Principle of Unvariance (revisited)
Stereopsis from Binocular Disparity

The Vieth-Müller Circle
**Relative Disparity**

(a) Crossed disparity

(b) Uncrossed disparity

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Stereovision in the brain

• Disparity-selective neurons:
  – some V1 neurons (and many in V2 and MT, among other areas) fire only when a line passed through their receptive field has the proper orientation, direction, and disparity.
Responses of a disparity-selective neuron.

Distribution of disparity tunings of neurons.
Stereovision in the brain (contd.)

• … notice that many neurons prefer zero disparity.

Correspondence problem

• We've talked about disparity as deriving from the different relative positions of images in the two eyes.
• But in order to calculate the offset (disparity), the brain must know which parts of each image to compare.
• In other words, there is a correspondence problem.
The correspondence problem: multiple possibilities for matching the inputs to the 2 eyes.

Correspondence problem (contd.)

• Sherrington (1906) proposed that each eye's image gets processed so that higher-level forms can be matched.
  – This technique, while easy to intuit, should seem somewhat improbable-- why would the visual system do everything twice?

• Austin (1907) publicized a phenomenon that provided early counterevidence against Sherrington's view:
  – when different faces are presented to each eye, the faces blend, yielding a single and novel face. Often, the face is more attractive than either of its components. Wow.
Do the faces blend, become more attractive?!

The Correspondence Problem (contd.)
The Correspondence Problem (contd.)

- Julesz's random-dot stereograms posed stronger challenges to both of these theories.
  - Remember that these random-dot patterns have no identifiable forms to match, but are somehow fused.
- Panum's fusional area:
  - When you fixate on an object at a certain depth, all other objects along the horopter, plus and minus a small amount, will also appear "fused". Objects outside this region (Panum's fusional area) will appear as double images.

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Binocular Vision and Stereopsis (cont’d)

- A few ways to solve the correspondence problem:
  1. Uniqueness constraint: A feature in the world will be represented exactly once in each retinal image
  2. Continuity constraint: Except at the edges of objects, neighboring points in the world lie at similar distances from the viewer
  3. Blurring the image: Leaving only the low-spatial frequency information

Low Spatial Frequency Random Dot Stereogram
Correspondence problem (contd.)

• Diplopia: double vision. Demonstrate this simply by holding your thumb near your eyes and looking at something far.
  – This is constantly occurring, in less extreme cases (i.e., objects further from your eyes than in the thumb demo), but you tend not to notice it. Why?

• Binocular rivalry: an example of when the visual system can't solve the correspondence problem.
  – In rivalry, very different images are presented to each eye. Instead of a blending, one eye's view dominates for a while, then the other eye's view dominates (with occasional mixes during transition periods).

Judging size and shape

• A fundamental of object perception is that the objects we see are in a 3D world. Therefore, we are very adept at transforming 2D images (like drawings) into 3D percepts.

• In the case of the Shepard Tables illusion, we cannot perceive the two rectangles as the same (merely rotated) because we cannot avoid perceiving them as table tops viewed in depth (which would not be the same size).
Judging size and shape (contd.)

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Judging size and shape (contd.)

• Size constancy. The visual system compensates for perspective and distance when judging size.
  – While we all know that objects (or people) who are far away yield a smaller retinal image than nearby things, the amount of compensation that our visual systems automatically perform is often surprising.
Judging size and shape (contd.)

- Shape constancy. Often, we view objects from an angle.
- The retinal image is accordingly slanted, but we don't really perceive much of this distortion.
- View this picture of Richard Nixon standing in front of a Richard Nixon poster.
Judging size and shape (contd.)

- Note that the photographer was at an angle from the poster, and notice that in the poster Nixon looks distorted (slanted).
- Now, if you turn yourself so that you are viewing the picture from an angle, notice that in the poster Nixon doesn't appear so distorted. Why?
Perspective in art

• If you refer back to the list of depth cues, you’ll notice that many of them are standard tools employed by artists to produce percepts of depth.
• However, there are also large stylistic differences over time and cultures in the representation of depth.
• Consider these examples and think about what they rely on to produce depth (and how effective they are):
  – Egyptian (lack of perspective)
  – Chinese and Japanese
  – Renaissance