Movements in art: from Rosso to Riley
Vision unifies the part of art and science that is of interest to the majority of readers of Perception. Artists are not always inclined to further the union. In this issue there are articles on works by two artists who have taken divergent views of the bond. On the one hand, David Melcher and Francesca Bacci provide an account of Medardo Rosso who strived to capture the features of the fleeting glance in his sculptures. On the other, Johannes Zanker, Melanie Doyle, and Robin Walker dissect some observational aspects of Bridget Riley's op art works. Riley, who is renowned for her scorn of optical analyses of her work (see Kudielka 1999), has had a major retrospective exhibition of her work on display at the Tate Britain in London (June–September 2003). The articles on both Rosso and Riley are concerned with the influence of eye movements (or their absence) on the effects their art produces. Both articles present interpretations of the respective artists from visual perspectives that differ markedly from those framed by art critics.

Some years ago, the geneticist C H Waddington wrote a book entitled Behind Appearance in which he cast an analytical eye over developments in painting from Picasso to Pollock. The title was apt because he delved into the sources for non-representational art, and he classified artists as either magicians or geometricisers. Bridget Riley was placed, of course, in the geometrical camp, and one of her illustrations reproduced by Waddington was Fall of 1963. Waddington remarked: “The element of intellectual, and still more of visual, paradox, is a powerful influence in one of the most recent types of painting—Op Art” (1969, page 214). The allure of Fall does not pall; it is the principal subject of Zanker et al's article.

Bridget Riley was born in London in 1931, and is best known for her high-contrast, black-and-white paintings of geometrically periodic patterns. More recently she has produced designs in colour. The works that have captured the imagination of visual scientists are those in black-and-white. Movements and distortions of the patterns are seen even though none are occurring on the picture plane. The dynamic changes are a consequence of processes within the visual system of the observer, and so they are truly interactive paintings. Riley came to international prominence when her work was shown in The Responsive Eye exhibition, held at the Museum of Modern Art, New York, in 1965. Her portrait in figure 1 is embedded in a drawn design that displays many of the visual distortions seen in her black-and-white paintings and prints, including Fall. The wavy radiating lines appear to shimmer and move, particularly around the inflection points of the curves; the contours fluctuate in clarity, being sharply defined at one moment and blurred at the next. It is when the contours are blurred that Bridget Riley’s portrait can be seen.

The phenomena manipulated by Riley and other op artists have long been known in visual science, but scientists have not exploited them with the élan of op artists. This reflects a fundamental difference in approach between science and art, even when dealing with the same phenomena. Artists enhance and elaborate the effects, whereas scientists contract and constrain them. Ever since Jan Evangelista Purkinje or Purkyne (1787–1869, figure 2) described the distortions that can be seen in gratings, concentric circles, and radiating lines, scientists have sought to account for their occurrence. The initial observations of the distortions have been attributed to Helmholtz so frequently (see Drysdale 1975; Millodot 1968; Mon-Williams and Wann 1996) that it is worth
repeating Purkinje’s earlier descriptions. He first gave an account of the waviness that can be seen in high-spatial-frequency gratings: “During intense viewing of the parallel lines of an engraving one observes an oscillation of the lines which on closer inspection involves some being closer together and others farther apart, so that the lines appear in the form of waves” (Purkinje 1823, page 122). In a second book on subjective visual phenomena, published two years later, he gave a lucid description of the distortions seen in patterns of concentric circles:

“One draws a series of closely spaced concentric circles, constructed as neatly as possible .... These are displaced outside the distance of distinct vision, and there appear in all directions bands of clearly distinguishable parallel lines, over which the multitude of lines slide and entwine as cloudy streaks and points; they all radiate from the centre to the periphery, and their number, width and direction differ with different individuals, but remain constant for any one .... One can produce the same appearance very clearly with a figure comprised of 16 or more radii.” (Purkinje 1825, pages 144–145)

The misattribution of the effects to Helmholtz is understandable because he reproduced Purkinje’s radiating and concentric circular figures together with a description of them in words very similar to those used by Purkinje, but without any mention of

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**Figure 1. The Responsive Eye (Bridget Riley)** from Wade (1995).
his name. Helmholtz did add the observation that, when the circles are held close to the eye but accommodation is for distance, then eight or ten sectors will be seen. He concluded: "Obviously, these phenomena are all due to some sort of asymmetry of the eye" (Helmholtz 2000, page 192). Paradoxically, in the historical section following this description, Helmholtz did mention Purkinje in the context of the distortions seen in gratings but not to those in concentric circles; this is even more puzzling because he cites the pages from Purkinje (1825) from which the above quotation was translated.

One perennial problem with these regular geometrical patterns is that they yield a range of phenomena, as Zanker et al point out, and so restricting consideration to one alone (like apparent motion) might be the basis for discrepancies between studies that have been made of them. Using a pattern of radiating lines, which produces effects similar to Fall, Wade et al (2001) recorded eight types of perceptual distortions, which could be rated (on a five point scale) independently. Rating scales are one way of indicating the perceptual strengths of the various phenomena, and they were used by Zanker et al, too.

Figure 2. Sehen in subjektiver Hinsicht (Jan Purkinje) from Wade (1995). The radiating, rotating blurred spokes that are seen in the pattern of concentric circles, and the rotary distortions seen with radiating lines, have been called Purkinje illusions. Purkinje's portrait can be seen when the figure is viewed from a metre or so.
Zanker et al have performed a signal service by recording eye movements when viewing Fall (or computer generated patterns similar to it) and control patterns that do not induce apparent motion, although there was surprisingly little difference between them. Purkinje noted that the perceptual effects are constant for a given individual, and Zanker et al find the same for the miniature saccades that they have measured: they remain much the same for the orientations of the patterns, for the region fixated, and for the different types of pattern presented. They conclude that “eye movements are essential for the full strength of the stunning illusion perceived under free viewing conditions”.

Interpretations of illusions have typically been based on correlations between stimulus features and the ensuing perception (see Wade 1998). When correlations are found, there is the belief that the illusion is understood. In the case of op art patterns the illusions occur without any change in the physical stimulus, and so states of the observer are correlated with aspects of the observed phenomena. When there are many perceptual effects generated by observation of a static pattern, correlations with one observer state might not assist in interpretations of others. In the case of Fall and its close relatives, two sets of correlations have been sought for the apparent motion induced by them. On the one hand, miniature saccadic movements of the eye displace the pattern relative to the retina; on the other, the changes in retinal stimulation follow from small, astigmatic changes in the optical characteristics of the lens.

Purkinje considered that the distortions were a consequence of an unspecified asymmetry of the eye. This has subsequently been associated with transient, small astigmatic variations in lens curvature, the axis of which is constantly changing. That is, the microfluctuations in accommodation that were measured by Campbell and Robson (1958) were not evenly distributed over the lens, so that the curvatures varied slightly in different orientations, which were themselves changing. Millodot (1968) examined the distortions seen in concentric circles, and provided experimental evidence in support of this hypothesis from four sources. First, the distortions increased (more radiating spokes were seen) with closer viewing distances (and therefore greater accommodation). Second, the distortions were reduced or abolished when the ciliary muscles were immobilised with cycloplegics. Third, the concentric circular pattern appeared stable when viewed with an aphakic eye as compared to the distortions seen with a normal eye in the same individual. Fourth, tachistoscopic exposures of less than 200 ms abolished the visibility of radiating spokes, but they were seen normally with exposures of more than 1 s. Others have supported this interpretation for some of the op art effects that yield apparent motion in high-spatial-frequency patterns made up of different orientations (see Wade 1978, 1982).

Zanker et al also found that the distortions decreased when the patterns are viewed through an artificial pupil, thus reducing the influence of such astigmatic changes. Moreover, afterimages of Fall (or similar patterns) were perceptually stable. Their afterimages were relatively short-lived, but much longer lasting ones (generated by flash discharges behind transparencies of concentric circles) also remain stable (Evans and Marsden 1966). Zanker et al’s statement that retinal image shifts “are the most likely candidates to account for the illusion” is probably correct, but it does not exclude the transient astigmatism hypothesis; retinal image shifts can be produced by internal or external eye movements, and both are bypassed when afterimages are generated. Even those rare individuals who can maintain an almost static eye voluntarily still see distortions in op art patterns (Kupin et al 1973).

One virtue of the transient-astigmatism hypothesis is that it would not require any differences in miniature saccades with the different patterns. The transient variations in the axis of small astigmatism would be the same for Fall and for checkerboards, but the latter would not have the stimulus characteristics to allow its expression in
The transient variations could also be sufficient to set in train the stimulation of motion detectors in the manner Zanker et al propose. It would appear that motion of the high-spatial-frequency images over the retina is a necessary condition for the distortions to occur, and that the movements might be a consequence of micro-fluctuations of eye position and astigmatism, as Mon-Williams and Wann (1996) have suggested.

Thus, the enigma of the *Fall* continues. In the gallery notes for the exhibition, Riley is quoted as saying “the eye can travel over the surface in a way parallel to the way it moves over nature. It should feel caressed and soothed, experience frictions and raptures, glide and drift .... One moment there will be nothing to look at and the next second the canvas seems to refill, to be crowded by visual events”. It is clear that Riley’s descriptions of her works do not correspond with those of visual scientists analysing them. Hers is the vocabulary of aesthetics; her descriptions are of visual poetry not of visual process.

Zanker et al examine Riley’s work in the context of small eye movements over the patterns. Melcher and Bacci, on the other hand, explore the frozen glance, as represented in Rosso’s sculptures and his photographs of them. Thus the movement of the eye is also a cardinal concern of Medardo Rosso (1858 – 1928), or rather the moment when the eye alights on one of his sculptures. Rosso (figure 3) was born in Turin and he studied art in Milan (see Caramel 1994). His artistic subjects were not the allegorical themes then common in sculpture, but the common folk with whom he was in daily contact.

![Figure 3](image-url)
He introduced novel techniques which blurred the distinction between sculpture and painting. It is in this regard that, along with Rodin, Rosso is considered to be one of the pioneers of modern sculpture. It has been said of him that:

“He succeeded in changing the basic understanding of the relationship between the sculptor and the material world. The sculptor was no longer a mechanic of materials, forming images that worked on the level of not very challenging symbols. Rosso transformed the practice of making sculpture into a form of thinking with material.” (Cragg 1994, page 65)

Rosso moved to Paris in 1890, and became friendly with Rodin; this friendship was severed when Rodin refused to acknowledge his debt to Rosso in his sculpture of Balzac, exhibited in 1898. Rosso's work wielded considerable influence on futurism as well as on twentieth century sculpture. However, it is not in these respects that Melcher and Bacci draw attention to his work, because they focus on his concerns with photography and his attempts to capture the momentary glance.

The late nineteenth century was a fertile period for the interplay between science and art. Melcher and Bacci indicate that discoveries in visual science, like the saccadic movement of the eyes described by Javal, were rapidly communicated to a wider public. Scientists, like Helmholtz and Rood, were distilling contemporary visual science and conveying the spirit to an eager artistic audience: some, like Seurat and Rosso, were intoxicated by it. Seurat carried the principles of additive colour mixing to extremes in his paintings, and Rosso tried to exclude the wandering eye from an appreciation of his sculptures. Rosso was trying to mimic the impression obtained by the initial glance, in which only the regions around the point of fixation will be sharply defined and more peripheral parts will be blurred. But how can the initial glance be controlled in a sculptural work? How can the point of fixation be defined?

As Melcher and Bacci make abundantly clear, Rosso was more at home with photography than with sculpture. Photography affords the constraints that he wished to impose on viewing his sculptures. His description of photographers as assassins is most apt—they kill their subjects by freezing them in time. It is all the more remarkable that he wished to join this band of assassins. He placed demands on the viewing of his works—observation from a particular viewpoint with fixation on a specific feature—that could only be matched by the frozen frame. His was a tachistoscopic art. It is ironic that he died at the hands (or feet) of the assassin he had embraced. In 1928, he dropped a photographic plate on his foot; this led to amputations of toes and then his leg, and his heart was unable to sustain the strain of the operations.

Rosso made plain in his art, as none had earlier, the distinction between central and peripheral vision. Again, this had been common currency amongst students of vision for centuries. Some, like Porterfield (1737), had contrasted the narrow region of central visual clarity with the impression we have of uniformly clear visual field; he also appreciated that rapid eye movements were involved in this “vulgar error” of our phenomenology. Differences between central and peripheral vision can play their part in op art works, too. The apparent motion is more readily visible in the regions of the paintings that project to the peripheral retina (Mon-Williams and Wann 1996).

The nature of the physical world has been explored by two general methods—observation and experiment. Naturalistic observation has a long recorded history in literature and the visual arts. The experimental method is a relatively recent adaptation and its results constitute the natural sciences. It has proved extremely viable owing not only to its formalised modes of operation but also to its rules for interpreting the results so produced. The observational method that is at the heart of art does not have such a bedrock of rules and it can be influenced by a variety of factors. In Behind Appearance, Waddington suggests that one of these influences has been the view of the material world developed in the natural sciences. His concerns were principally
with physics and biology. To these should be added the influence of the visual sciences. The kinship between visual science and visual art has been celebrated in many articles in *Perception* over the past 32 years, and it has been fostered in the art exhibitions that have been a feature of many European Conferences on Visual Perception (see Spillmann 2003). There have been articles on numerous artists and movements in art, but few have examined aspects of eye movements in the manner of the two articles in the current issue. Medardo Rosso (figure 4, left) sought to halt the eye in its tracks and to represent the momentary view of a solid structure. Bridget Riley (figure 4, right) induces the eye to track over the fine contours of her designs, which are transformed perceptually in beguiling ways. Knowledge about the process of perception is embraced and made explicit in Rosso’s photographs; it is rejected by Riley but implicit in her paintings and prints.

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Figure 4. Left, Medardo Rosso and right, Bridget Riley.
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