Feature Blur and the Break of the Curveball

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In the game of baseball, a pitcher stands on a mound and throws a 2.9-inch diameter ball in the direction of home plate. The pitcher creates different types of pitches by releasing the ball at different velocities and with different spins. A typical major league "curveball" travels at about 75 mph, and spins at an oblique angle at about 1500 rpm; this means that the travel time from the pitcher's hand to home plate is about 0.6 sec, during which time the ball undergoes about 13 rotations.

The spinning of the curveball creates both a physical effect ("the curve") and a perceptual puzzle. The curve arises because the ball's rotation creates an imbalance of forces on different sides of the ball, which leads to a substantial deflection in the path of the ball. The perceptual puzzle arises because the deflection of the ball should appear gradual, but from the point of view of the batter standing near home plate, the flight of the ball often appears to undergo a dramatic and nearly discontinuous shift in position (this sudden shift is referred to as the curveball's "break").

Here we present an illusion that suggests that the perception of a "break" in the curveball's path may be related to physiological differences between foveal and peripheral vision. We contend that the visual periphery frequently reports a perceptual combination of features (a process we refer to as "feature blur") because it lacks the neural machinery necessary to maintain separate representations of multiple features.

Illusion 1: Rotating reversals

In the Rotating Reversals illusion, we illustrate feature blur. In this illusion, six ovals rotate counter-clockwise, but gratings internal to the ovals rotate clockwise.
(See also http://www.illusionsciences.com/2008/12/rotating-reversals.html. As discussed at this site, the Rotating Reversals effect was discovered independently by Shadlen and Meilstrup.)

1. When the observer looks directly at the ovals, the observer can discern both the direction of the ovals and the spin of the grating.
2. When the observer views the display in the periphery, the ring of ovals reverses direction and appears to spin clockwise. We believe that the reversal results from the perceptual combination of the internal and external features ("Feature blur"; see Shapiro, Knight and Lu, SFN abstract).

Illusion 2: The curveball

The curveball illusion consists of a single oval that drifts from the top of the screen to the bottom. The oval contains an internal grating that drifts from right to left. The illusion is analogous to a real curveball because the motion of the global object (i.e., a ball) is independent of the internal motion (i.e., a spin).

1. When the observer tracks the oval foveally, the motion will follow the oval (i.e., the oval appears to descend vertically).
2. When the observer fixates to the right of the screen so that the oval falls in the far periphery, the oval appears to drift down the screen at an oblique angle.
3. When the observer initially fixates to the right of the screen (i.e., viewing the oval in the periphery) and then, in the middle of the oval's descent, shifts his/her gaze to look directly at the oval (so that the oval is in the fovea), the flight of the oval "snaps" suddenly from an oblique to a vertical descent.

The dramatic shift in direction seen in step 3 of Illusion 2 is analogous to the "break" of the curveball. From a batter's point of view, the ball in the pitcher's hand has a visual angle of 0.23 deg; and the ball, when two feet away from home plate, has a visual angle of 6.89 deg. Even if the batter can fixate on the center of the ball, the portion of the ball's image that falls outside the fovea increases over the course of the ball's flight. If the batter shifts eye position during the pitch, then the change from fovea to periphery (or vice versa) will be even more dramatic. The perceptual jump (step 3 of Illusion 2) is interesting because humans spend a great deal of time shifting their eyes to move objects from the periphery to the fovea; we are likely to encounter apparent changes in speed and even the trajectory of moving objects on a regular basis.