

MTTTSI7 Dimensionality reduction and visualization

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Lecture 5: Human perception (part I)
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Human perception (part I)

According to a research at Cambridge University, it doesn't matter in what order the letters in a word are, the only important thing is that the first and last letter be at the right place. The rest can be a total mess and you can still read it without problem. This is because the human mind does not read every letter by itself, but the word as a whole.

Human perception (part I)

Most strikingly, a recent paper showed only an 11% slowing when people read words with reordered internal letters:



The screenshot shows the Wiley InterScience website interface. At the top, the Wiley logo and 'InterScience' branding are visible. Below this is a navigation bar with 'Home / Psychology / Psychology (general)'. The main header features the journal title 'Psychological Science' in large red letters, with the subtitle 'RESEARCH, THEORY, & APPLICATION IN PSYCHOLOGY AND RELATED SCIENCES' to its right. Further right is the logo for 'A JOURNAL OF THE ASSOCIATION FOR PSYCHOLOGICAL SCIENCE' with the acronym 'aps'. The main content area includes a thumbnail of the journal cover, the title 'Psychological Science', and issue information: 'Volume 17 Issue 3, Pages 192 - 193', 'Published Online: 23 Feb 2006', and '© 2009 Association for Psychological Science'. To the right of this information is a list of interactive links: 'Get Sample Copy', 'Recommend to Your Librarian', 'Save journal to My Profile', 'Set E-Mail Alert', 'Email this page', 'Print this page', and 'RSS web feed (What is RSS?)'. Below these links are three buttons: 'Save Article to My Profile', 'Download Citation', and 'Request Permissions'. A horizontal line separates this section from the article details. The article is identified as a 'Short Report' titled 'Raeding Wrods With Jubmled Lettres' (sic) with the subtitle 'There Is a Cost'. The authors are listed as Keith Rayner¹, Sarah J. White², Rebecca L. Johnson¹, and Simon P. Liversedge². A footnote explains the superscripts: ¹ University of Massachusetts, Amherst, and ² University of Durham, Durham, United Kingdom. The contact information for Keith Rayner is provided at the bottom: 'Address correspondence to Keith Rayner, Department of Psychology, University of Massachusetts, Amherst, MA 01003, e-mail: rayner@psych.umass.edu.'

Human perception (part I)



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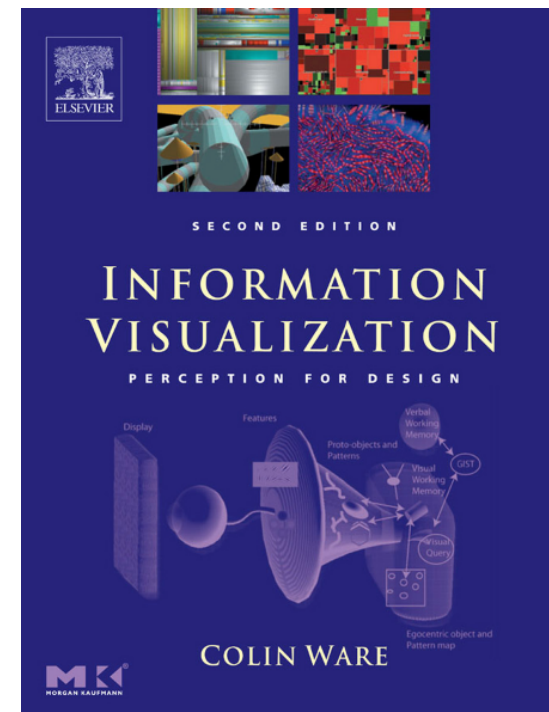
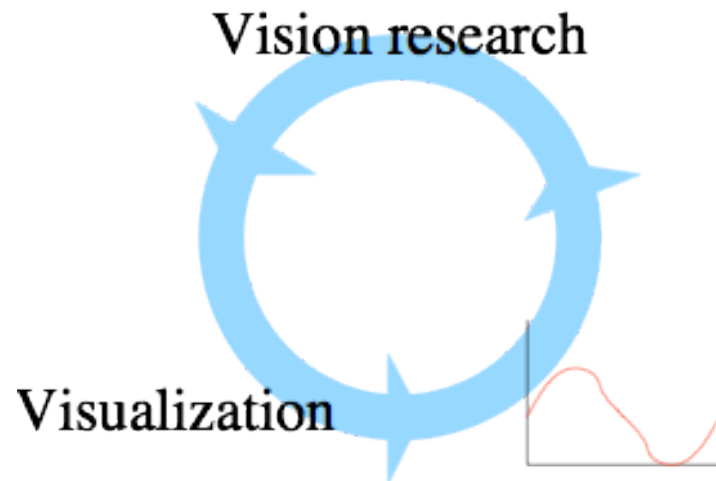
Human perception (part I)

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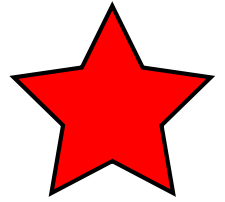


Human perception and visualization

- Visualization is young as a science
- The conceptual framework of the science of visualization is based on the human perception
- If care is not taken bad designs may be standardized

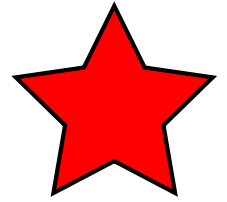


Gibson's affordance theory



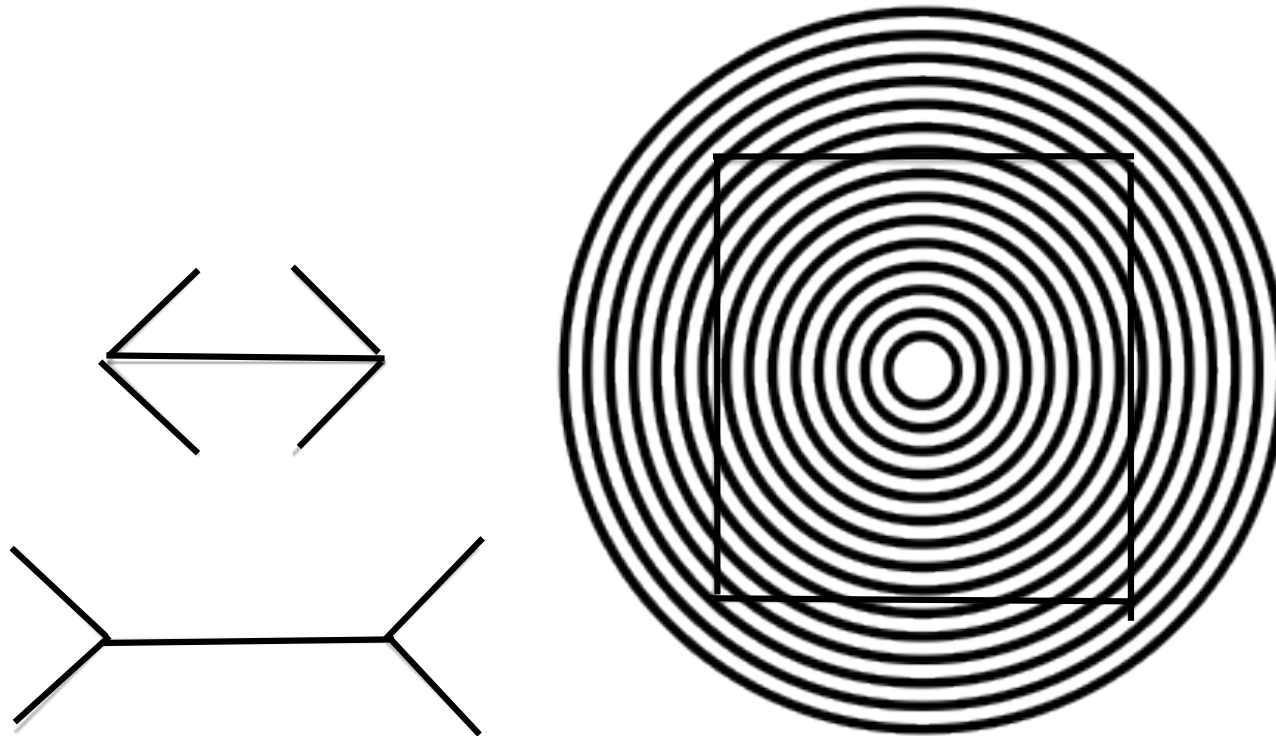
- “We perceive in order to operate.”
- We do not perceive elementary units (points of light, . . .)
- We perceive possibilities for action, or *affordances* (where to step etc.).
- Gibson claimed that we perceive affordances directly, by the visual system as a whole. Visual system *resonates* to respond to properties of the environment.
- Influential theory, but it is not to be taken too literally, unless we want to dump results of years of vision research (e.g. what we know of colors).

Sensory and arbitrary symbols



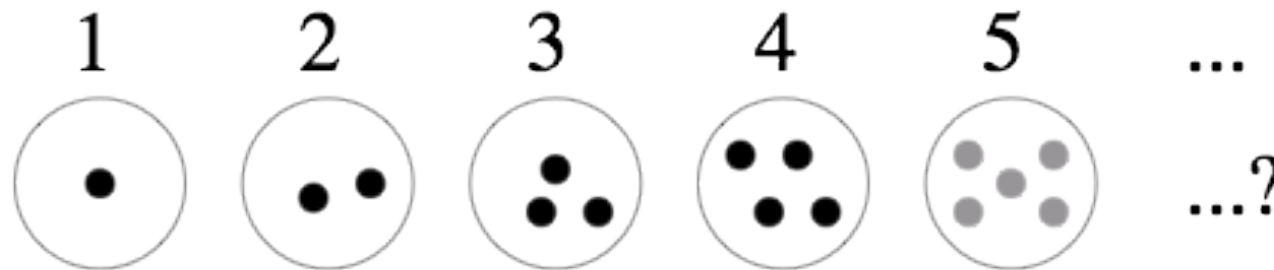
- Sensory symbols
 - Understandable without learning
 - Processing is hard-wired and fast
 - Resistant to instructional bias (results of millions of years of evolution)
 - Cross-cultural
- Arbitrary symbols
 - Hard to learn and easy to forget (except when overlearned)
 - Formally powerful
 - Capable of rapid change
 - Culture-specific

Sensory symbols: resistance to instructional bias



Müller-Lyer illusion

Arbitrary symbols



Arbitrary symbols are harder to learn, but easier to extend.

(Could you tell the difference between 10000 dots and 9999 dots?)

- Distinction to sensory and arbitrary symbols is difficult
- If all symbols were arbitrary, the problem of visualization would reduce to establishing a consistent notion (*standardization*)

Stages of perceptual processing

1. Parallel processing to extract low-level properties of the visual scene

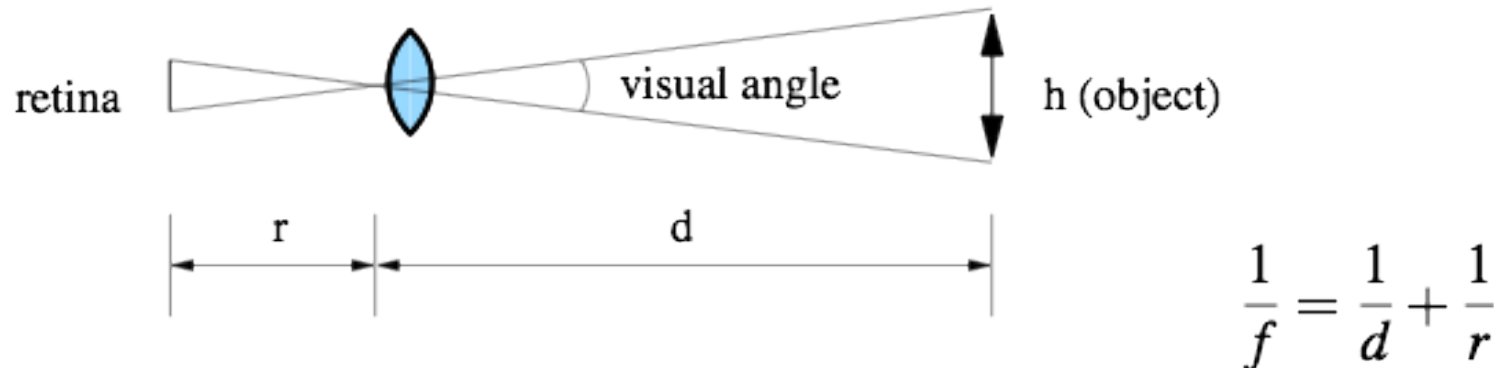
- rapid parallel processing
- extraction of features, orientation, color, texture, and movement patterns
- iconic store
- bottom-up, data driven processing

2. Pattern perception

- slow serial processing
- involves both working memory and long-term memory
- arbitrary symbols relevant
- different pathways for object recognition and visually guided motion

3. Sequential goal-driven processing

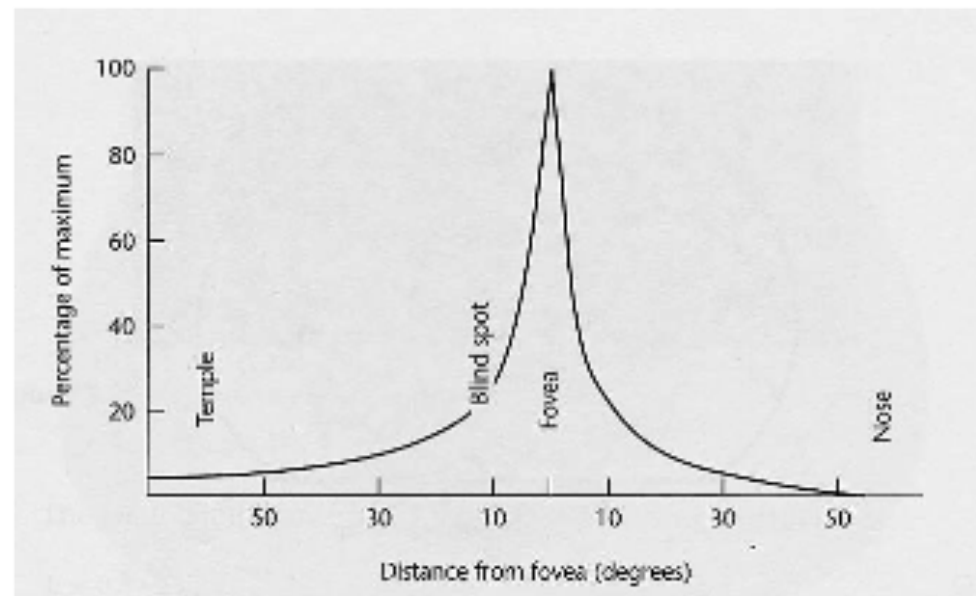
Optics



- The human lens system has a *focal length* of about $r = 0.017$ m.
- The power of the lens is $1/f = 59\text{m}^{-1}$ diopters (corresponding to $d = \infty$).
- Young children are capable of adjusting the lens 12 diopters or more, which means that they can focus to about $d = 0.08$ m.
- Flexibility drops by age at rate of about diopter per five years (the lens of people of the age over 60 is almost completely rigid!).

Acuity

- Visual acuities are measurements of our ability to see detail
- Acuity is at maximum at the center of the fovea
- Peripheral acuity drops rapidly; at 10° the acuity is 20 % of the maximum
- The point acuity at the center of the fovea (about 1 minute of arc) corresponds to the separation of receptors there



[W 2.18].

Simple acuities

- Simple acuities are limited by spacing of receptors at the center of the fovea (about one minute of arc)

- Point acuity describes the ability to resolve two distinct point targets:



- Grating acuity describes ability to distinguish grating pattern from uniform



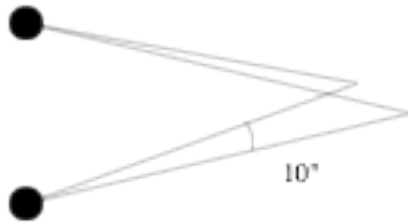
- Letter acuity describes ability to resolve letters:



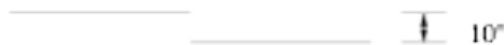
Superacuity

- Superacuity is ability to achieve better resolution by integrating information over space (or time!)

- Stereo acuity is describes the ability to resolve objects in depth:

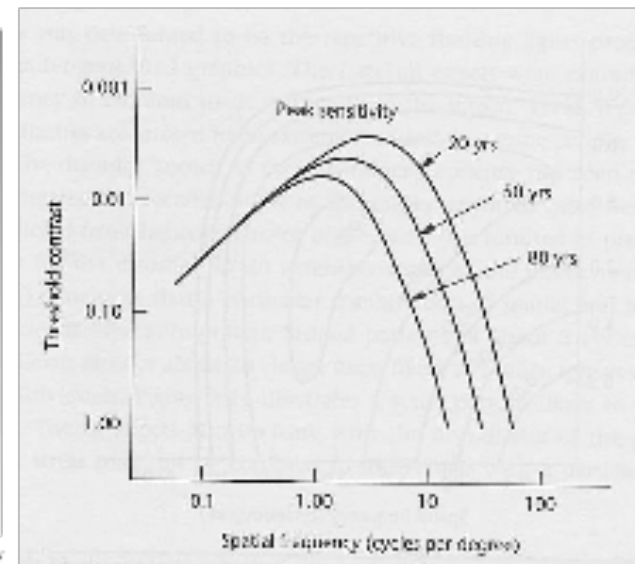
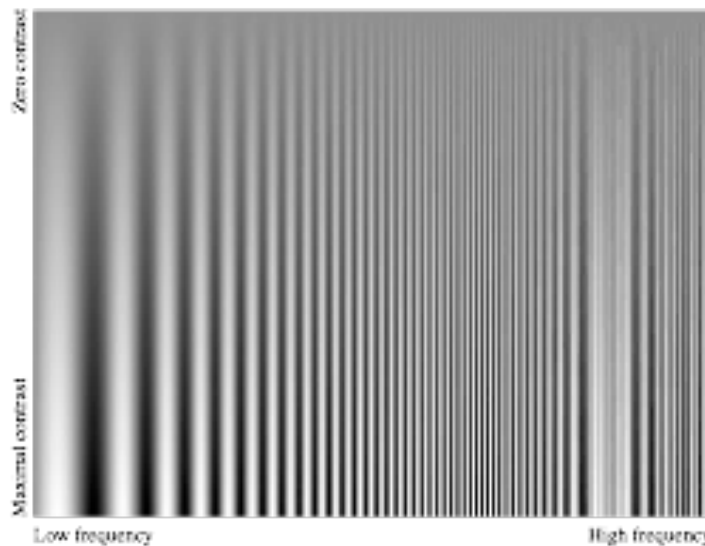


- Vernier acuity describes ability to see if two line segments are colinear:



Contrast sensitivity

- Contrast sensitivity is lowest at high frequencies (60 cycles per degree for young people)
- Sensitivity also falls off at low frequencies. Sensitivity is highest at about 2 or 3 cycles per degree.
- Contrast sensitivity falls off by age



[W 2.22].