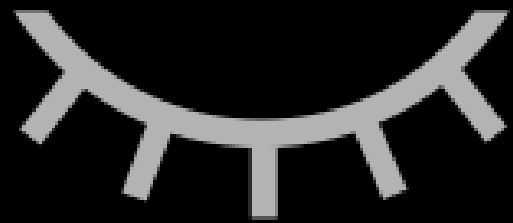


# DEEP HISTORY OF THE STUDY OF **Haptic Perception**

By: Ahmed Nadeem





# BACKGROUND COLOR INDICATES PROGRESSION THROUGH TIME

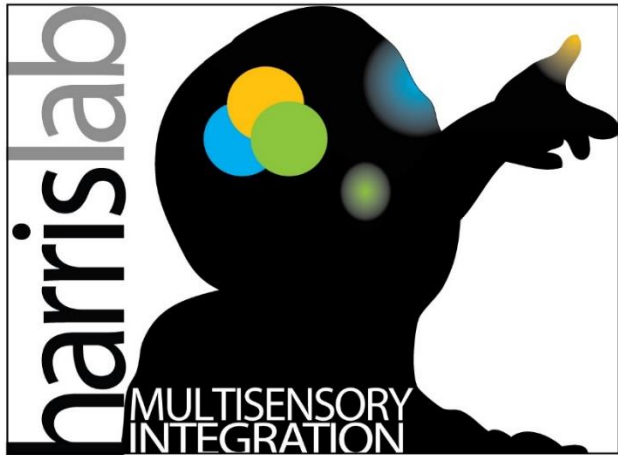
**BCE and Middle  
ages**

**Recent History**

**Present Day**

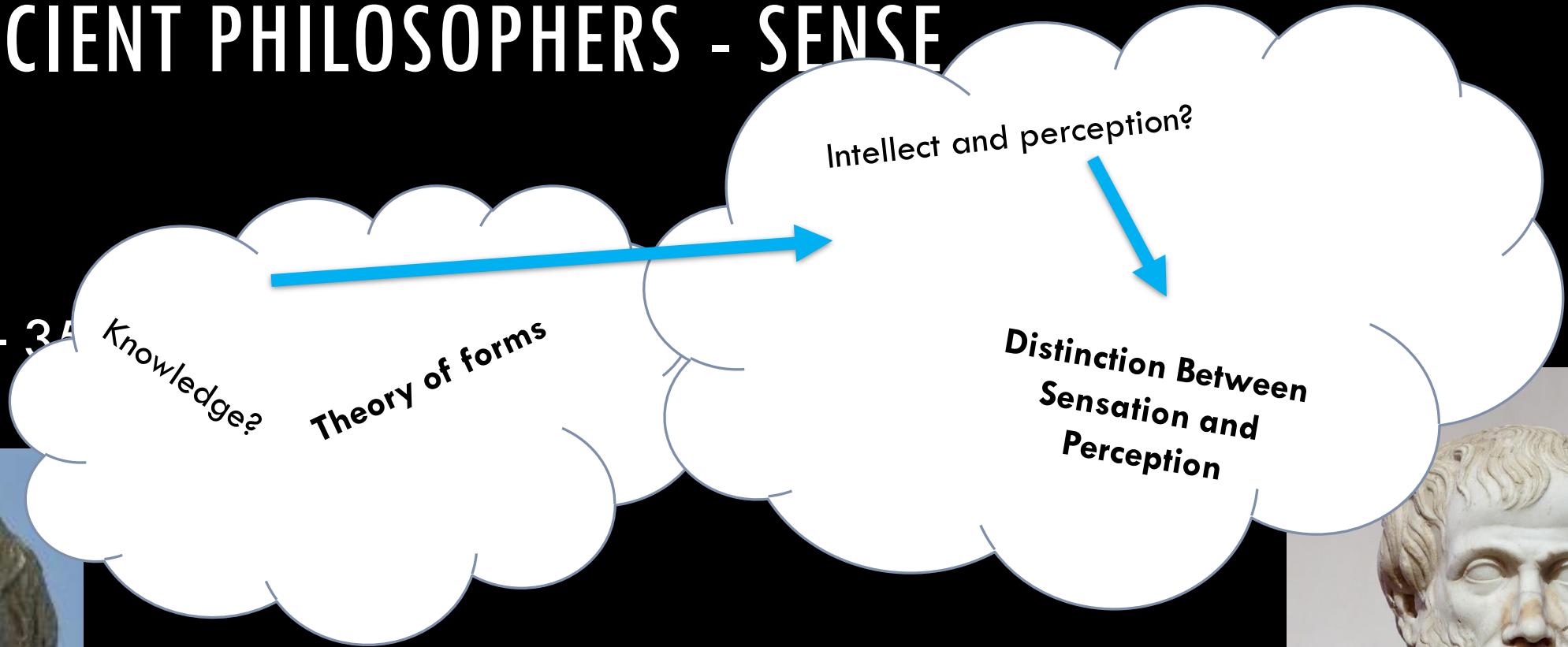
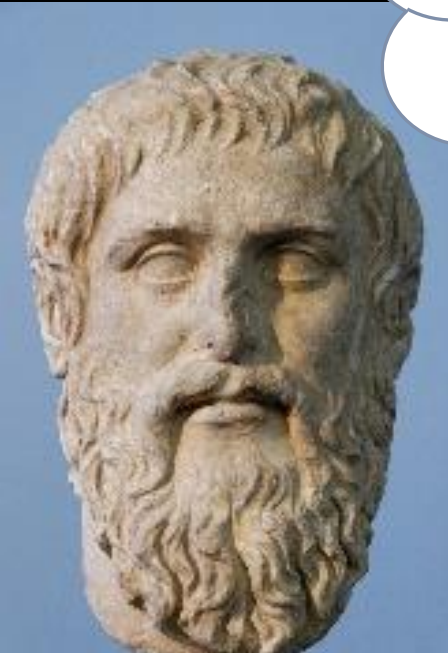
# CONTENT / BIOLOGICAL TOPIC

Before we begin



# ANCIENT PHILOSOPHERS - SENSE

**Plato**  
(430 BCE – 340 BCE)

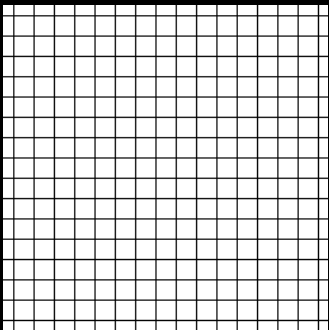


**1. STARTED THE SCIENCE/PHILOSOPHY**

**Aristotle (380 BCE – 320 BCE)**

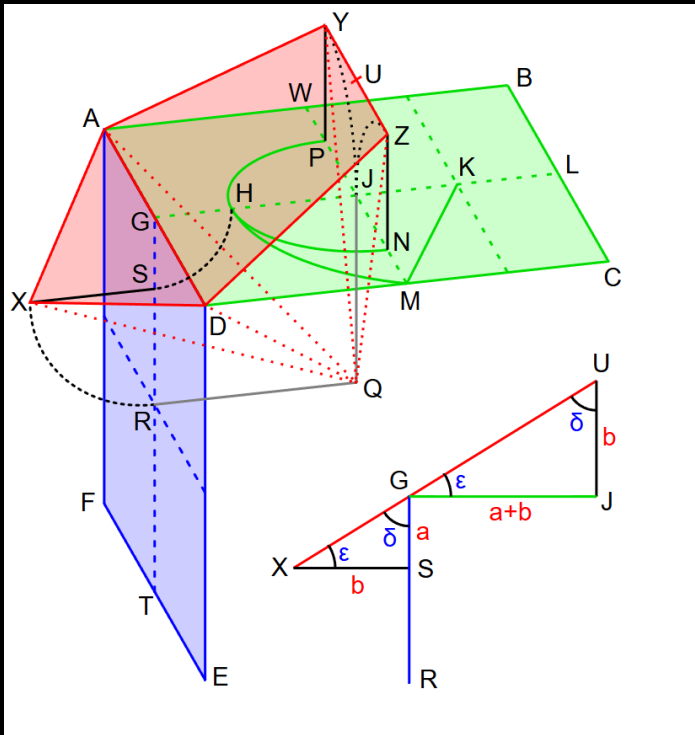


# ANCIENT PHILOSOPHERS PT.2



Euclid  
(300 BCE)

- 1. Defined Space
- 2. Worked on size/distance perception



300 BCE -> 1600s  
- lots of physiology work



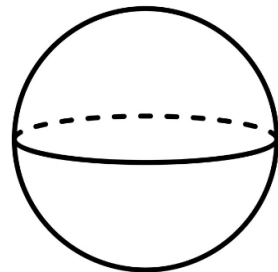
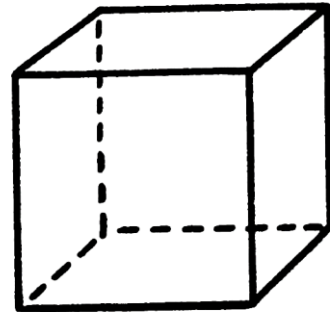


(Brandt et al., 2024; Gibson, 1987; Gregoric & Fink, 2022; Kant's Views on Space and Time (Stanford Encyclopedia of Philosophy), n.d.; Mach, 1960)

# PRE SCIENTIFIC REVOLUTION (1600S) – 1800

**Empiricism**  
Start of the  
Scientific  
method

**William  
Molyneux  
(1656–1698)**



## Kant's Views on Space and Time

*First published Mon Sep 14, 2009; substantive revision Fri Apr 1, 2022*

Even a casual reader of Kant's *Critique of Pure Reason* (*Kritik der reinen Vernunft*, first published in 1781) will notice the **prominence he gives to his discussion of space and time.**



**Immanuel  
Kant  
(1724–1804)**



## PRE SCIENTIFIC REVOLUTION – 1800

- PEOPLE STARTED TO THINK
  - WHAT ARE SENSES
  - WERE THE GREEKS RIGHT?
  - WHAT IS KNOWLEDGE?
  - WHAT IS ...

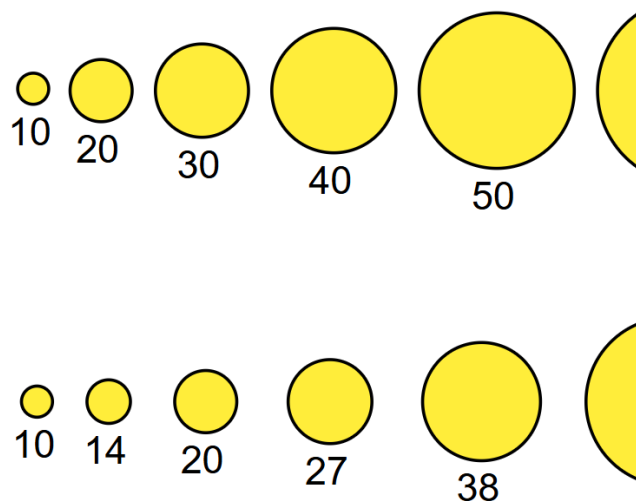
# 1800S ONWARDS — PSYHOPHYSICS! WHAT IS PERCEPTION?

Ernst Heinrich Weber  
(1795–1878)

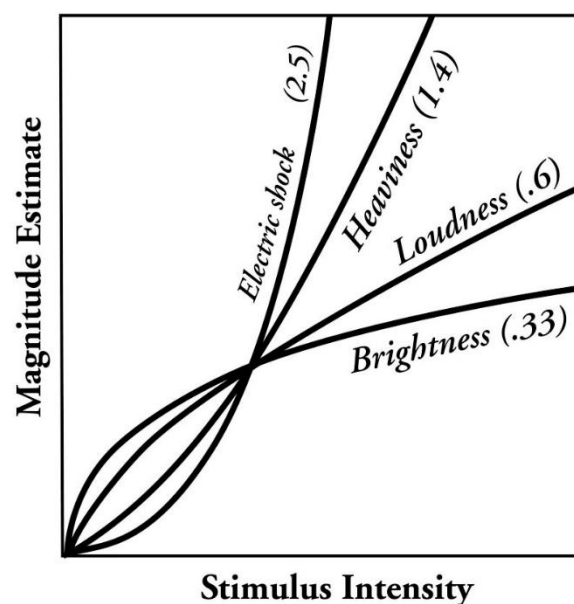


## 1. Weber's Law

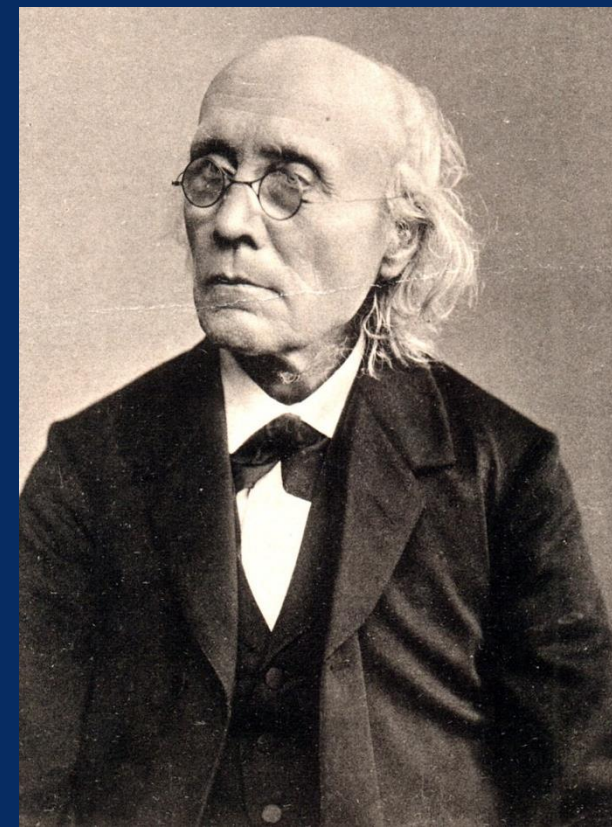
$$\frac{\Delta I}{I} = k$$



Gustav Fechner  
(1801–1887)



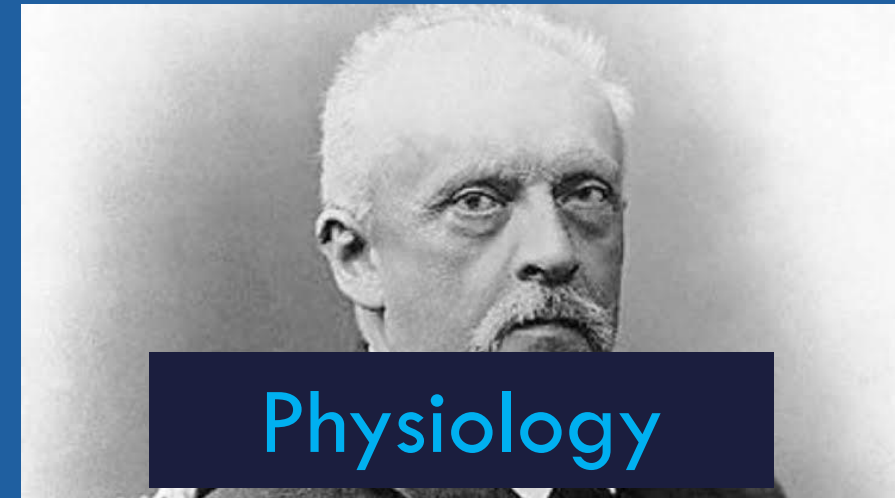
## 1. Fechner's Law 2. The two-alternative forced-choice (2AFC) paradigm



## Hermann von Helmholtz (1821–1894)

# 1850S ONWARDS

3. Physiological  
Sense Perception Research



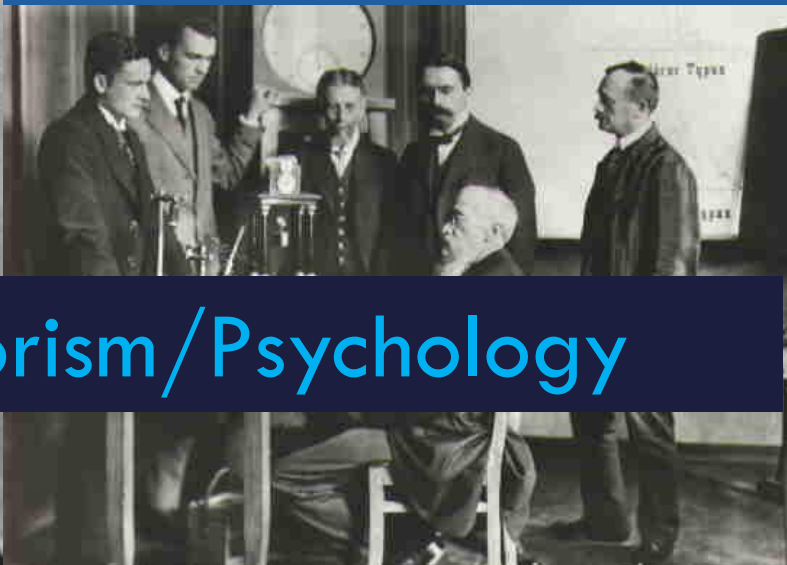
Physiology

## Wilhelm Wundt (1832–1920)

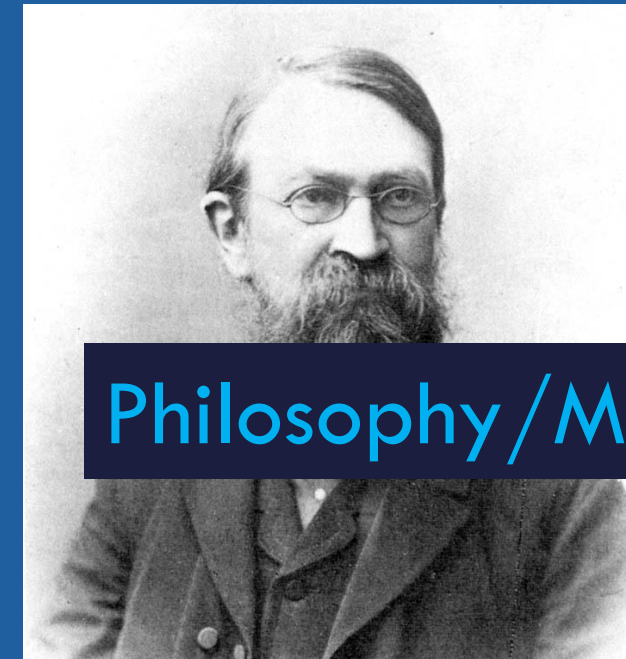
1. Psychological Labs
2. Formal Procedures and definition of the field



Behaviorism/Psychology



## Ernst Mach (1838–1916)



Philosophy/Math

Space and Geometry

*In the Light of Physiological,  
Psychological, & Physical Inquiry*

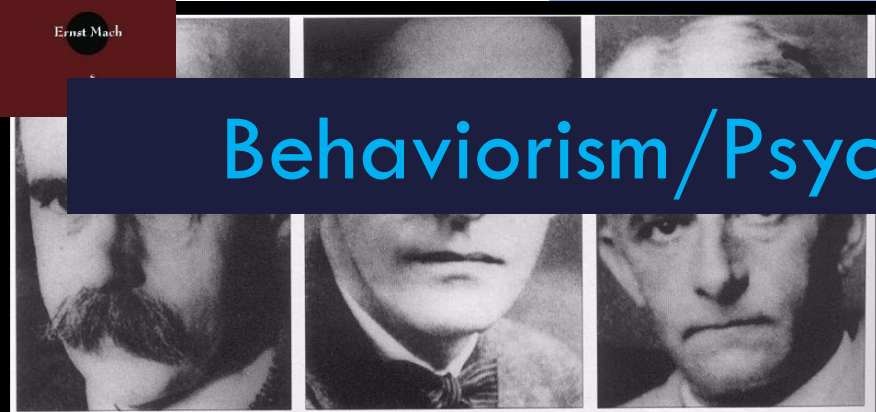
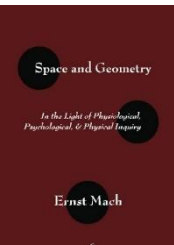
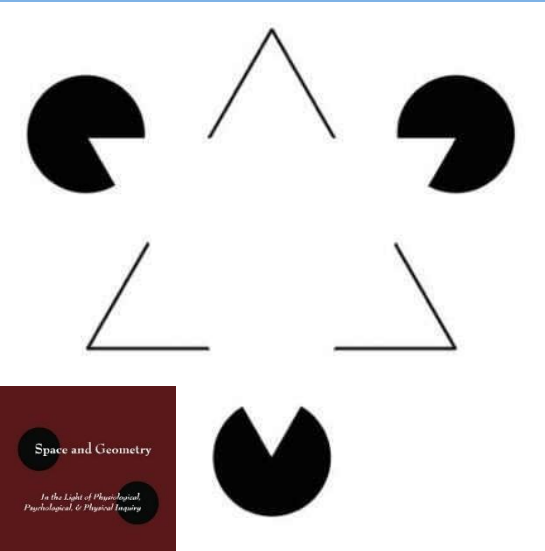
Ernst Mach



# 1. Gestalt Psychology

## 2. Connecting Psychology and Physiology

### 1900S-1950S ONWARDS

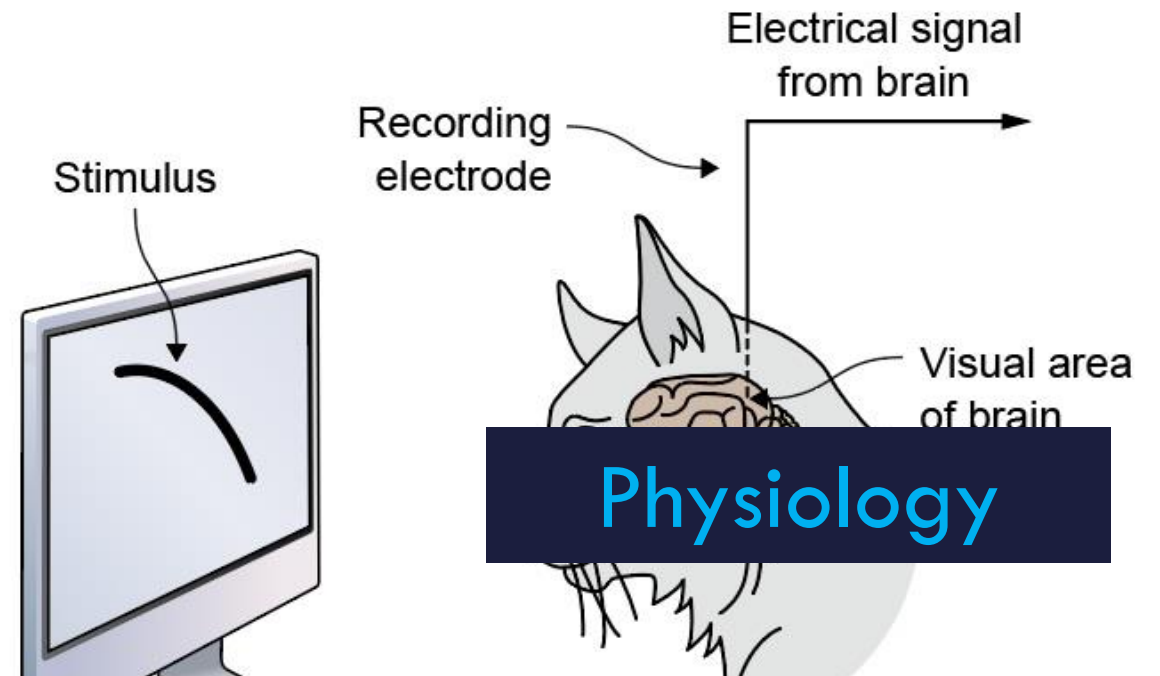


Max Wertheimer  
(1880-1943)

Kurt Koffka  
(1886-1941)

Wolfgang Kohler  
(1887-1967)

## Behaviorism/Psychology



Recordings of single neurones in the cat's striate cortex

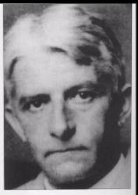
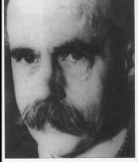
D. H. Hubel, T. N. Wiesel

First published: 01 October 1959

<https://doi.org/10.1113/jphysiol.1959.sp006308>

Citations: 3,058

(Albert, 1993, 1993; D H Hubel & T N Wiesel, 1959; Patton, 2018; Wertheimer, 1923)



Max Wertheimer  
(1880-1943)

Kurt Koffka  
(1886-1941)

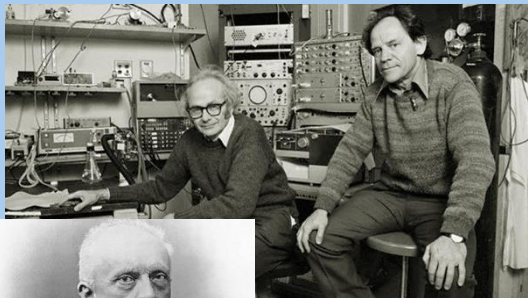
Wolfgang Kohler  
(1887-1967)

# 1900S-1950S ONWARDS

## Behaviorism/Psychology



## Philosophy/Math



## Physiology

# 1950S-1999

Behaviorism / Psychology

Philosophy / Math

Physiology

Biology

Computers



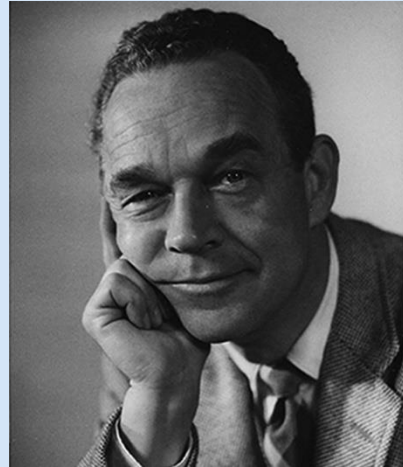
1950S-1999

Biology

Computers

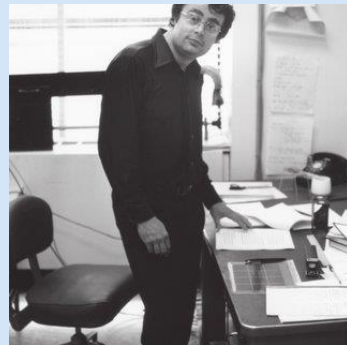
# 1950S-1999

Biology &  
Psychology



J.J Gibson

Brain's Algorithms



David Marr

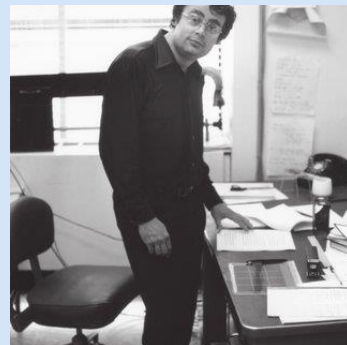
1. Worked on the idea of a sketch in the brain
2. Understood basics of brain processing\*

1950S-1999

Biology &  
Psychology

Brain's Algorithms

Einstein of  
neuroscience



David Marr

(David Marr, 1982)

II: Vision

## Chapter 2: Representing the Image ■

DOI: <https://doi.org/10.7551/mitpress/9674.003.0009>

### 2.2 Zero-Crossings and the Raw Primal Sketch

69



(a)



(b)



(c)

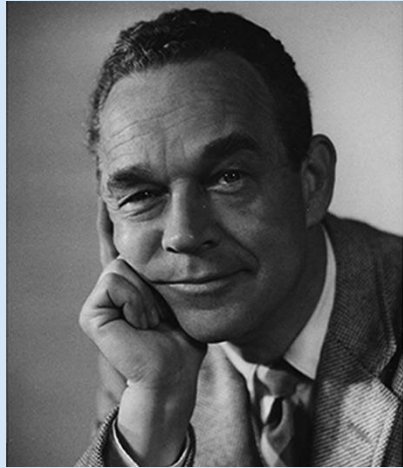


(d)

*Figure 2-20.* The image (a) has been convolved with  $\nabla^2 G$  having  $w_{2-D} = 2\sqrt{2}\sigma = 6, 12,$  and  $24$  pixels. These filters span approximately the range of filters that operate in the human fovea. (b), (c), and (d) show the zero-crossings thus obtained. Notice the fine detail picked up by the smallest. This set of figures neatly poses the next problem—How do we combine all this information into a single description? (Reprinted by permission from D. Marr and E. Hildreth, "Theory of edge detection," *Proc. R. Soc. Lond. B* 204, pp. 301–328.)

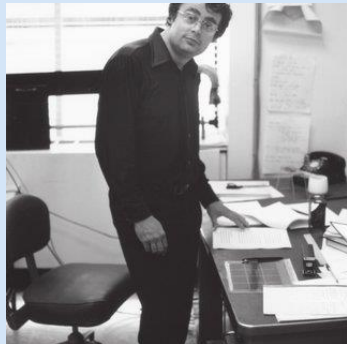
# 1950S-1999

Biology &  
Psychology



J.J Gibson

Brain's Algorithms



David Marr

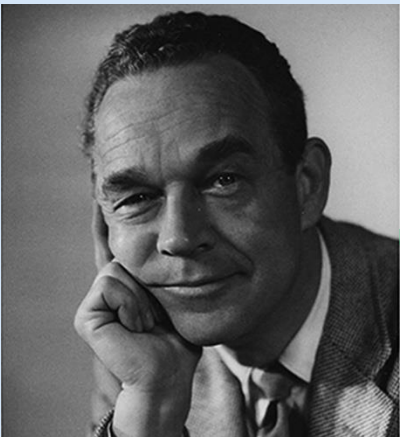
(Gibson, 1969, 1987)

1. Ecological Optics

2. Combined psychology, neuroscience, and physiology

3. Invariants

1950S-1999



Biology & Psychology

Brain's Algorithms

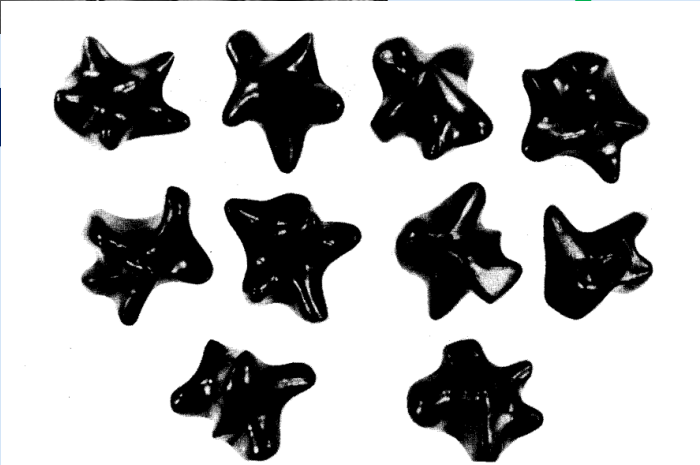
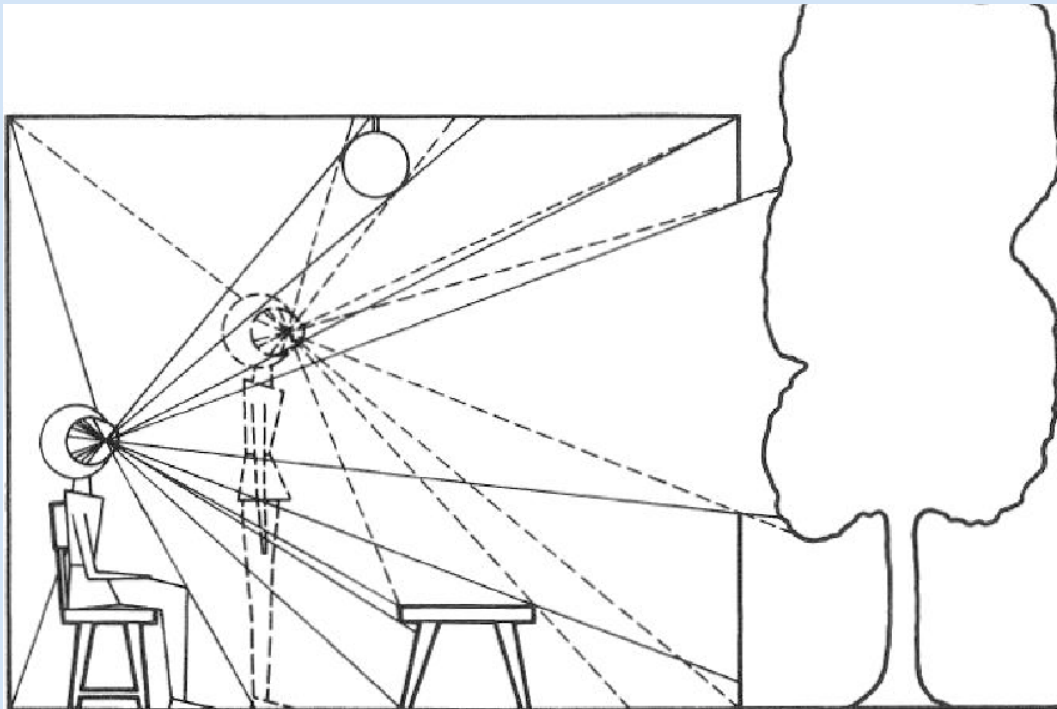


Figure 7.3 Sculptured objects for studying the haptic perception of shape. One set of feelable objects is shown; a duplicate set is available for haptic comparison or for visual-haptic matching.



ense

Joint  
Positi

Skeletal S

110 / THE SENSES CONSIDERED AS PERCEPTUAL SYSTEMS

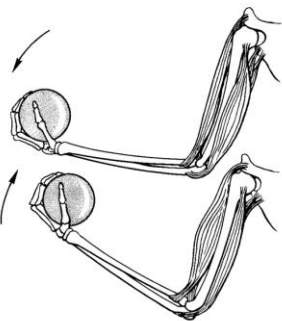
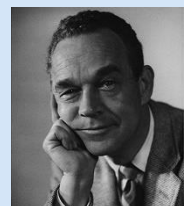


Figure 6.5 Bones, joints, and muscles. A pair of antagonistic muscles is represented, a flexor and an extensor of the upper arm. They are so innervated that when one is contracted the other is relaxed. The bending of the joint at the elbow through an angle of 30° is shown.

1950S-1999



Biology  
Psychology

J.J. Gibson



Brain's  
Algorithms

David Marr

Klatzky, Roberta L.

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HUMAN  
HAND  
FUNCTION



LYNETTE A. JONES  
SUSAN J. LEDERMAN

## Toward a computational model of constraint-driven exploration and haptic object identification

Roberta L Klatzky

University of California, Santa Barbara, CA 93106, USA

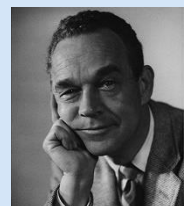
Susan J Lederman

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Received 3 August 1992



# 1950S-1999



Biology  
Psychology

J.J Gibson



Brain's  
Algorithms

David Marr



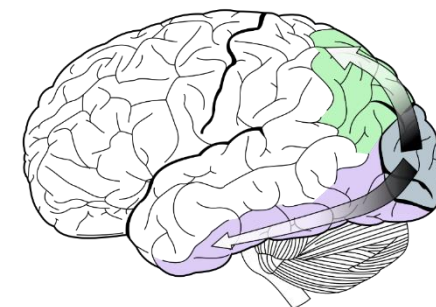
Volume 15, Issue 1, January 1992, Pages 20-25

Review

## Separate visual pathways for perception and action

Melvyn A. Goodale<sup>a</sup>, A.David Milner<sup>b</sup>

[Show more](#) ✓



### The visual brain in action

D Milner, M Goodale  
Oup Oxford

7258 2006

### A neurological dissociation between perceiving objects and grasping them

MA Goodale, AD Milner, LS Jakobson, DP Carey  
Nature 349 (6305), 154-156

1921 1991

### Two visual systems re-viewed

AD Milner, MA Goodale  
Neuropsychologia 46 (3), 774-785

1818 2008

### Size-contrast illusions deceive the eye but not the hand

S Aglioti, JFX DeSouza, MA Goodale  
Current biology 5 (6), 679-685

1465 1995

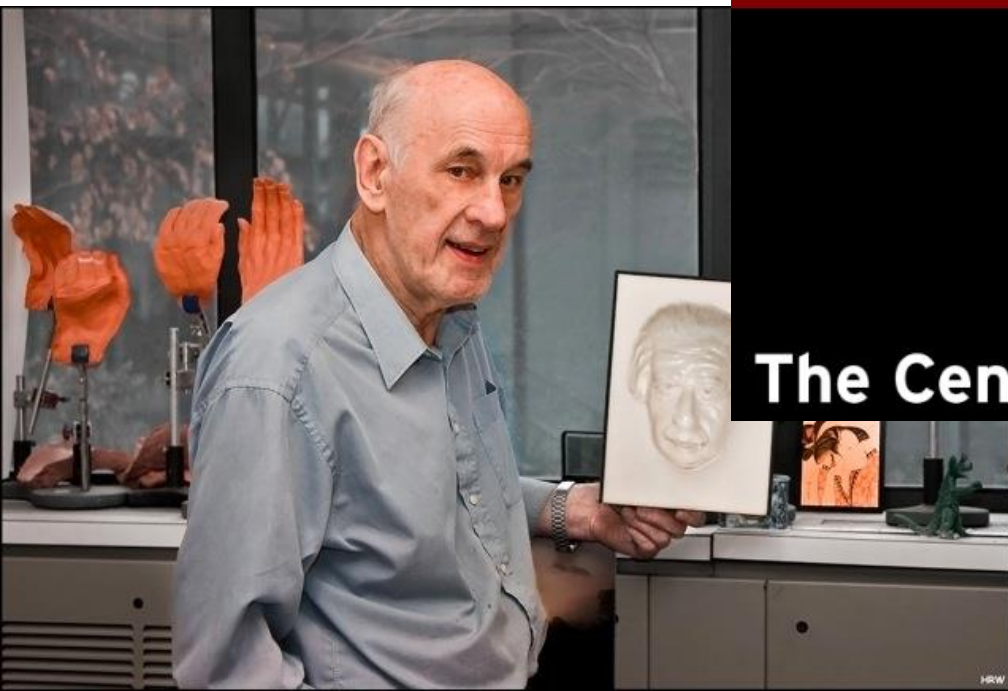
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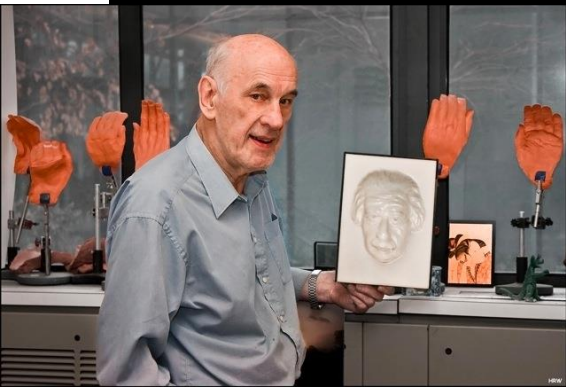
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Article | [Open access](#) | Published: 13 March 2024

## The effects of long-term exposure to microgravity and body orientation relative to gravity on perceived traveled distance

[Björn Jörges](#) , [Nils Bury](#), [Meaghan McManus](#), [Ambika Bansal](#), [Robert S. Allison](#), [Michael Jenkin](#)  
& [Laurence R. Harris](#) 



Haptics?

A Final Passion Project

## THE PERCEPTION OF UPRIGHT UNDER LUNAR GRAVITY

L. R. Harris<sup>1,2</sup>, M. R. M. Jenkin<sup>1,3</sup>, R. T. Dyde<sup>1†</sup>

<sup>1</sup> Centre for Vision Research,

<sup>2</sup> Departments of Psychology, and

<sup>3</sup> Computer Science and Engineering,  
York University, Toronto, Ontario, M3J 1P3, Canada

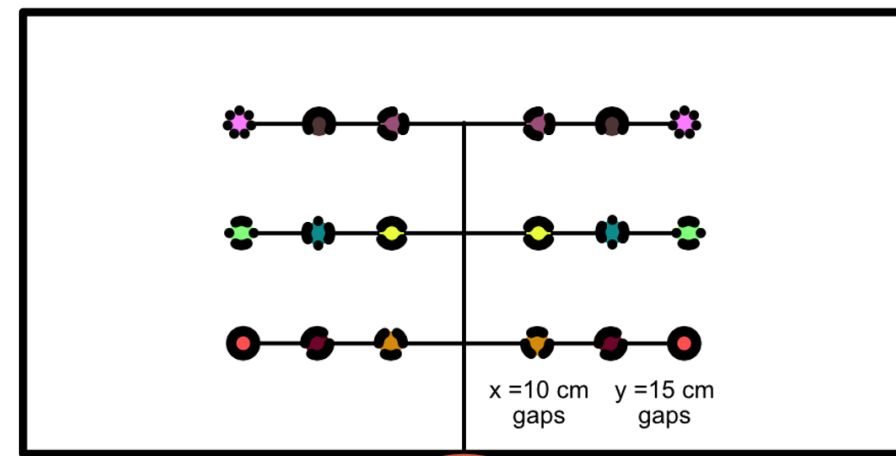
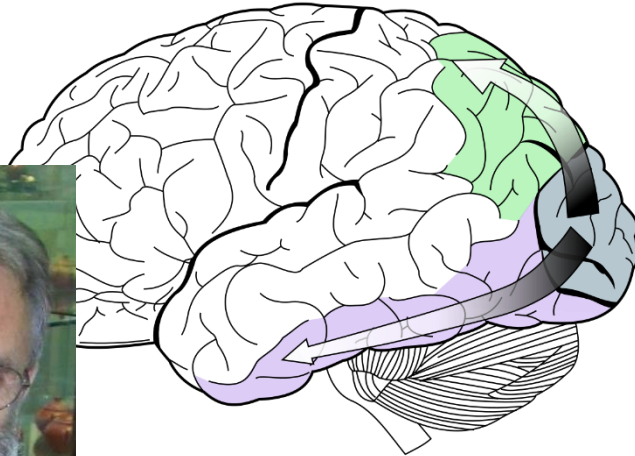
<sup>†</sup> deceased



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## Haptic perception of spatial relations

AML Kappers, JJ Koenderink  
PERCEPTION 28, 781-796



Klatzky, Roberta L.

Lederman, Susan J.

Toward a computational model of constraint-driven exploration and haptic object identification

Roberta L Klatzky

University of California, Santa Barbara, CA 93106, USA

Susan J Lederman

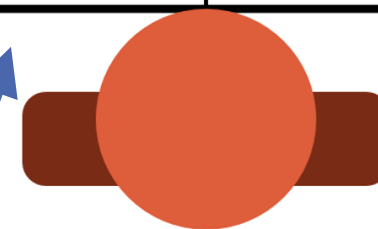
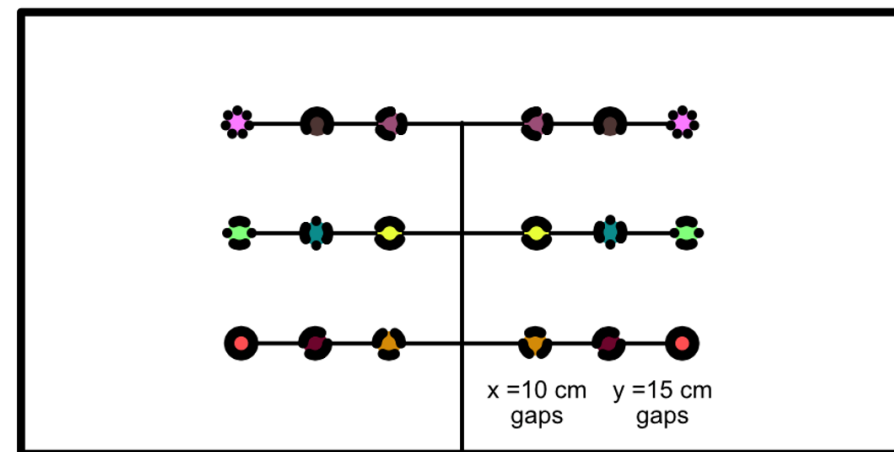
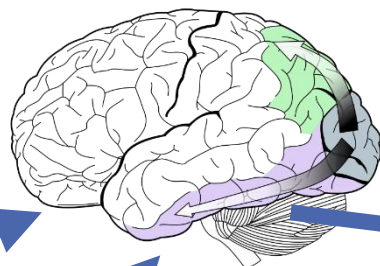
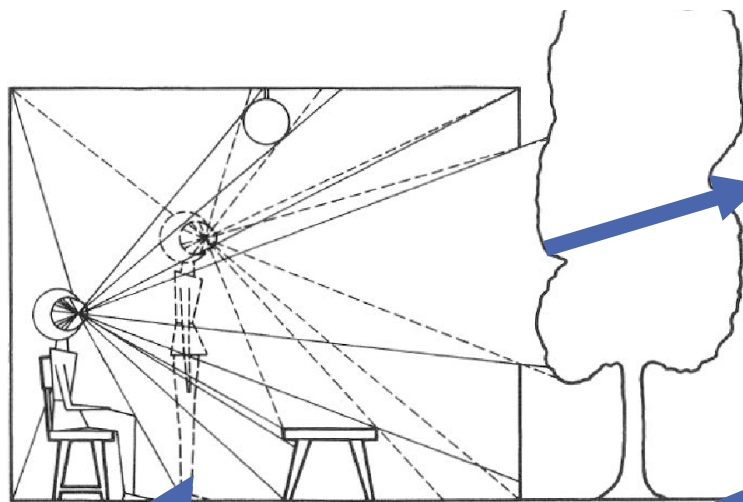
Queen's University, Kingston, Ontario K7L 3N6, Canada

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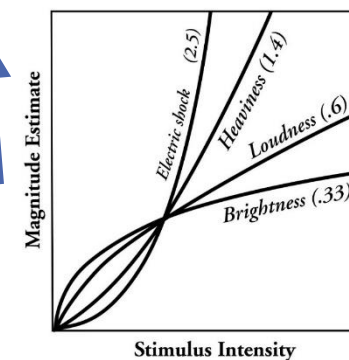
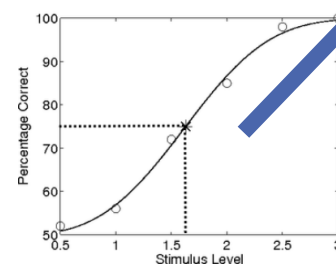
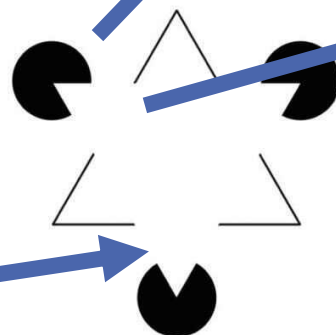
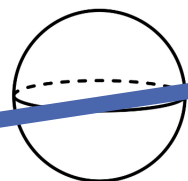
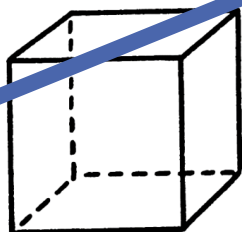
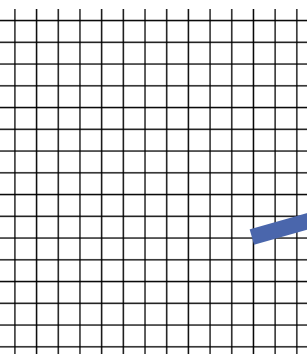
## Haptic perception of spatial relations

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PERCEPTION 28, 781-796



## Toward a computational model of constraint-driven exploration and haptic object identification

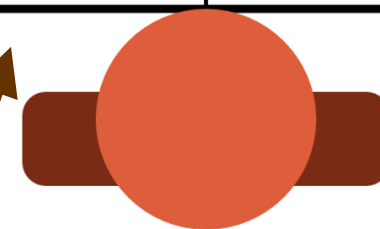
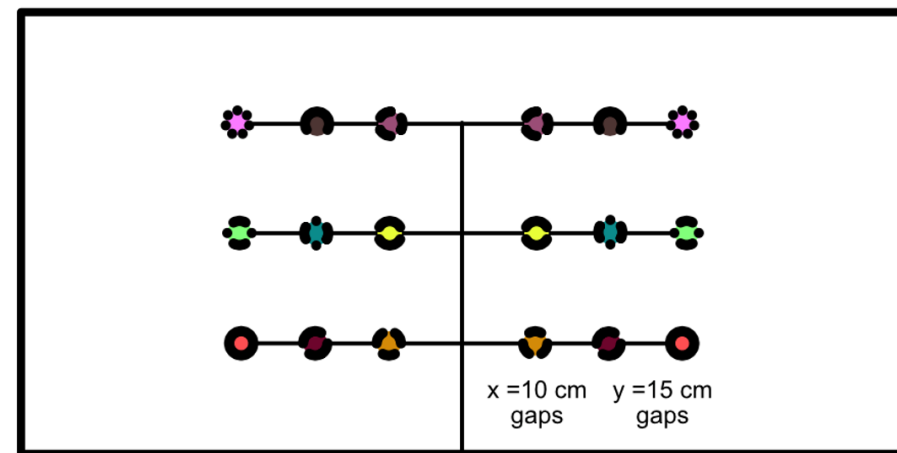
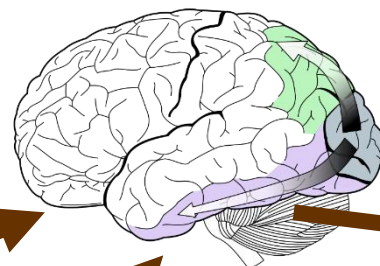
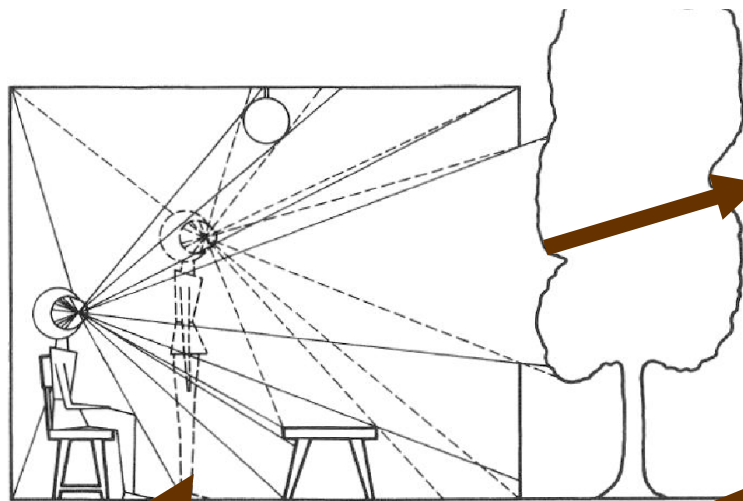
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Susan J Lederman  
Queen's University, Kingston, Ontario K7L 3N6, Canada  
Received 3 August 1992



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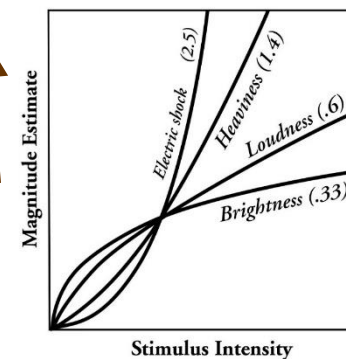
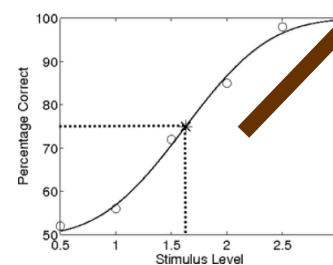
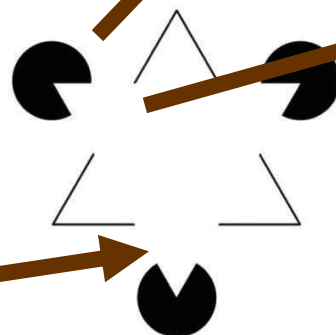
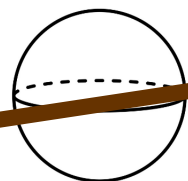
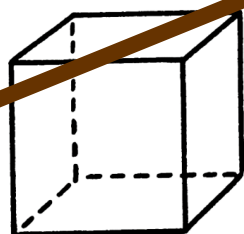
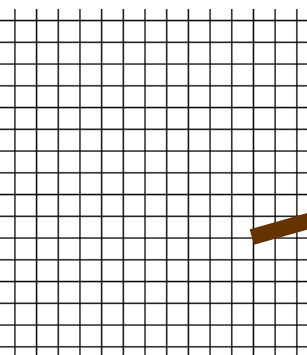
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PERCEPTION 28, 781-796



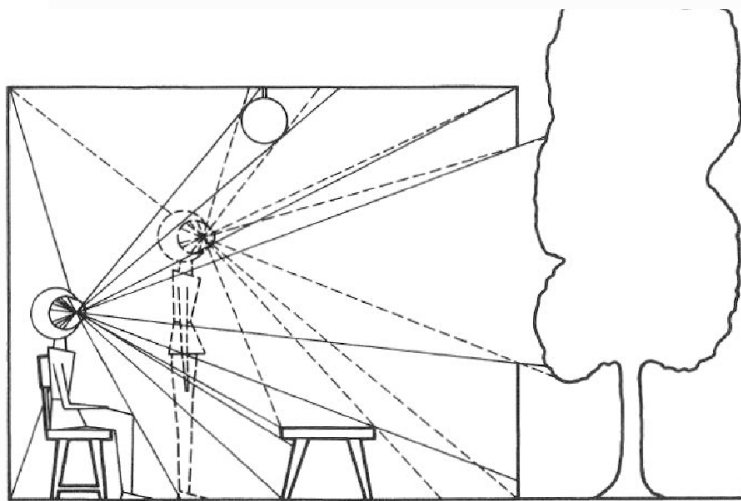
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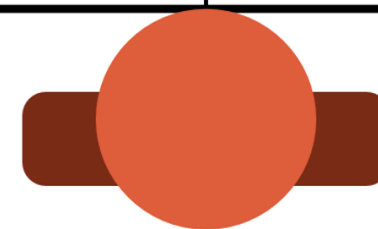
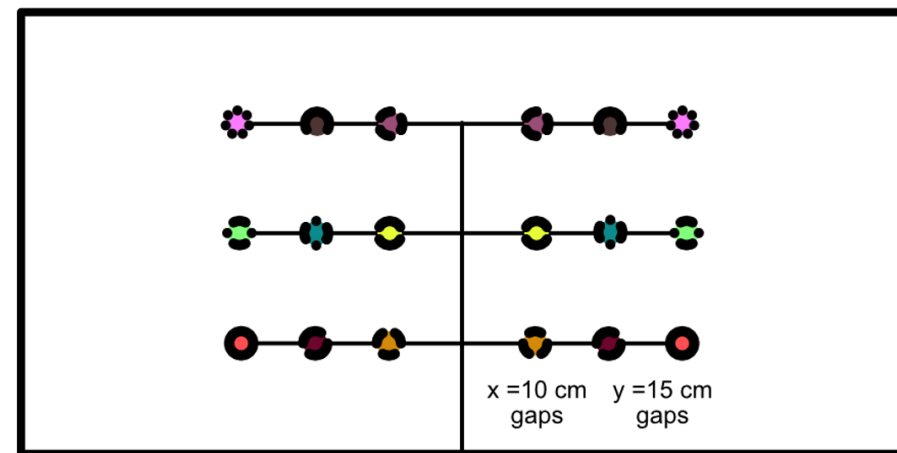
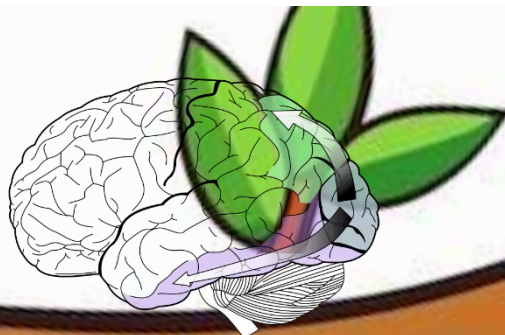


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AML Kappers, JJ Koenderink  
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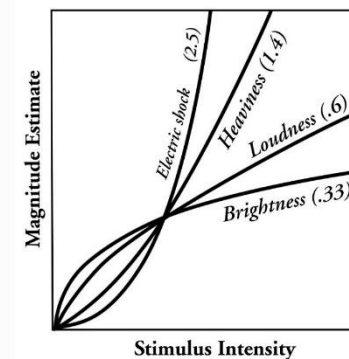
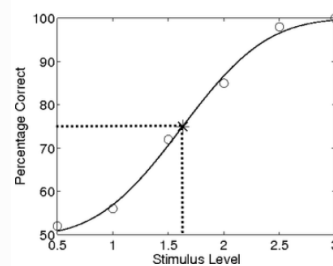
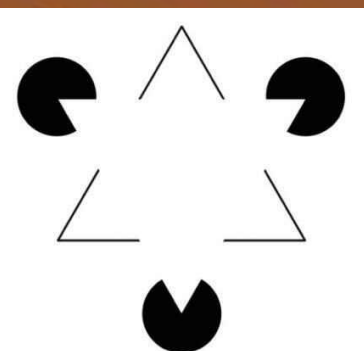
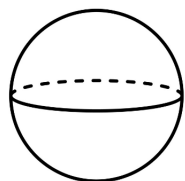
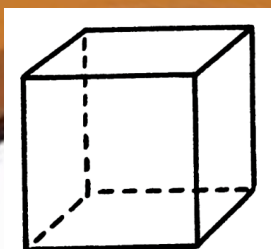
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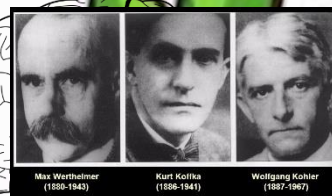
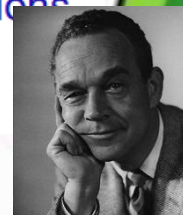
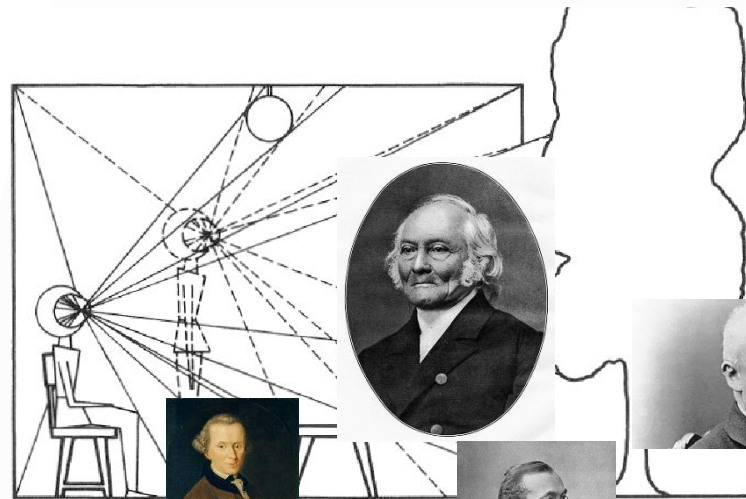


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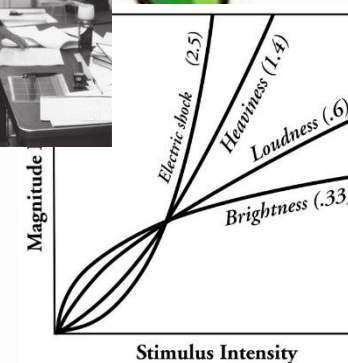
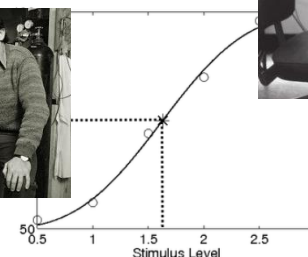
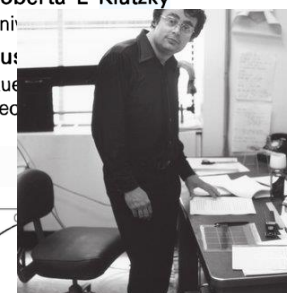


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# REFERENCES

- Albert, M. K. (1993). Parallelism and the Perception of Illusory Contours. *Perception*, 22(5), 589–595.  
<https://doi.org/10.1068/p220589>
- Brandt, T., Dieterich, M., & Huppert, D. (2024). Human senses and sensors from Aristotle to the present. *Frontiers in Neurology*, 15, 1404720. <https://doi.org/10.3389/fneur.2024.1404720>
- D H Hubel & T N Wiesel. (1959). Receptive fields of single neurones in the cat's striate cortex—PMC.  
<https://pmc.ncbi.nlm.nih.gov/articles/PMC1363130/>
- David Marr. (1982). *Vision*. <https://books.apple.com/us/book/vision/id1521739041>
- Gibson, J. J. (1987). *The Perception of Visual Surfaces*.
- Goodale, M. A., & Milner, A. D. (1992). Separate visual pathways for perception and action. *Trends in Neurosciences*, 15(1), 20–25. [https://doi.org/10.1016/0166-2236\(92\)90344-8](https://doi.org/10.1016/0166-2236(92)90344-8)
- Gregoric, P., & Fink, J. L. (2022). *Introduction Sense Perception in Aristotle and the Aristotelian Tradition*. Brill.  
[https://doi.org/10.1163/9789004506077\\_003](https://doi.org/10.1163/9789004506077_003)

# REFERENCES

James J. Gibson. (1969). The Senses Considered as Perceptual Systems. *Rukin House*, 44(1), 104–105.

<https://doi.org/10.1086/406033>

James, W. (1887). The Perception of Space. (I.). *Mind*, 12(45), 1–30.

Johnson, M. R. (2011). Spatial Cognition, Spatial Perception. *The Yale Journal of Biology and Medicine*, 84(1), 63.

Kant's Views on Space and Time (Stanford Encyclopedia of Philosophy). (n.d.). Retrieved November 6, 2024, from

<https://plato.stanford.edu/entries/kant-spacetime/>

Killeen, P. (2019). The Behavioral Psychophysics of SS Stevens.

Klatzky, R. L., & Lederman, S. J. (1988). The Intelligent Hand. In G. H. Bower (Ed.), *Psychology of Learning and Motivation*

(Vol. 21, pp. 121–151). Academic Press. [https://doi.org/10.1016/S0079-7421\(08\)60027-4](https://doi.org/10.1016/S0079-7421(08)60027-4)

Klatzky, R. L., & Lederman, S. J. (1993). Toward a Computational Model of Constraint-Driven Exploration and Haptic Object

Identification. *Perception*, 22(5), 597–621. <https://doi.org/10.1068/p220597>



# REFERENCES

- Lanczos, C. (1970). *Space through the Ages The Evolution of Geometrical Ideas from Pythagoras to Hilbert and Einstein* (Vol. 30). Academic Press London and New York.
- Lederman, S. J., & Klatzky, R. L. (2007). New directions in touch. *Canadian Journal of Experimental Psychology / Revue Canadienne de Psychologie Expérimentale*, 61(3), 169–170. <https://doi.org/10.1037/cjep2007017>
- Mach, E. (1960). *Space and Geometry in the Light of Physiological, Psychological and Physical Inquiry* (T. J. McCormack, Trans.). Cambridge University Press. <https://doi.org/10.1017/CBO9781107338449>
- Melvyn A. Goodale & G. Keith Humphrey. (n.d.). The objects of action and perception—ScienceDirect. Retrieved November 4, 2024, from <https://www.sciencedirect.com/science/article/pii/S0010027798000171>
- Millar, S. (2008). *Space and Sense*. Psychology Press. <https://doi.org/10.4324/9780203938645>
- Patton, L. (2018). Helmholtz's physiological psychology 1. In S. Lapointe (Ed.), *Philosophy of Mind in the Nineteenth Century* (1st ed., pp. 96–116). Routledge. <https://doi.org/10.4324/9780429508134-6>
- R. Steven Turner. (1994). *In The Eye's Mind*. Princeton University Press.

# REFERENCES

Skrodzki, M. (2020). Illustrations of non-Euclidean geometry in virtual reality (No. arXiv:2008.01363). arXiv.

<https://doi.org/10.48550/arXiv.2008.01363>

Wagner, M. (2006). *The Geometries of Visual Space*. Psychology Press. <https://doi.org/10.4324/9780203837627>

Weber, E. H. (1834). *E.H. Weber on the Tactile Senses* (E. R. Helen & J. M. David, Eds.; 2nd ed.). Psychology Press.

<https://doi.org/10.4324/9781315782089>

Wertheimer, M. (1923). *Investigations on Gestalt Principles*.

Zhou, J., Duong, L. R., & Simoncelli, E. P. (2024). A unified framework for perceived magnitude and discriminability of sensory stimuli. *Proceedings of the National Academy of Sciences*, 121(25), e2312293121.

<https://doi.org/10.1073/pnas.2312293121>



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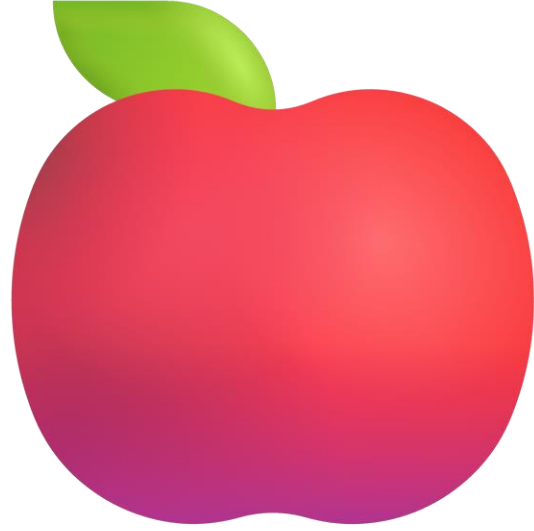
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- [https://www.researchgate.net/publication/235626691\\_The\\_Vision\\_of\\_David\\_Marr](https://www.researchgate.net/publication/235626691_The_Vision_of_David_Marr)
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