, on which part of the perception 'problem' you're working on!

FORM, PERCEPTION AND COGNITION

- **Key principles to think about**

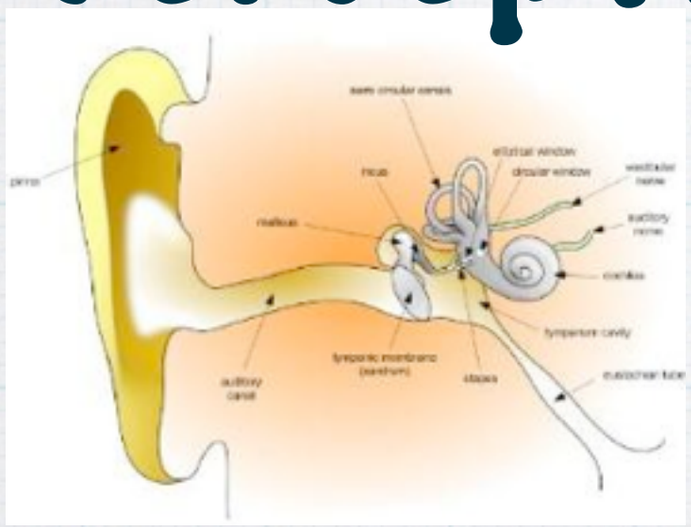
- Consider the relationship between stimulus and perception/cognition (how much do we know about the materials you are using)

- Consider how different senses may relate to each other

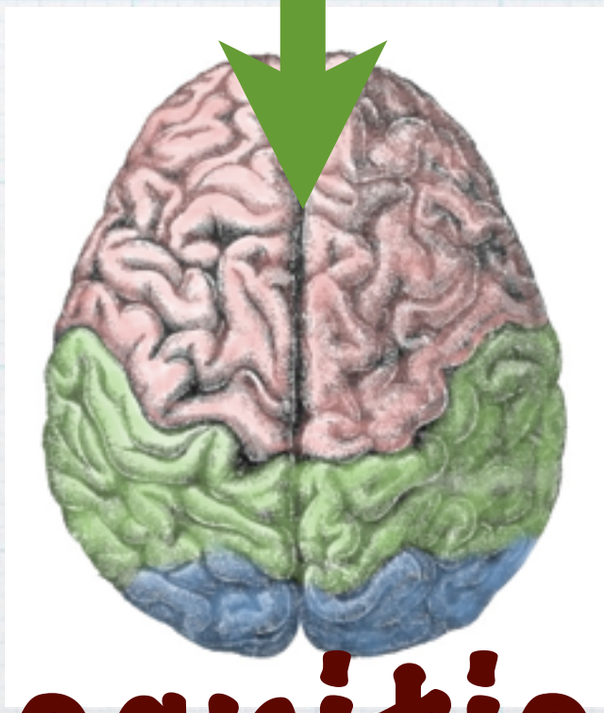
- Consider using an interface's spatial or physical form to guide interactions (based on ideas of affordances and image schemas)

- Use what we've covered to creatively exploit machine learning, vision or listening systems

Perception



Form



Action

Cognition