Motion phenomena

9.35

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Motion phenomena are rich and varied

Some examples :

Ames trapezoid

Motion parallax and head motion

Apparent motion

Square wave missing the fundamental

The Ames trapezoid

(Image removed due to copyright considerations.)

A trapezoid rotates about a vertical axis. The object is interpreted as a rectangle in perspective, and the short side always appears to be farther away than the long side. As a result, it looks like a rectangle flapping back and forth, but never making a full rotation. This shows that static depth cues (in this case spurious) can overwhelm the depth cues that are there from motion (in this case valid).

Motion parallax and head motion

(Image removed due to copyright considerations.)

Take an array of random dots. Move each row left or right, with a sinusoidal motion. Let the amplitude of the motion vary sinusoidally with the height of the row. It looks like a 3-D corrugated surface oscillating left and right. The dots moving in one direction look closer, and the ones moving in the opposite direction look farther. But it's ambiguous: either direction can look closer.

Now move your head side to side in synchrony with one row of dots. That row tends to be seen as farther, with the opposite moving row closer. This is consistent with what would happen if you really were moving with respect to a 3-D object.

More motion parallax and head motion

(Image removed due to copyright considerations.)

Another example. The yellow strips move one way while the neutral strips move the other way (both sliding back and forth). You see two surfaces at different depths. By moving your head in synchrony with one set of strips, you can change which strips are seen in front.

Apparent motion: position change

(Image removed due to copyright considerations.)

When you view one frame, and then the other, in alternation, you have the perception of motion through the intervening space. The Gestalt psychologists took this as evidence that "the whole is greater than the sum of its parts," since each frame by itself is static.

Apparent motion: shape change

(Image removed due to copyright considerations.)

When you view one shape and then the other, you do not have the impression of one object disappearing and another appearing. Instead, you see one object that is changing shape.

Apparent motion: color change

(Image removed due to copyright considerations.)

Suppose that the two objects are at different positions and have different colors. You see a single object that is moving and changing color.

Apparent motion: looming.

(Image removed due to copyright considerations.)

If the two objects are the same shape but different sizes, you have the impression that the object is expanding (or shrinking). It can be seen as a 3-D effect, so it is an object of fixed size that is getting closer (or farther) from you. The perception of something coming toward you and increasing in retinal size is called "looming."

You can scare a cat by pointing an umbrella at it and opening the umbrella. It looks like a small object getting big very fast, which suggests that it is coming toward the cat at great speed.

Apparent motion: rotation.

(Image removed due to copyright considerations.)

An object viewed alternately at two different angles will appear to rotate back and forth. It will tend to take the shortest path, e.g., will tend to rotate 45 degrees clockwise rather than 225 degrees counerclockwise.

Apparent motion: internal patterns

(Image removed due to copyright considerations.)

If the two objects have some internal texture, such as the gratings here, you will tend to see the the patterns transform into each other. In this case the grating appears to rotate.

The basic idea of apparent motion

Apparent motion: displacement in time and space leads to impression of motion.

Interpretation in terms of feature matching: match a local feature at time 1 to the corresponding local feature at time 2.

Recall Julesz random dot stereogram.

(Image removed due to copyright considerations.)

Julesz considered the analogous issue in stereopsis. Are objects first recognized and then matched, or is the matching done on low-level non-interpreted information? The random dot stereogram showed that matching could happen with low-level information.

Random dots in time.

(Image removed due to copyright considerations.)

The same effect happens in temporal presentations. There is a square of dots in the center that moves left or right between frame 1 and frame 2. It is easy to see the motion, even though the square is invisible in each frame alone. It turns out that cells in V1 can detect this motion.

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Shift and compare with time delay

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Models for motion detectors generally contain a shift in time and space with a combination rule like multiplication. The term “Reichardt detector” is sometimes used for all of them, since Reichardt was an early pioneer.

What is getting matched? Features or frequency components? Consider the components a jumping square wave.

(Image removed due to copyright considerations.)

A square wave grating, and the same grating missing its fundamental.

(Image removed due to copyright considerations.)

Which way will the grating appear to move when the fundamental is removed?

(Image removed due to copyright considerations.)

Answer: it seems to move backwards (leftward), in accord with the 3rd harmonic, and contrary to the prediction of feature matching.