

Gibson's Work 'An Extended Reply to Helmholtz'

When I began to study with Eleanor Gibson as a graduate student in the 1970s, I learned of Helmholtz for the first time. Hermann von Helmholtz, the great physicist, physiologist, and psychologist, was frequently cited, with the deepest respect, as the proponent of an approach to psychology that was fundamentally wrong. Delving into his work, and comparing it to that of Eleanor Gibson, one can see the reasons for this opposition. Helmholtz was arguably the greatest experimentalist of the 19th century. It is he who discovered, as a student, how to use behavioral measurements-differences in the timing of a frog's muscle contractions in response to stimulation at different locations-to measure a hidden neural process-the speed at which the frog's nerve impulses travel. It is he who later used psychophysical measurements to elucidate building blocks of human perception of color and tone. And it is he who donned prisms to measure the plasticity of spatial vision, launching a line of study that continues to this day. When it came to the developmental origins of our perceptual capacities, however, Helmholtz issued a warning: Although we can debate the role of sensory experience in the development of perception, assembling logical arguments in support of one or another conclusion, we can never discover the origins of human perceptual capacities through experiments. Human infants can be observed, but they cannot be studied either through the psychophysical methods that Helmholtz applied to adults or through the invasive methods he applied to other animals. And observations of infants' behavior will never reveal conclusively what infants do and do not perceive.

One way to view the work of Eleanor J. Gibson is as an extended reply to Helmholtz's skepticism. She showed us how indeed we can study the capacities of inexperienced perceivers through experimental methods that are as ingenious, and rigorous, as those of Helmholtz himself. She devised experiments to shed light not only on the basic perceptual capacities that humans share with other animals but also on uniquely human perceptual and cognitive skills, such as reading. Finally, she showed how a set of theoretical ideas profoundly opposed to those of Helmholtz-ideas linking perception to action and to the extraction of invariants in the flow of visual stimulation over space and time-could be tested most decisively, through studies of the youngest human perceivers.

To reveal the origins of visual space perception, Gibson adopted a comparative approach. Although humans are a highly altricial species that cannot ethically be studied by methods of controlled rearing, many of the perceptual mechanisms found in humans may be homologous to those of other species. One can devise rigorous methods to test for such homologies. When true homologies are found, experiments on non-human animals can test for the role of experience in the development of those mechanisms and of the perceptual capacities they support.

Gibson's classic studies of locomotor behavior on the visual cliff provide the most shining example of this approach. With Richard Walk and Thomas Tighe, Gibson measured the spontaneous locomotion of young animals of many species on two plexiglas surfaces of equal true distance, that presented visual information for surfaces at different distances. As everyone knows, most animals stepped onto the optically near surface and avoided the optically distant one, the "cliff". By varying the visual information for surface distance, Gibson was able to show that infant animals of species as diverse as rats and humans relied primarily on patterns of relative motion to specify surface distance. This common pattern provided evidence that the mechanisms of visual perception and visually-guided locomotion were common to humans and other animals.

Having discovered this homology, Gibson was able to conduct decisive experiments testing the role of visual experience in the development of cliff avoidance. Newborn kids and lambs avoided the cliff at birth, providing evidence that visual experience was not necessary for cliff avoidance in those precocial walkers. Young altricial animals including rats and cats could not be tested on the cliff until some time after birth, when they began to show visually-guided locomotion. To investigate the development of cliff avoidance in those animals, therefore, Gibson and her collaborators undertook a series of controlled rearing experiments. Rats who were reared only in the dark, with no visual experience, avoided the cliff on first exposure to the light. Cats did not: They required a few days in a lighted environment before they began to engage in visually guided locomotion and cliff avoidance. What was happening during those few days: were the cats learning about the tactile consequences of different visual patterns? To investigate this question, Gibson gave dark-reared cats a few days of visual experience on the plexiglas cliff itself. If cats learn which visual patterns are safe and which are dangerous, then these cats should have shown no cliff avoidance, since the plexiglas surface was safe to walk on. After this experience, however, these cats began to avoid the cliff as much as their normally reared counterparts. Cliff avoidance therefore occurs without any opportunity to learn that cliffs are dangerous, in every animal tested. Given the evidence that cliff avoidance depends on

homologous mechanisms across animals and humans, this line of research meets Helmholtz's skeptical challenge. The origins of human perceptual capacities indeed can be studied through a combination of comparative and developmental experiments. Such studies are thriving today.

The approach to perceptual development exemplified by research on the visual cliff does not, however, appear to answer all questions about perceptual development. What can we learn, in particular, about perceptual and cognitive capacities that are unique to humans? In the middle of her career, Gibson turned her attention from visual surface perception to reading. With Anne Pick and other students, she developed a research program based on a simple and powerful assumption: When human children develop new culture-specific perceptual skills, they deploy older perceptual and cognitive mechanisms that evolved for other purposes and are shared by other animals. Study of those mechanisms, in younger children and in non-human animals, therefore can shed light on older children's accomplishments. In the case of reading, controlled-rearing studies of animals provided evidence that a wide range of animals learn to discriminate between sets of objects by seeking out and discovering the contrastive features that distinguish them. Pick and Gibson applied this principle to children's learning of letters and letterlike forms. They discovered that children, too, learn to discriminate letters and forms by discovering their contrastive features. Their studies are a prototype for current work that seeks to decompose complex, uniquely human skills into their ontogenetically and phylogenetically older building blocks.

Finally, how can experiments help us to arrive at the right theoretical conception of human capacities to perceive and act? According to Helmholtz, every perceptual experience is a kind of inference, in which a set of disparate sensory data are evaluated and their most likely causes, among the possible objects and events in the surrounding world, are assessed. In contrast, the approach to perception developed by James J. Gibson holds that perception depends on the detection of higher-order invariances in the flux of stimulation, and it results not in disembodied experiences but in adaptive actions. Are these just different ways of looking at the same phenomena, or are they different substantive theories leading to contrastive empirical predictions?

I, personally, am not sure how I would answer this question. But Eleanor Gibson clearly viewed this fundamental debate over the nature of perception as an empirical matter to be settled ultimately by experiments. Her efforts to settle it produced some of the most beautiful studies of infant perception that the field has seen.

I was lucky to be at Cornell when Gibson founded her infant perception lab. At the time, most students of infant perception were guided, at least implicitly, by the Helmholtzian framework, and they attempted to discover the sensory building blocks of perception by testing infants' discrimination of colors, lines, and patterns in two-dimensional displays. Gibson, in contrast, used her new lab to test infants' sensitivity to invariant relationships in a flow of stimulation produced by real objects and events. With Cynthia Owsley, Arlene Walker-Andrews, and others, she showed that young infants are sensitive to visual information specifying whether a surface is rigid or flexible. The Gibson lab also showed that young infants relate such visual information to the feel of a rigid or flexible object. When older infants begin to locomote, information for rigidity or flexibility guides their locomotion over a variant of the visual cliff. With this work, Gibson's developmental research returned to its beginnings. Her reply to Helmholtz's picture of this field, and its limits, was complete, and the contemporary study of infant perception began.

Today, the approaches that Gibson initiated are so widespread that it is easy to forget how much we owe her. Gibson herself did not help us to appreciate her contribution, because she always downplayed her own role in the field. Sitting now at my computer, I can imagine her reaction to this brief history. "There you go, Liz, getting carried away again. You're paying way too much attention on Helmholtz and to me. Our field is the result of work by many people." As always, Eleanor Gibson's criticisms give me pause. But in the end, I stand by my claims. On December 29, 2002, we lost the greatest experimental psychologist of the 20th century. Twenty-first century psychology will be built on the comparative, developmental, and experimental foundations that Eleanor J. Gibson gave us.

-Elizabeth Spelke