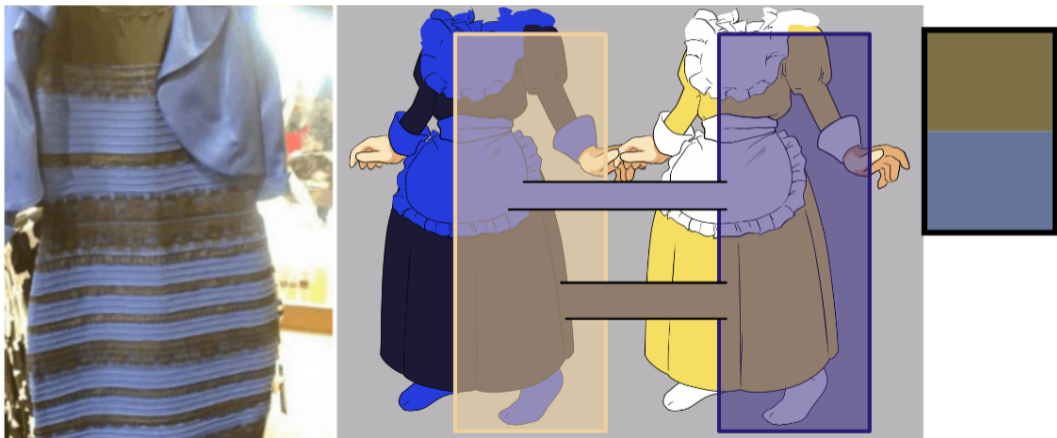# Vision Part 1

Informatics 1 Cognitive Science

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In vision context matters

Moravec's paradox

Articulated by Hans Peter Moravec, Carnegie Mellon University in 1988:

It is comparatively easy to make computers exhibit adult level performance on intelligence tests or playing checkers, and difficult or impossible to give them the skills of a one-year-old when it comes to perception and mobility.

This was important at a time when it was believed symbolic approaches could be used to produce intelligence.

Rodney Brooks pointed out in 2002 that intelligence according top AI research is

...best characterized as the things that highly educated male scientists found challenging.

1993: A perceptron recognises gender in images
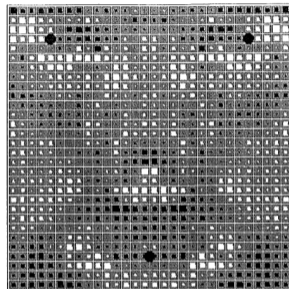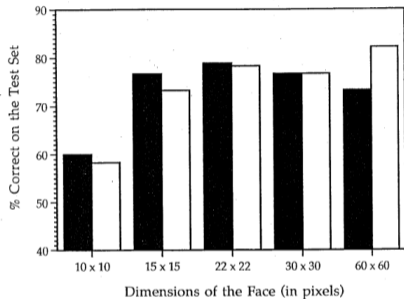
Source: Golomb, Beatrice A., and Terrence J. Sejnowski. (1993) A Perceptron Reveals the Face of Sex.

An everyday task for the brain
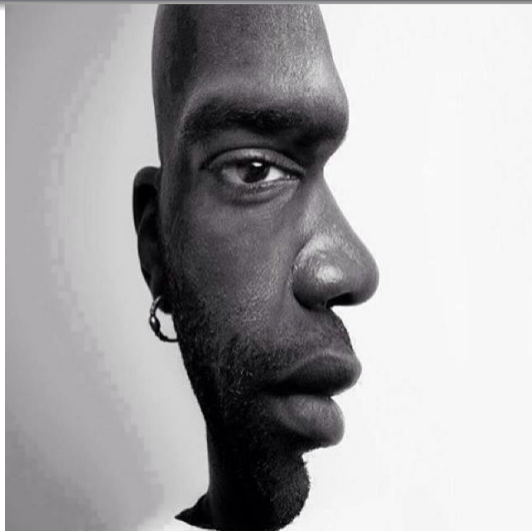

Sensory input

Motor output
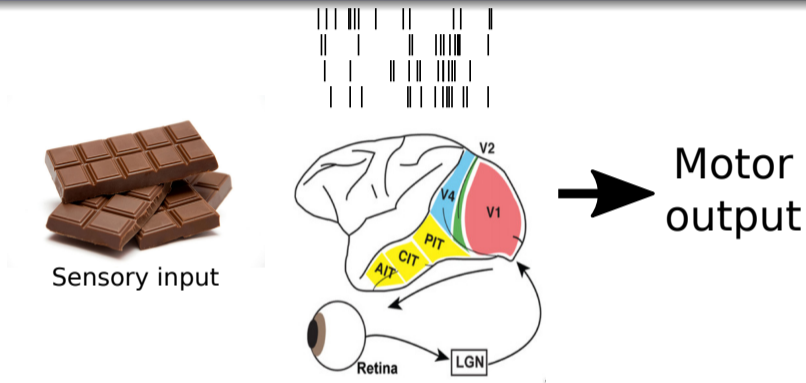
In daylight conditions, about 6 million photoreceptors send their signals to various brain areas that process visual information. What we perceive is an interpretation of the image, much detail is discarded along the way.
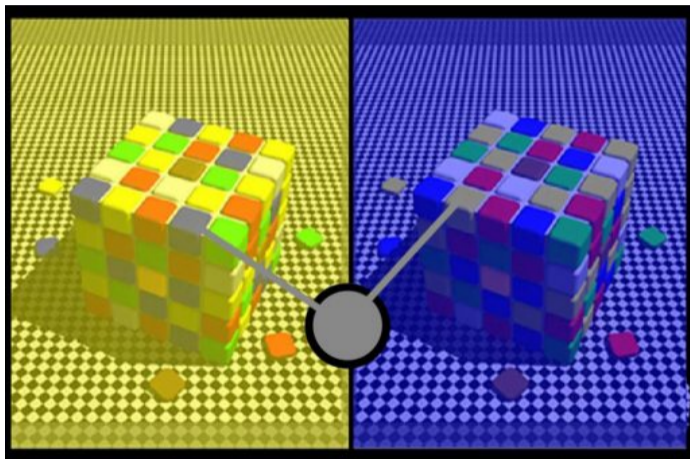
An everyday visual scene?

Three Sphinxes of Bikini - Salvador Dali
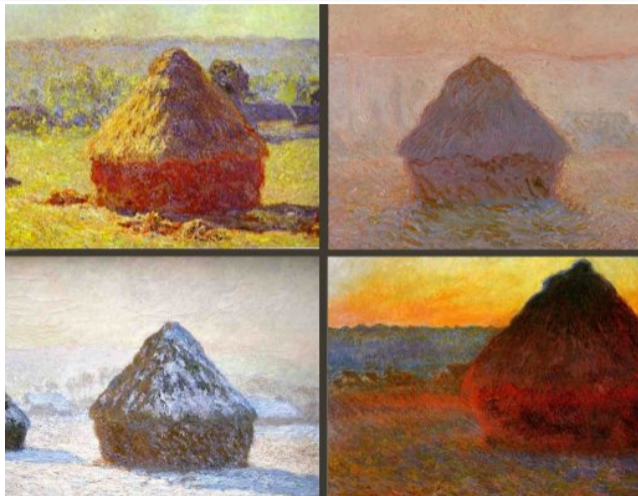
Are visual percepts unambiguous?

Bistable perception

Does the same always look the same?

Colour constancy

Is this the same Haystack?

Claude Monet's Haystacks

Understanding visual perception

- The sensory world is high-dimensional: Requires compression and simplification.
- Biological systems have limitations: Optimality under resource constraints.
- Elanor and James Gibson's ecological constraints: Environment and animal are inseparable, hence the senses are adapted to the environment.

The Occipital Lobe
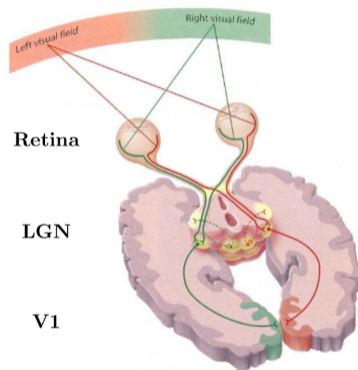
Light $\rightarrow$ Retina $\rightarrow$ Lateral Geniuclate Nucleus (LGN) $\rightarrow$ Primary Visual Cortex (V1)
Information also travels to other sub-cortical brain areas. Visual cortex activation is
required for conscious perception.

Representation of the Visual Field

The projection from the retina to V1 is *retinotopic* – adjacent points in the image are represented by neighbouring neurons. The largest part of the visual cortex is dedicated to the central visual field - the fovea in the retina.

Retinotopy enables Image Decoding
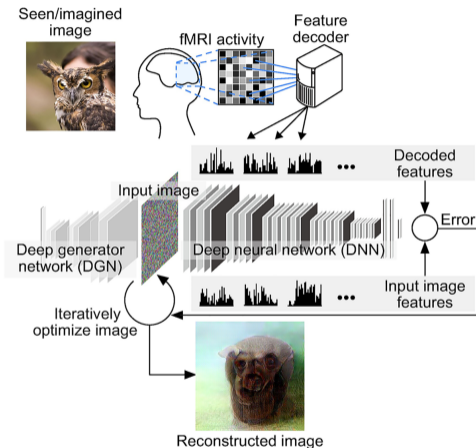
A decoder (here a neural network) is trained on fMRI recordings. (Shen G, Horikawa T, Majima K, Kamitani Y (2019). PLoS Comput Biol 15(1): e1006633)

Higher Visual Cortices
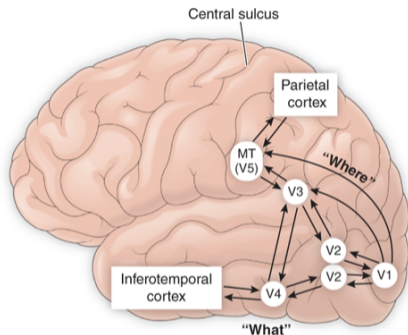
Source: F.R. Amthor, A.B. Theibert, D.G. Standaert,
E.D. Roberson: Essentials of Modern Neuroscience
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Dorsal "where" pathway: Location and movement, spatial and attention.
Ventral, "what" pathway: Form, shape and object recognition.

Complexity of Anatomical Visual Pathways