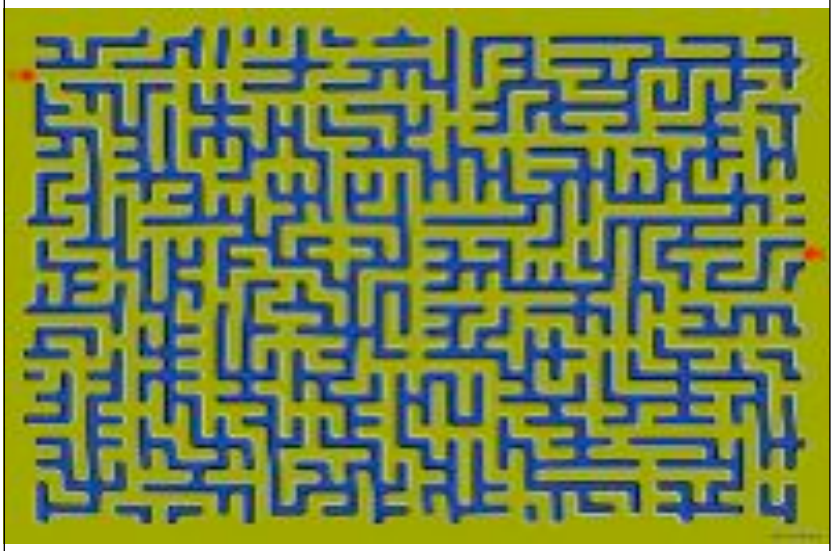
Visual Sensation and Perception

Chapter 3



Outline

- Sensation vs. perception (focus on vision)
  - Bottom-up and top-down processing
- Neurons and knowledge about the environment
- Perception and action
- The interaction between perception and action
  - Mirror neurons

Sensation vs. Perception

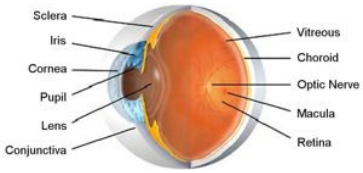
(*forget about book definition of these terms*)

- **Sensation**
  - receiving sensory stimulation and encoding it into the brain
  - detecting elementary sensory features
    - e.g., visual patterns of light and dark
- **Perception**
  - organizing, recognizing, and interpreting sensory information
  - relies on factors such as memory, context, attention

Bottom-up processing: Neural

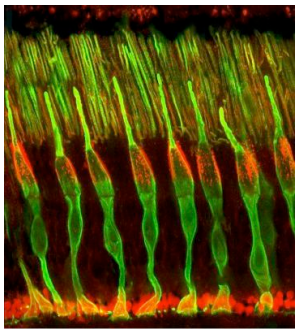
- Something to consider: is the eye an externalized part of the brain?
- Is the eye necessary to see things?
  - Hallucinations
  - Synesthesia

Parts of the eye:



The Retina and Choroid

Back of the Eye

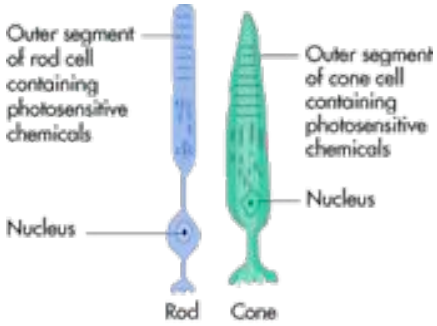


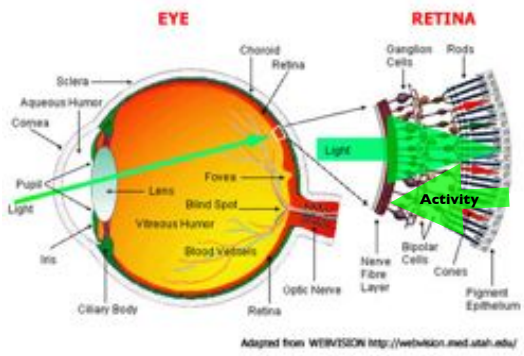
Choroid

Retina

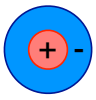
Front of the Eye

Photoreceptors





On-center, Off- surround
receptive field of a bipoar cell

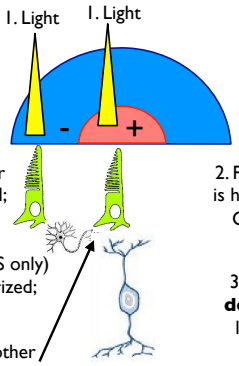


Photoreceptor (e.g., rod)

Horizontal Cell

Bipolar Cell

Ganglion Cell (not shown, because it does exactly what the bipolar cell does)



2. Photoreceptor is hyperpolarized; Glutamate ↓

3. Horizontal cell (S only) is also hyperpolarized; Glutamate ↓

4. This depolarizes other photoreceptor; Glutamate ↑

5. Bipolar cell is **hyperpolarized** from more Glutamate!

6. Hyperpolarization causes **inhibition**.
Cell is quiet.

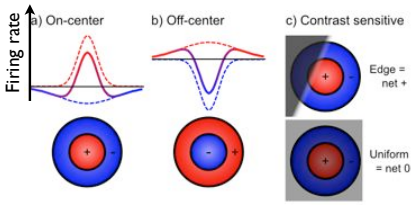
2. Photoreceptor is hyperpolarized; Glutamate ↓

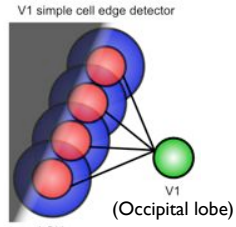
3. Bipolar cell is **depolarized** by less Glutamate

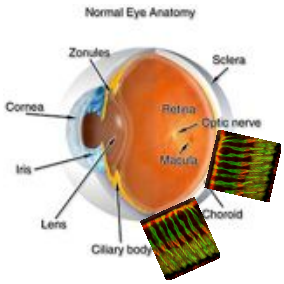
4. Depolarization causes **excitation**!
Cell fires!
"I see the light!"

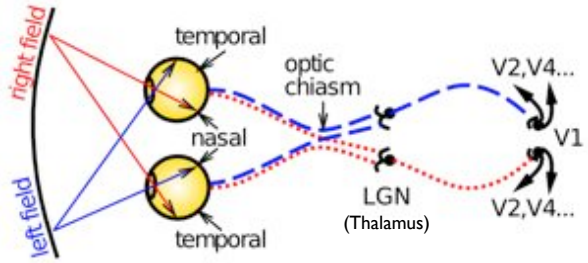
Receptive Fields

- Retinal cells respond only to **contrast** (really simple cells!)
- On-center: more firing when center is exposed to light
- Off-center: more firing when surround is exposed to light
- **Overlapping RFs form feature detectors (V1)**



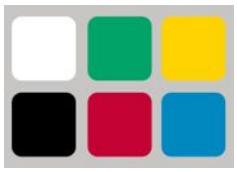






Opponent-Process Model

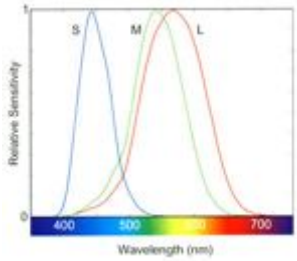
- The opponent color theory suggests that there are three opponent channels:
  - black versus white (or luminance).
  - red versus green
  - blue versus yellow
- Receptive fields excited by one color of an opponent channel are inhibited by the other color.



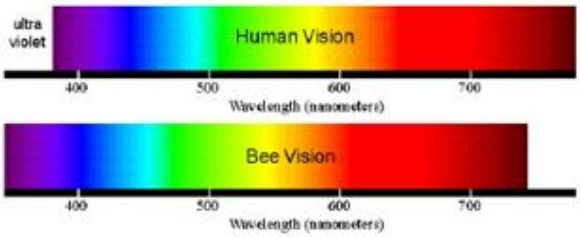
- Since one color produces an excitatory effect and the other produces an inhibitory effect...
  - the opponent colors are never perceived at the same time.

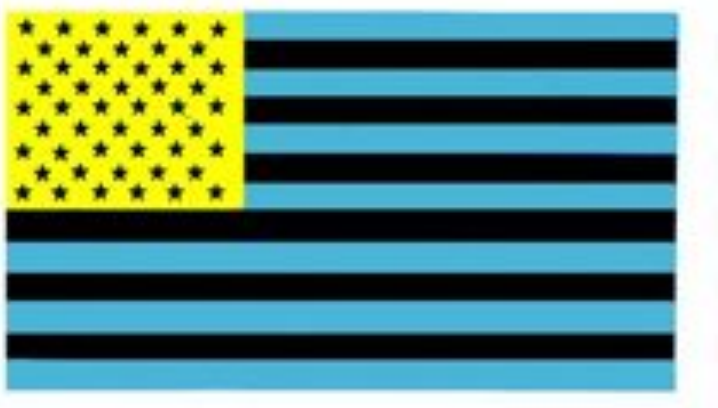
Rods and Cones

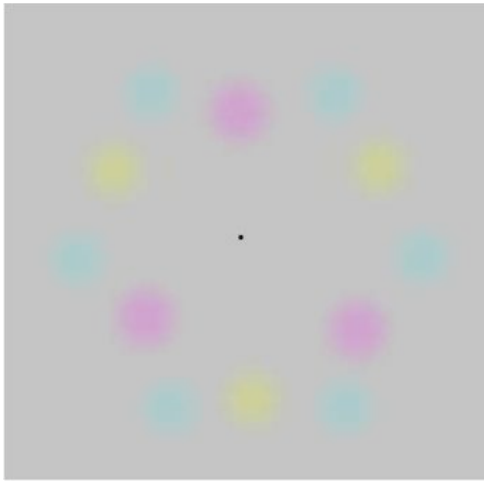
- Properties of Rods:
  - Luminance
  - Low spatial acuity
  - Mostly in the periphery

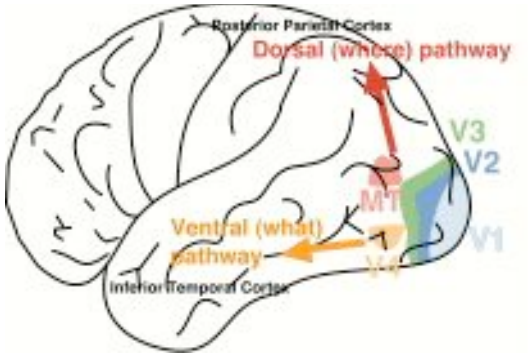


- Properties of Cones:
  - Color vision
  - High spatial acuity
  - Mostly around the fovea
  - There are 3 types of cones: S-cone, M-cones, and L-cones (based on wavelength)



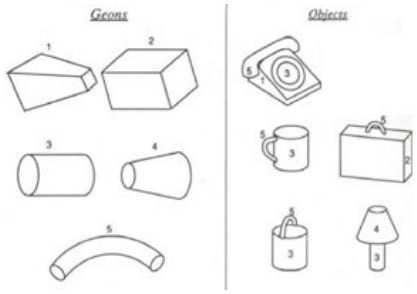




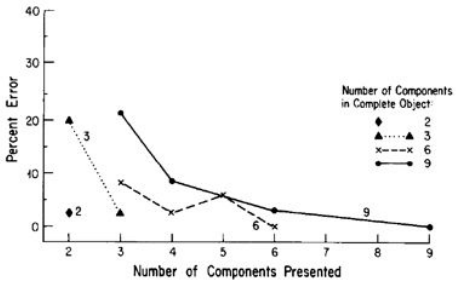


Bottom-up processing: Behavioral

- Recognition by components (RBC) theory
  - (Biederman, 1987): we perceive objects by perceiving their elementary features.

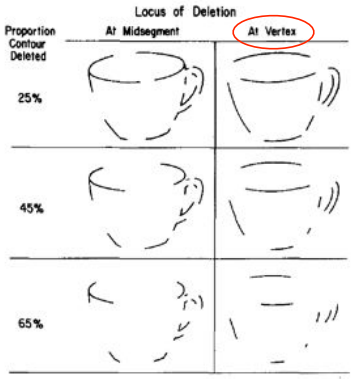


Recognition by components



Recovery of components

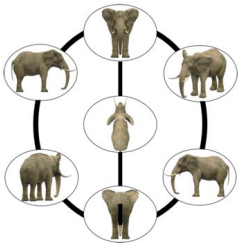
- People are much slower and less accurate with vertex deletion.
- Vertexes contain more information about component geons!



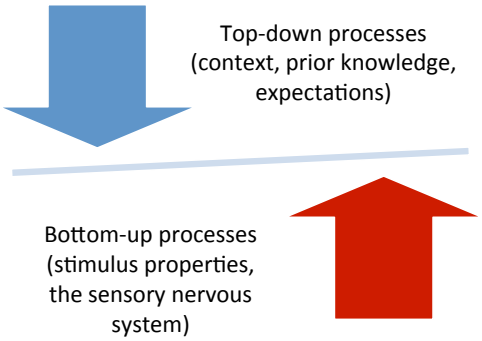
Problems with RBC

- RBC cannot differentiate sub-categories of objects and individuals.

- Object recognition is more dependent on viewpoint than predicted by RBC.



Beyond bottom-up: Top-down

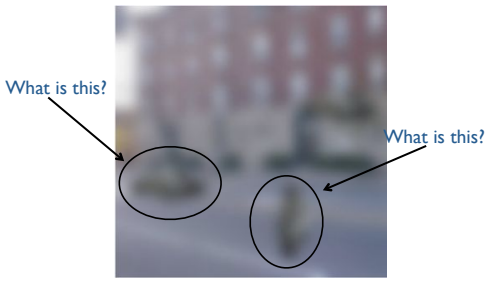


Top-down processes (context, prior knowledge, expectations)

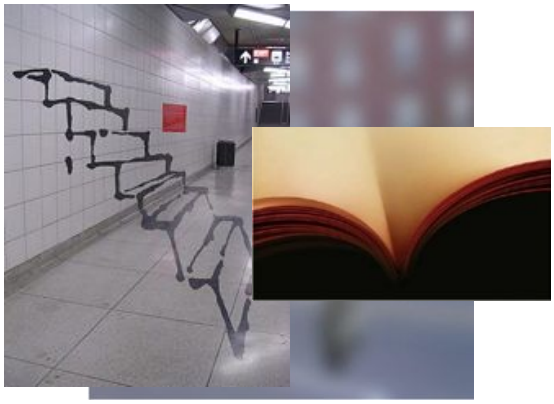
Bottom-up processes (stimulus properties, the sensory nervous system)

Perception depends on top-down processes

- What we see is not the same as what we perceive.

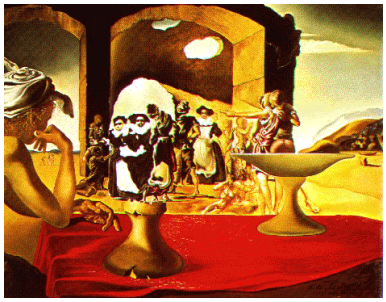


Oliva & Torralba (2007)



Attention

Attention



Attention

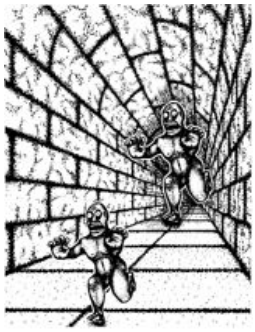
Perceiving size and distance

Size constancy

Perceiving Size

Size constancy:
How tall is the man in white walking away?

Size/distance illusion



The importance of top-down perception

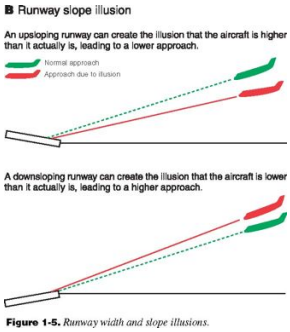


Figure 1-5. *Runway width and slope illusions.*

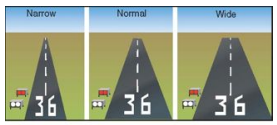


Figure 15-4. Runway Illusions.

Understanding how our perceptual system makes mistakes is critical for preventing accidents in a wide range of fields!

Gestalt laws of organization

Herman von Helmholtz
1821-1894

- Helmholtz proposed the theory of unconscious inference (1866).
- Unconscious inferences are based on the **likelihood principle**; that is, we perceive the object that is most likely to have a generated a pattern of stimuli.
- Related to Gestalt psychologists later approach to perception.

Gestalt laws of organization

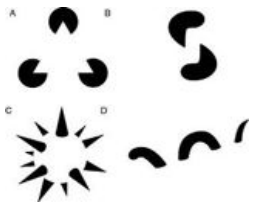
- Gestalt = literally, the essence or shape of an entity's complete form; "the whole is greater than the sum of its parts".
- Gestalt psychology is concerned with the rules that govern perceptual organization.

The principle of good continuation

- Good continuation states that: *points, when connected, results in straight or smooth lines, and when overlapped by other objects, lines are perceived as continuing behind the overlapping object.*

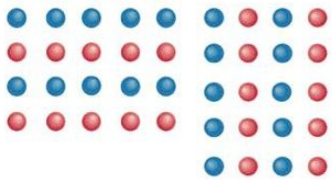
The principle of good figure (Pragnaz)

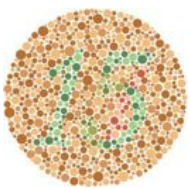
- Every stimulus pattern is seen in such a way that the resulting structure is as simple as possible.



The principle of similarity

- Similar things appear to be grouped together.





Meaningfulness and familiarity

- Things that form patterns that are familiar or meaningful will be grouped together.

Depends on context:

ABC

12
13
14

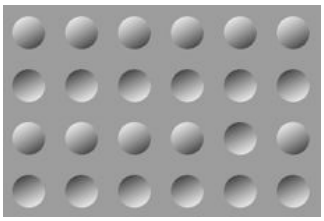
Gestalts are heuristics, not “laws”

- Ecological Psychology: to fully understand behavior we need to understand the context (environment) in which the behavior took place.

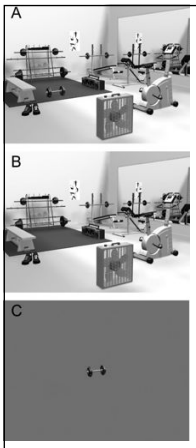
James J. Gibson
1904-1979

- Gestalt principles are heuristics that we develop because they lead to the correct answer *most* of the time.

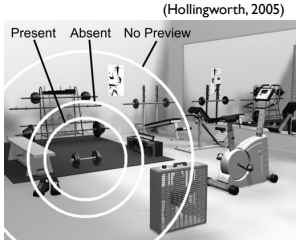
Bumps & Depressions



- **The light-from-above heuristic**: our previous experience with light and shadow in the environment biases our interpretation of shape.
- This is an example of a **Physical Regularity**.



(Hollingworth, 2005)

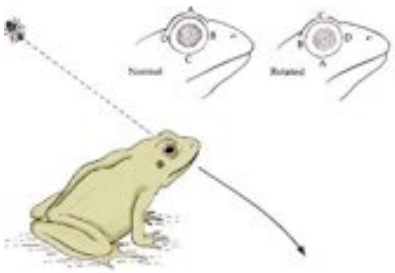


- Even subjects who did not see the target object ("absent" condition, B) were able to extrapolate, based on **prior experience**, to approximate the location of the target object.
- This is an example of a **Semantic Regularity**.

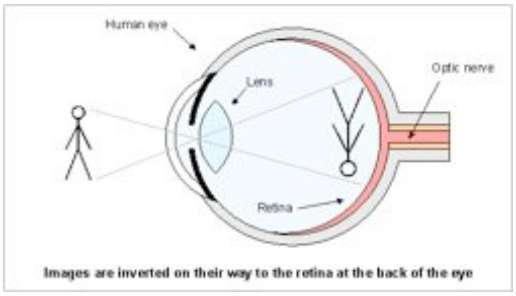
Neurons and knowledge about the environment

- Underlying every behavior, something is happening at the neural level.
- Or brains are partly genetic creations, but the structure and function of brain areas is also determined by the environment.
  - Experience Dependent Plasticity
  - Perceptual Adaptation (George Stratton, 1890s)

Plasticity



Roger Sperry (1940)



Images are inverted on their way to the retina at the back of the eye

Faces

Giuseppe Arcimboldo

Remember the FFA…

- The FFA is part of the temporal lobe that responds preferentially to faces.
- But is this an innate property of the FFA or is this learned?
  - Are we genetically engineered to recognize faces?
  - Or does the brain learn to specially represent faces because of their importance in human life?

Templates in Machine Vision

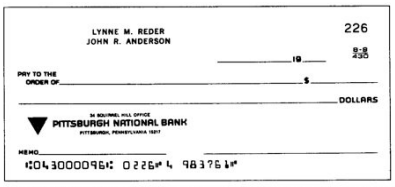
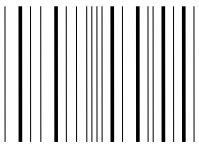
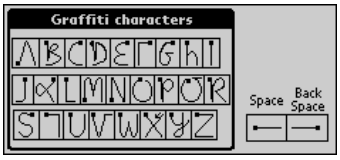


FIGURE 2.16 A typical blank check, with account numbers specially designed to permit successful template matching.

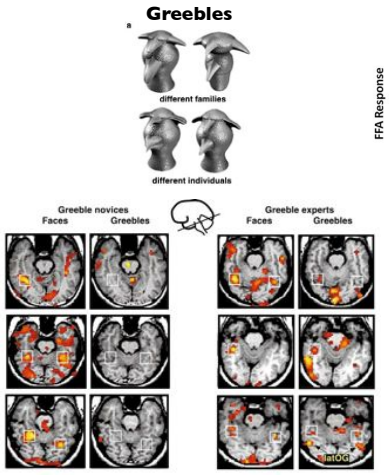


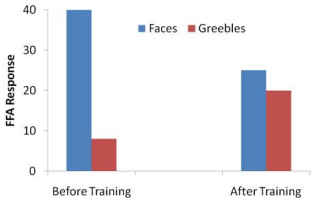
Bar Codes



Palm Pilot

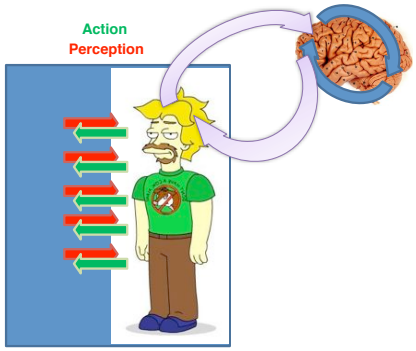
Experience Dependent Plasticity





Isabel Gautier
Vanderbilt

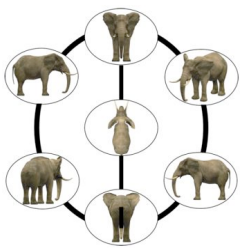
What is Cognitive Psychology?



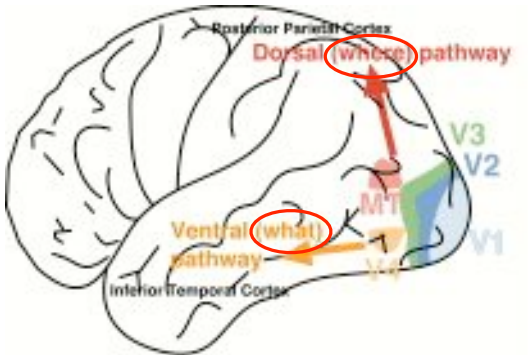
The interaction between perception and action

- Movement modifies our perceptions.
- Our perceptions modify our movements.
- How does the human body use perceptual information to control movements so accurately?

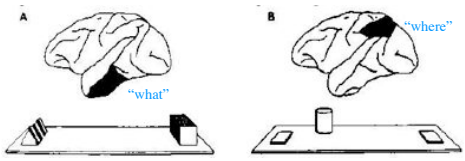
Viewing



Interacting



What vs. Where in Visual Perception



- Inferior Temporal Lobe Lesions
  - Impairs visual object identification ("what")
- Parietal Lobe Lesions
  - Impairs spatial perception ("where")

- *Good Example of "Double Dissociation"*
  - *Two lesions producing opposite effects*

Motor Learning - Mirror Neurons

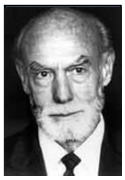
Giacomo Rizolatti
Universita Degli Studi de Parma

- A neuron in the frontal cortex that fires both when an animal views an action and when an animal performs an action.
  - Directly observed in primates and birds.
  - Neuroimaging in humans suggests mirror neurons in PreMC, sMC, S1, and inferior parietal cortex.

- Critical for **observational learning**.

Mirror Neurons

- Common Coding Theory: there is a shared representation (common code) between perception and action systems.
  - Perception is a means to action.
  - Action is a means to perception.



Roger Sperry
1913-1994

- **Observational learning** in dolphins.
  - Dolphins map hand signals more quickly onto pectoral fins; foot signals onto tail fins.

Dolphin
Present day