

OUR "POLAR PARTNERSHIP" WITH THE WORLD AROUND US

by Edwin H. Land

A hundred and forty years ago, during one of the most fruitful periods in the history of science, a hint of one great science was treated as if it were a toy. A clue to the solution of a principal metaphysical mystery was passed by unappreciated.

In my hometown library the chief delight of the younger patrons was not the books but the Brewster stereoscope. Through its lenses children saw boats and bridges and camels and mountains and—the best of all three-dimensional subjects—grottoes. Having converted two slightly faded sepia, flat, dull photographs into a vivid reality, the stereoscope transported the child through the interplay of stalagmites and stalactites into the distant depths of the caves. The child could hear the dripping water, smell the dampness, fear the darkness as he sat with legs crossed under him on the chair in the dear old library. Where did this new reality exist? In his chest, in his head, in his eyes, or rather did he exist in it? A toy? Or the most powerful metaphysical clue to emerge in three thousand years?

Our Western race, hopelessly immersed in philosophic intricacies, was not ready to notice that this presumed toy was a device in which the child and the three-dimensional space he rejoiced in seeing comprised a union of mind and matter, of soul and body, of man and nature, a single union of what in fact had never been divided and did not need reuniting. In this particular pre-Darwinian period no one could have had the courage to imagine what in the next two hundred years would become the scientific basis of an unpartitioned reality.

In 1838 Sir Charles Wheatstone held a cubic block in front of him and made two drawings, one of the appearance of the cube from the position of his right eye, and the other of the appearance of the cube from the position of his left eye (fig. 1). He arranged a set of mirrors so that he could look back at the drawings, seeing simultaneously with his right eye only the drawing made from the right-eye point of

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perspective, and with the left eye only the other. There came into existence for him a real three-dimensional cubic block.

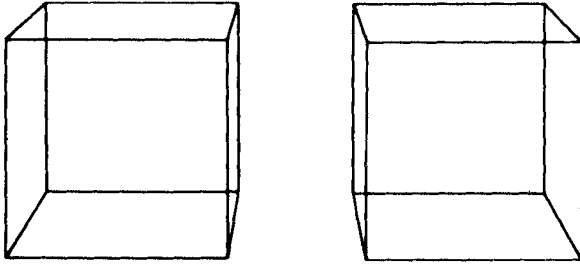


FIG. 1.—The third dimension: Sir Charles Wheatstone's cubes.

In 1959 Bela Julesz replaced Wheatstone's two drawings with two astonishing substitutes. What the left eye saw instead of a drawing was the whole area where the picture had been but now sprinkled with black dots at random, as if Julesz had dipped a toothbrush in black ink and run a pencil across the bristles. (He did in fact use a computer to insure the randomness of the spacing of the dots.) For the right eye also an array of random dots was presented. In neither presentation was any pattern visible because in fact there was no pattern (fig. 2). When the left- and right-eye images were combined in a Wheatstone mirror stereoscope, however, they projected a rectangular area in the foreground, hovering in space, three-dimensionally separated from the whole background.

What Julesz had done to prepare this phenomenon was the equivalent of using three cards with identically spaced random dots on all three. He left one card untouched to provide, for example, the right-eye view. To make the left-eye view, a rectangular area was punched out of the second card; the hole left in that card was filled with a rectangular area punched out of the third card in a position slightly displaced laterally from the hole in the second card. Since in fact all of the dots were located by instructions to a computer, there was no trace of a cutout edge that might have revealed monocularly the location of the rectangle. The left-eye card and the right-eye card had on them individually only random dots. Somewhere in the brain, after the images of the cards were formed on the respective retinas, the images were compared and the displacement with respect to the surrounding set of dots in the one rectangle from the identical set of dots in the other was discovered, utilized, and seen as a rectangle cut out from its surround and displaced in space.

Seen as a rectangle? Who sees it as a rectangle? Now Julesz suggests a family of mechanisms, cellular arrangements, models within the brain that might compare the two random-dot displays and might

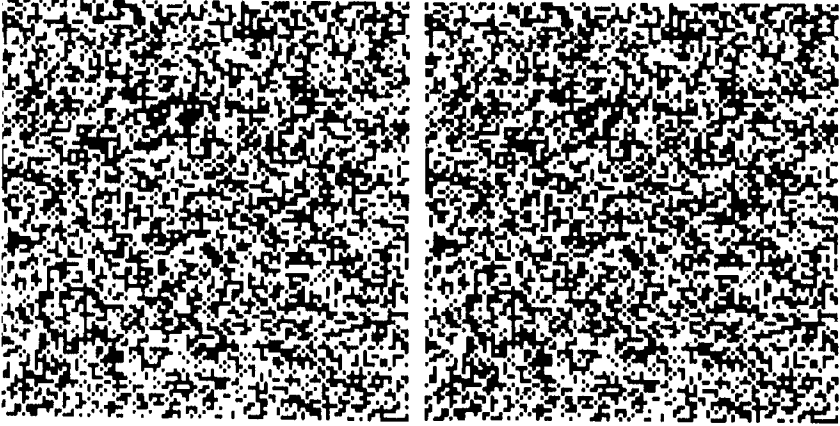


FIG. 2.— A typical random-dot stereogram devised by Bela Julesz. Neither of the two arrays of dots shows a pattern by itself. When they are stereoscopically fused, they show a rectangular area cut out from the background and displaced in space.

react symbolically at least with a pattern that would be the analogue of a three-dimensional representation. As I contemplated this mechanism and the color mechanism I am about to describe, there grew within me a sense of the general significance of this class of mechanisms. We must ask who or what looks at the analogue. Is there another stratum in the cortex, or another whole domain, that looks at these results? If there is, to whom does this stratum report—to still another stratum?

REFLEXIVE MECHANISMS

Let us save the answer to this question until we have examined another aptitude equally remarkable: the aptitude for characterizing the surface of objects with a color name largely irrespective of the wavelength composition of the light falling on the object and of the light reaching the retina from the object.

If, as has long been thought, the color name characterizing the surface of an object were determined essentially by the wavelength composition of the light reaching the retina from the object, then a simplistic mechanism in which rays of light tie the object point by point to related points on the retina would suffice conceptually for the first step in seeing objects as colored. Such a scheme would be an evolutionary failure because the moment-to-moment and place-to-place variations in the composition of illumination in the world around us would change the moment-to-moment wavelength composition of the radiation reaching the retina from the object and hence would lead to complete unpredictability of the color names characterizing the surfaces of the objects around us.

We do find it to be a fact that the color characterizing a point in the field of view is not determined by the radiation from that point (and conversely a given composition of light from a point in the field of view is not associated with any particular color of that point). Thus there is implied a much more interesting association of the retina, the cortex, and the object in the field of view. By mechanisms as yet unknown, the rate of change of energy above some threshold value of the rate of change is determined across the field of view. Most significant, it is determined independently for three wave bands. For every point in the field of view the three summations of the changes over the whole field up to that point are compared. These three values together are the color dark brown, or white, or deep red, or gray, or orange, or black.

If we assume that there is a monitoring cell responding to the summation, is there some other cortical stratum surveying all of the monitor cells, and if there is, is there still another stratum surveying the surveyor? It seems to me that these questions suggest that there is a bit of absurdity in carrying on the succession of observational cells or loci for the spatial mechanism as well as for the color mechanism. What is implied are arrangements of processes so remarkable, intricate, elegant, quick changing, and utterly precise that it would be increasingly absurd to monitor these mechanisms with a simplistic overriding mechanism. When the color mechanism has within it the responses that characterize an external area with the color name red, there is no place, no cell that can make better use of the characterizing conclusion than the mechanism that arrived at it in the first place.

IDENTITY OF PROCESS AND END

For many years the scientific community has admired the investigations of David Hubel and Torsten Wiesel of the responses along the neural pathways between sensing organs and the cortex. A particularly dramatic and significant experiment allows the audience to hear as clicks the response of a cell that is monitoring an area of the retina where there is an edge in the image on the retina. This focused result from a hard-won experimental program does not suggest offhand that an array of analogous results from similar discoveries would constitute by themselves a matrix of phenomena that we could regard as being in itself, ourselves. The magnificent mechanisms in their entirety that we use for space, the other magnificent mechanisms we use for color, and the others we use for sound are at this date beyond our technological competence to imitate; if it were to turn out that all we are *is* this group of magnificent mechanisms, that would be nothing of which to be ashamed. These processes then would be what we are.

I became impressed with the concept that the animal evolved in what we might call a "polar partnership" with the world around him. What we call chaos in the world around us can be regarded also as including most possible kinds of order, some of which are transient on a solar-year basis, some of which persist for eons on a solar-year basis. Any animal that is going to evolve in the universe must be related genetically to a time scale of permanency; that is, the animal must evolve an inner order related to an outer order, one of the outer orders in chaos, and if he is to do that then the outer order must persist long enough for a strain of the animal to evolve.

The second concept that forced itself upon me is that when we talk about an inner order we must mean not a static cellular order but a dynamic program in which all of the evolved internal cellular orders are a framework for a dynamic continuum of waves and discharges and ionic shifts, all curiously chaotic when seen detachedly and uninformedly, all hurrying to their special purposes for each kind of significant structured result, such as the bringing into being of a spatial continuum with great accuracy, or the bringing into being of a sense of color with great accuracy. The total concept becomes quite an exciting one: Not only is there a unity between matter and being internally, but also the end product of the process is, so to speak, the process itself.

If, in addition, we feel that all of this has evolved in intimacy with the kinds of order that exist over extended periods of chaos in what we call the outside world, then we can see that there really is no outside world and no inside world. There is just one world. It is perhaps a little bit like moss growing on a rock, clinging to it, the tendrils penetrating the crevices in the rock and the cavities of the rock, where the rock/moss combination is the object and not the rock or the moss separately.

Consider, rather than rock/moss, the concept of a tree. Does the tree exist without the observer? Long before we get to an obscure metaphysical response, we must notice that in many ways the tree certainly does not exist in the physical sense without the observer. The tree does not exist for radio waves of a certain wavelength; nor does it exist for neutrinos. The tree exists as part and parcel of the interaction between that part of the cosmos and our part of the cosmos, namely, the "we" that has evolved over many centuries to be a partner with the tree.

Similarly we ask if a color exists on the objects around us without our being there to see it. The answer is analogous to that for the tree, but it is even more dramatic, as discerned earlier in this discussion. If, for example, we were to take a projection photometer, a telescopic photometer, and scan the world around us line by line, trying to find

objects in the world outside—here I am thinking of color in the Newtonian way of expecting to find shortwave light from blue objects and longwave light from red objects—we would be impressed to find that we can hardly discover the objects at all, let alone describe their color in terms of distribution of wavelength. The trace of the response of the meter after such an experiment would look like peaks and valleys with a confused interlocking of them as a function of wavelength; so it is correct to say that color does not exist in terms of being defined by wavelength-concentration distribution.

On the other hand, since we do have the reliable experience that we call color, we must now ask the question “With what outer order did the inner-order evolution relate itself?” I am happy to report that we have learned what outer order our evolving systems did discover and evolve with as a partner.

As our photometer traverses the field of views it traces a line for its response. This trace may move up and down and across in quite an unpredictable way, free from relationship with the color we see. We note, on careful examination, that we do not see most of the slow, gradual changes shown in the photometer’s trace. However, each time the photometer crosses what we see as the edge of an object, the trace of the photometer shows an abrupt change in the amount of light. It then occurs to us as we look at the whole map of the field of view that a system evolved not with a relationship to the amount of energy but rather with a relationship to sudden changes in energy, marked changes such as edges. Although the abrupt changes in energy are in the same place for each of three wave bands, they usually have different heights for each of the three wave bands. Since the system did not evolve with a relationship to the amount of energy, it did not evolve with a relationship to the amount of energy on any wave band. It evolved with a relationship to three independent sets of sudden changes or edges. This system can find permanences. It can find the outer order for the polar partnership.

INTERLOCKING WORLD AND MIND

Ordinarily when we talk about the human as the advanced product of evolution and the mind as being the most advanced product of evolution, there is an implication that we are advanced out of and away from the structure of the exterior world in which we have evolved, as if a separate product had been packaged, wrapped up, and delivered from a production line. The view I am presenting proposes a mechanism more and more interlocked with the totality of the exterior.

This mechanism has no separate existence at all, being in a thousand ways united with and continuously interacting with the

whole exterior domain. In fact there is no exterior red object with a tremendous mind linked to it by only a ray of light. The red object is a composite product of matter and a mechanism evolved in permanent association with a most elaborate interlock. There is no tremor in what we call the "outside world" that is not locked by a thousand chains and gossamers to inner structures that vibrate and move with it and are part of it.

The reason for the painfulness of all philosophy is that in the past, in its necessary ignorance of the unbelievable domains of partnership that have evolved in the relationship between ourselves and the world around us, it dealt with what would indeed have been tragic separation and isolation. What meaning is mind by itself without the world? That is tragic. Of what meaning is the world without mind? The question cannot exist.

It is not error in grand policies that endangers our planet but imprisonment in our own minds, which, if set free, would guide us individually first of all and collectively after all. The first step in freeing the mind of its own chains is to turn it toward reverence, insight, and appreciation of itself. It is now becoming apparent that insight into its nature can be pursued with all the modern techniques for thoughtfulness that the mind has used for investigations away from itself. I believe we will find in the processes within it a sacred evolutionary heritage, characterized by a miraculous combination of incessant action and serene and dignified form. It is as if all science has been schooling itself to acquire the new techniques for speculation and experiment appropriate for using the mind on the mind. In the gradual acceptance of the hypothesis that the processes involved in exercising the polar partnership are themselves reality, I find it helpful to think of a symphony in which the opening theme asks a question and the closing theme states that the question is itself the answer.