Eleanor Jack Gibson

December 7, 1910–December 30, 2002
Elected to the NAS, 1971

A Biographical Memoir by Elizabeth S. Spelke

The official photograph announcing the establishment of the Eleanor J. Gibson Laboratory at Cornell. *Division of Rare and Manuscript Collections, Cornell University Library.*

Eleanor J. Gibson's ground-breaking research challenged the concepts and methods of behaviorist and introspectionist psychology to forge a unified experimental, comparative, and developmental psychology of perceptual learning and development. Gibson faced obstacles throughout her career: She held a full-time faculty position, with her own lab and graduate students, for only three of her ninety-two years. Nevertheless, her life was extraordinarily productive and remarkably happy. She viewed humans and animals as lifelong learners who perceive and explore the world from the beginning, progressively discovering more of its structure and meaning. Her rigorous, innovative methods transformed research on the origins and nature of knowledge and intelligence, inspiring current studies of intelligence in machines, brains, and human minds.

Eleanor Jack was born in Peoria, Illinois, on December 7, 1910. Although she was raised in a milieu in which, as she recalled, "no one ever suggested that I was a particularly bright child, or even wanted me to be bright,"[1] she began her formal schooling two years early, skipped another grade, and entered high school at age twelve and Smith College at age sixteen. At the time, Smith, a small college for women, was building a premier psychology department by welcoming eminent psychologists fleeing fascism in Europe. Gibson majored in psychology and took her first elective courses, as a sophomore, in animal and child psychology. These topics remained central to her interests for seven decades.

At the end of her junior year, she met James Gibson, a philosophy major and psychology Ph.D. who had joined Smith's faculty at age 24, and she signed up for his year-long class for seniors, "Advanced Experimental Psychology." Students performed original experiments addressing wide-open, fundamental questions. With classmate Gertrude Raffel, Eleanor conducted an experiment that tested a central claim of behaviorism, that learning depends on associations between elementary sensations and responses. As college students read aloud with one hand on a plate that delivered mild shocks, preceded by a buzzer, they began to raise their hand in response to the buzzer without interrupting their reading. Then the shocks ceased but the buzzer continued, with the same and then the opposite hand resting on the plate. On hearing the buzzer, most participants lifted whichever hand contacted the plate while continuing to read aloud. Because stimulation to one hand elicits sensations and responses only in that hand, Jack's and Raffel's findings refuted behaviorist predictions and called for a new account of learning, perception, and action: an account that Eleanor would later develop and test.[2]

Upon her graduation in 1931, Eleanor was admitted to Smith's two-year post-graduate program in psychology with a teaching fellowship, which was essential aid during the Great Depression. James Gibson served as her thesis advisor, and their relationship developed on multiple levels. They married in the summer of 1932. On completing her master's degree, she took a full-time position at Smith as an instructor in the Psychology Department, with lab facilities but a heavy teaching load. In 1934, she was accepted to the Ph.D. program at Yale University, but Yale offered fellowships and housing only to men, and Gibson could not afford Yale's tuition. Smith thereupon provided her with a one-year fellowship to cover one year of Yale's tuition. During this year, she completed all the required coursework for the Ph.D., passed exams in two foreign languages, and found an advisor for the dissertation experiments that she hoped to conduct, either on animals or on children.

None of this was easy. Women in Yale's graduate programs were not allowed to live on the graduate campus or access its library, so Gibson's studies depended on male colleagues. Her first choice of a dissertation advisor, animal psychologist Robert Yerkes, allowed no women in his lab. Also, Yale's reigning developmental psychologist, Arnold Gesell, did not condone experiments involving children. Fortunately, Clark Hull, whose behaviorist theory had taken a considerable hit from Jack's and Raffel's research, accepted Gibson as a student, for they shared the view that theories in psychology must be tested and revised when disconfirmed. Gibson thereby gained an excellent advisor, and Hull gained one of his greatest students. By the spring of 1935, she had finished all the requirements for the Ph.D. except the major area exam and the dissertation prospectus and experiments.

Back at Smith, Gibson resumed her full-time teaching position, with six classes each year. In two years, she passed Yale's major area exam, developed her research plan (with frequent visits to Hull), and completed her thesis experiments. The prospectus was articulated in the language of Hull's stimulus-response (S-R) theory and crafted in accord with his detailed methods for formulating and testing hypotheses. Nevertheless, its proposed experiments, conducted at Smith, pointed beyond behaviorism by focusing on perception as a guide to learning.

Gibson received her Ph.D. from Yale in 1938, continued in her teaching position at Smith, and was promoted to assistant professor in 1940. Although her course load remained heavy, she published four papers based on her dissertation. The first, a theoretical paper in *Psychological Review*, was entirely written in the language of Hull's stimulus-response (S-R) psychology but challenged the central behaviorist picture of how learning works.[3] Her theory centered on the claim that perceptual learning is permanent and requires no external reinforcement, in contrast to the perpetually modifiable associations of prevailing learning theories, both in the 1930s and today. The mechanisms underlying enduring changes are now under study by some of the best contemporary learning theorists, including C. R. Gallistel and Samuel Gershman.

The empirical paper, published in the *Journal of Experimental Psychology* (1941), used the method of paired-associate learning invented by Mary Whiton (later Calkins), an 1882 Smith graduate.[4] Participants first learned to pair each of a set of drawn shapes with a different name and then were tasked with naming the original shapes, which were presented amid new shapes that varied in their geometric similarity to the originals. The participants initially extended the names to new shapes with similar geometric properties. Over time, their responses to the shapes became more differentiated, independently of feedback, and remained so when they were tasked with learning new names for the familiar shapes. Thus, learning involved a change in shape perception, and it was enduring and independent of the specific responses to each figure.

After Eleanor completed her graduate studies, she and James Gibson bought an old, lovely home close to Smith's campus. Her son, Jerry, was born in 1940 as she continued teaching her classes and advising her students' research projects, when the U.S. entered World War II in December, 1941. She increased her teaching to cover the courses of departing male faculty, including her husband, who joined a military research group. When the term ended, Gibson and her son Jerry joined James first in Texas, where her daughter, Jean, was born in 1943, and then in California, when James's research group was transferred there. Those years were difficult for Eleanor, who conducted no research. Characteristically, however, she drew a positive message from them: Her years without research revealed how greatly she valued it.

In 1946, James and Eleanor returned to Smith as full-time faculty members, but James's research on visual perception had made major progress during the war. With the promise of continued progress and grant support, he yearned for a larger laboratory that Smith could not provide. Smith also had closed its student research labs, limiting Eleanor's research opportunities. James Gibson therefore accepted a faculty position in the Psychology Department at Cornell University, and the Gibson family moved to Ithaca.

This move had a negative consequence: Cornell's anti-nepotism rules barred Eleanor from any faculty or staff position. She received only an unpaid appointment as a research associate, allowing her to volunteer in the labs of Cornell faculty members. Faced with this situation, Gibson showed extraordinary ingenuity and resourcefulness. From 1949 to 1972, she pursued research of the highest quality, albeit with no lab of her own and few of the rights or privileges of a faculty member: She could not admit or formally mentor students whose interests converged with her own, and (at first) she could not apply for grants to support her research in her collaborators' labs. Despite these conditions, Eleanor made fundamental contributions to multiple areas of psychology.

Gibson first volunteered at an animal research facility headed by Howard Liddell, Cornell's esteemed professor of psychobiology, and managed by Liddell's brother-in-law (to whom Cornell's anti-nepotism rules evidently were not applied). With a promise that her own research could follow, she helped the manager with Liddell's research on "experimental neurosis." Young lambs, confined to a chamber, received unavoidable shocks preceded by the dimming of a light. When the light dimmed, the lambs exhibited diverse and changing behaviors interpreted by Liddell as signs of neurosis but by Gibson as rational attempts to escape the shocks. After completing Liddell's experiment, Gibson tested their competing interpretations by randomizing new lambs to one of two replications of Liddell's experiment, with unavoidable shocks on all or a subset of trials, or to a condition in which the shocks could be avoided by performing a single escape behavior—leg lifting—when the light dimmed. Consistent with her hypothesis, the lambs in the latter condition tested the different escape behaviors and learned to avoid the shocks. Thus, the behaviors observed by Liddell were not manifestations of neurosis but of a search for effective actions. Gibson published these findings in the *Journal of Comparative and Physiological Psychology* (1952)[5]: the journal in which a much-cited report of "learned helplessness" appeared fifteen years later.

Gibson next designed an experiment to test a much-studied question in child psychology: do different sources of maternal care have differing impacts on developing animals? She tested goats because they are born as twins, allowing her to control for both the genetic relatedness of a kid to its parent and for aspects of the prenatal environment. One member of each pair was assigned to an experimental condition and the other to the control condition of normal rearing on the farm, with the mother, other animals, and the farmers. Gibson planned to test twin pairs in four experimental conditions that varied the identity of the kid's primary caregiver: the biological mother, a foster mother (another lactating goat), a peer (another kid), and a human (with feeding from an artificial nipple in the latter two cases).

Gibson intended to measure the psychological functioning of the kids as they grew to maturity. Had she completed her research, her experiment would have preceded that of Harry Harlow, on infant rhesus monkeys, by nearly a decade and with a design of more immediate relevance to children's social cognitive development. Unfortunately, Gibson's study could not be completed. On the first working day after Easter, she arrived at the lab to discover that the kids in her control group had been given to friends of Liddell's brother-in-law for their holiday dinners. Gibson therefore left Liddell's lab and never returned to the question that her experiment addressed, depriving the field of social cognitive development of the first study of effects of mothering that controlled for the genetic relatedness of mothers and offspring. Two titans in the field of animal psychology—Yerkes at Yale and Liddell at Cornell—had now thwarted her efforts to conduct experiments on animals.

The logical next step for Gibson was to turn to studies of children. This too was difficult. Hermann von Helmholtz, the eminent nineteenth-century physicist and physiologist, had conducted fundamental research on audition and vision using psychophysical methods, probing relationships between physical stimulation and phenomenal experience. Because the latter is accessible only to the experiencer, however, he argued that a psychophysical experiment can only be conducted on oneself.[6] Moreover, psychophysics depends on careful observations that require training: for example, attending to peripheral flashes of light without moving the eyes, or judging whether two flashes differ in hue, brightness, or saturation. Because these experiments can only be conducted by highly trained observers who test themselves, Helmholtz argued that children are not fit subjects for psychophysical research.

Helmholtz's foremost follower in the United States was Edward B. Titchener, a student of Wilhelm Wundt, who presided over psychology at Cornell University from to 1890 to 1925. Titchener's student, Edwin Boring, was chair of Harvard's Psychology Department from 1928 to 1956. Drawing their lessons from Helmholtz, neither Titchener nor Boring included developmental psychology within the purview of their departments: decisions with long-lived consequences. At Harvard in 1967, when I arrived, those who wished to study developmental psychology majored in the Department of Social Relations, which included a mix of sociology, social psychology, personality theory, and social anthropology. The Department of Social Relations was disbanded shortly after I graduated and child development moved to Harvard's Department of Psychology, but at Cornell, the Department of Human Development and Family Studies was housed in the School of Home Economics (later, Human Ecology) and merged with the Psychology Department only in 2021.

Gibson's next research project challenged Helmholtz's thesis that psychophysical experiments required adults with extensive training, judging the properties of isolated points of light. On several large, open fields on Cornell's campus, she tested untrained Air Force recruits' judgments of absolute and relative distances. Participants were randomized to two conditions of training, with and without feedback on their judgments. Absolute distance judgments in yards were initially inaccurate and improved with feedback, but the improvement generalized, with no further training, to a new environment and task: judging the size of an object.[7,8] Relative judgments, requiring no metric, were accurate from the beginning and unaffected by feedback.[9] In contrast, when the recruits were presented with still photographs of the fields, their judgments of object distances and sizes were less accurate, consistent with the thesis that perception of the surface layout depends on detection of optic flow.[10,11,12]

With these studies, Eleanor Gibson's research showed that rigorous psychophysical experiments can be conducted outside the laboratory on untrained participants. Moreover, such experiments reveal perceptual abilities that could never be discovered by measuring a trained observer's experiences of isolated points of light, for they depend on the rich arrays of optical stimulation that are available in natural environments. Further laboratory experiments isolated the effects and properties of optic flow by presenting participants with cast shadows of 3D textured surfaces.[13,14] Vision scientists in diverse fields have used the latter methods ever since, presenting perceivers with visual motions, now generated by computers, to study the computational properties of human vision, the brain systems that underlie perception and navigation, and the development of those systems in fetal and newborn animals.

In 1957, Richard Walk joined Cornell's Psychology Department and opened a laboratory for studying learning in rats, giving Gibson another opportunity to conduct research on control-reared animals. After studying dark-reared rats' abilities to distinguish between visible objects based on their shapes, Gibson and Walk turned to the problem of depth perception. They built a "visual cliff" consisting of a slightly raised, long, and narrow platform centered above a horizontal glass plate. Thus, both sides of the platform could be safely traversed, but the glass was invisible: on one side, the platform appeared to end at a cliff (patterned paper on the floor below) and on the other side, it appeared to stand a safe step away (the same paper, directly below the glass). When placed on the platform, both light- and dark-reared rats stepped onto the glass covering the visually near surface and avoided walking over the visual cliff.

Many studies followed with diverse species, including newborn goats and crawling human infants. In all these species, cliff avoidance depended on detection of optic flow and was unaffected by other depth cues.[15] They achieved their most interesting results in a study on dark-reared kittens. When placed on the cliff, kittens reared in the dark crossed over both the deep and shallow sides on the first day of testing. With further days in the light however, all eventually came to avoid the visual cliff, even though all their experience had revealed that it was safe. Thus, "it could not be argued from their behavior that experience with drop-offs was required for avoidance of them to appear…. Experience should have taught them that it was as safe as the other side, if it taught them anything."[16] With the advent of computers, experimenters have followed in Gibson's and Walk's footsteps by placing animals in virtual worlds whose properties differ from their natural environment, testing the robustness of intrinsic abilities to perceive, act, and learn.

Gibson and Walk's findings led to numerous insights. First, perception of the ground surface is fundamental to perception and locomotion, not only in adults but at the onset of visual experience. Numerous experiments in psychology and neuroscience have now revealed that the ground surface, and the optic flow that specifies it, also is critical for navigation and for rapid encoding of the navigational affordances of visual scenes. Second, Helmholtz's arguments against the applicability of psychophysical experiments to studies of development were vitiated: human infants and animals can be tested rigorously when they focus on a child or animal's motivation to explore the environment. This research brought studies of children and animals solidly within the purview of psychology and the cognitive sciences. Third, visual cliff experiments showed that claims of innateness are testable through behavioral experiments: They pose no imponderable mysteries. Indeed, studies of innateness and learning are complementary, and both are needed to explain development. Gibson and Walk resolved a central question in the centuries-long controversy over the origins of depth perception, and they laid the groundwork for further studies of perceptual learning, as well as studies of the origins and development of action and knowledge.

These accomplishments did not, however, lead Cornell University to offer Eleanor Gibson a position on its faculty. Her research continued to depend on the success and good will of other faculty members, and her research with animals was ended in 1959, when Richard Walk left Cornell. Gibson's situation did not improve until 1965, when Cornell received a Career Research Award from the U. S. National Institutes of Health on behalf of James Gibson. This award fully funded his salary at Cornell and released Eleanor Gibson from the confines of Cornell's anti-nepotism rules. In 1966, she was offered a half-time position as a professor in Cornell's

Psychology Department, but still with no lab, even after her election to the National Academy of Sciences in 1971.

Accordingly, Gibson contributed to a new research venture proposed by two full-time faculty members: studies of reading. Her first studies focused on children's discrimination of alphanumeric characters based on their geometric properties: abilities now known to be universal across cultures and highly flexible in adults. When presented with the left-right reversals and up-down transformations that distinguish letters, children's performance improved in synchrony with their progressive learning to read: findings prefiguring later evidence, from Stanislas Dehaene and collaborators, that learning to read transforms shape-sensitive regions of the brain.[17] In later studies, Gibson emphasized the importance of children's home environment and the intrinsic motivation to learn that it fosters: "providing young children with an environment supplied with plenty of literature of the kind one wants them to be curious about, and letting them explore a variety of reading material with adults who are ready to answer questions and provide role models by reading themselves and to their children…. One doesn't *teach* reading to someone, rather that person *learns* to read. We can only learn to read by engaging in reading, and we have to do it for ourselves."[18] The findings of recent field experiments in education highlight the difficulties faced by children who lack the supportive home environments that Gibson described, underscoring the prescience of her observations.

As research on reading progressed, Gibson completed the book that was the culmination of decades of thinking about perceptual learning. *Principles of Perceptual Learning and Development* (1969) received the Century Award, given to the best psychology book of the year, and it was named a "citation classic" ten years later.[19] In its final chapter, Gibson discussed three overarching trends in perceptual development: perception becomes more specific, consistent, and economical; it is sharpened by children's progressive optimization of attention; and it becomes progressively more attuned to hierarchical structure in stimulation. She ended with a gesture that extends beyond the study of perception to developmental cognitive science writ large, in the form of a call for more research into the third trend:

> "Psychology has not gone far enough in investigating the growth of ability to detect regularity, order, and structure. This ability is basic for cognition. The detection of similarity, equality, symmetry, transitivity, and congruence is essential for learning mathematics, and the good teacher does his best to make them perceptible by clearing away the superfluous details and baring the skeleton."

Again, Gibson's prescience is attested by research in education and cognitive science over the last three decades.

With the publication of this book, Gibson began to achieve the recognition at Cornell that she had long received beyond its walls. In 1972, she was named the Susan Linn Sage Professor of Psychology, her first full-time faculty appointment. One aspect of this appointment excited her most of all: "For the very first time, I was to have a lab of my own! I decided on an infant lab, which I had always wanted, and it totally changed my research outlook and program."[20] Cornell's retirement rules, however, allowed Gibson to remain on its active faculty and keep her Sage professorship for only three years.

After her retirement in 1975, Gibson was allowed to keep her lab on the condition that she continue to receive extramural grants covering all her research expenses and training costs for graduate students. In this manner, Gibson remained active at Cornell until 1987. Her first research focused on infants' perception of surface rigidity and deformability, using a simple, powerful method based on young infants' intrinsic motivation for exploring and learning about objects and events. In a series of familiarization trials, infants viewed a foam-rubber object undergoing three rigid motions. Then the object underwent a fourth rigid motion and a deforming motion on alternating test trials. Each event occurred for as long as an infant looked at it, and their looking times were recorded. Looking time declined over the familiarization period and remained low for the new rigid motion but rose for the deforming motion, which revealed a new substance property. Thus, infants responded to motion-carried information for an object property.

Further studies with her student, Arlene Walker, focused on older and younger infants' exploration of objects by vision and touch. In one experiment, one-year-old infants were familiarized with either the rigid or non-rigid object in the dark. Infants given the non-rigid object tended to exert pressure on the object, deforming it, whereas those given the rigid object tended to strike it against a surface. These events were followed by a visual preference test presenting the rigid and non-rigid motions from the previous studies. Infants looked longer at the object that they had manipulated in the dark. Thus, their manual activities likely increased their motivation to explore the object by looking. In another experiment, infants just one month of age explored a rigid or non-rigid object in their mouths and then showed the opposite looking pattern. Perception therefore was amodal at both ages, but only the older infants differentiated between the two modalities, focusing on the visual information that touch did not provide.

Using these methods, Gibson turned to a question that could not be answered by her research with human infants on the visual cliff: Do human infants perceive the affordances of visible surfaces for action before they are able to locomote independently? With student John Carroll, she focused on infants' perception of the affordances of obstacles and apertures at three months of age, before infants can crawl, sit, or even reach for objects. They presented infants with a rectangular, flat, bounded, and textured surface (a potential obstacle) and with a larger flat surface with a rectangular hole where the obstacle had been removed (an aperture). In alternating trials, the obstacle and the aperture progressively moved toward and away from the baby, whose head movements were measured by a pressure transducer placed against the headrest of the seat from which they viewed the array. As the obstacle approached, the infants moved their heads backward, a behavior that likely functions to avoid a collision. As the aperture approached, the infants moved their heads forward and to the two sides, likely to explore the scene that came progressively into view.

Beyond these substantive findings, Gibson's research on infants provided methods that were adopted by many developmental cognitive scientists to study the origins of knowledge in diverse domains, from language learning to object permanence and numerical, geometrical, and social cognition. The methods, focused on selective looking as an early-emerging exploratory behavior, have proved to be extremely robust and successful. While Gibson was planning and conducting her research, the simplest measure of such exploration—the judgment, by an unbiased observer, of which of two concurrent displays an infant looked at more on each of a series of trials—had shed light on the origins and growth of a host of perceptual functions studied by Helmholtz, including color vision, contrast sensitivity, and stereopsis. For example, simple, forced-choice judgments by human observers, based on the timing and direction of infants' looking, were sufficiently robust to allow psychophysical functions to be calculated for each individual infant in Richard Held's now-classic research on the emergence and acuity of stereoscopic depth perception: a cortical function that emerges between two and four months of age.

With great generosity, Gibson used her lab to foster not only her own research but that of her students: both research that she helped to design and research that she inspired her students to design on their own. Like Hull (who did not claim authorship on Gibson's published thesis experiments), Gibson gave students the freedom to conduct their own research and test their own ideas, while instilling in us both a love for research and a commitment to its rigorous pursuit. With frequent (and friendly) theoretical disagreements, Gibson guided the research of many investigators of infant cognition and language development every step of the way, just as Hull guided her own independent investigations of perception, a field beyond his chosen domain.

Gibson received numerous awards. She never seemed particularly excited about them, but here I mention a few. Before she had her own lab, she was elected not only to the National Academy of Sciences but also to the American Academy of Arts and Sciences and the Society of Experimental Psychologists, and to the presidency of the Eastern Psychological Association, and she received the APA Award for Distinguished Scientific Contributions from the American Psychological Association. In later years, she was awarded the Wilbur Cross Medal from Yale (1973), the National Medal of Science (1992), and at least five honorary degrees, including from Smith College (1992) and Yale (1996).

From the closing of her lab in 1987 to her passing on December 30, 2002, Gibson's research activities diminished, but she continued to travel, to engage with scientists and their students, and to write and speak about psychological science. She published three more books, *An Odyssey in Learning and Perception* (1991), *An Ecological Approach to Perceptual Learning and Development*, with co-author Anne Pick (2000), and, in her last year, *Perceiving the Affordances: A Tale of Two Psychologists* (2002). The goal of her last book, she reported, was,

> "[T]o show that it is possible to raise a family and do one's job … without sacrificing one's independence. Yes, there were what some would consider sacrifices (when I gave up my safe teaching job at Smith for a completely uncertain research future), but with plenty of love, family support, and imagination it can turn out to be far more interesting than sticking to that safe spot. My husband and I both loved intellectual adventure, and it led to frequent travel, new friends, well-educated children, and most important, some new insights in science."

Gibson's last book also includes her 1987 commencement address to all the graduates of the University of South Carolina. She reflected on the opportunities and obligations faced by the graduating students: "Among you are the people who are going to do the teaching, guide the universities, pursue research, protect the rights of the less privileged in legislatures and courtrooms, heal the sick, and make decisions about life and death—in short, protect humanity in our society." She then described three pressing issues that the students would face: threats to the continued existence of human life on Earth posed by nuclear weapons; threats to human health posed by pandemic diseases; and a threat that concerned academia most directly: "an ominous trend toward greater inequality (enrichment of some at the cost of the impoverishment of others)." Gibson described the effect of widening income inequality on students, who no longer felt that they could choose a career with the goal of helping others and improving the world. She noted, "we seem to be living in a hard-edged, competitive society." She ended her address with a question:

> "How do we make education an experience that leads students to seek ideals and loyalties beyond their personal ones? To value integrity in scholarship, in science, in business, and in law? A part of the answer is that you yourselves, the people who have enjoyed the most that society has to offer in an excellent education, must constitute the models."

Gibson faced challenges far greater than those faced by women in science today, but today's students and academics in all fields face the larger problems that she described, compounded by climate change and by a widening of inequality. Her story, however, reveals a life in balance. She was equally devoted to work and family; to research she loved and to teaching and mentoring that paid her own education forward; to intellectual arguments between lasting friends; to the core questions addressed by her research and to larger issues calling for collective action. She lived richly, happily, and responsibly in challenging times.

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