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James J. Gibson—An Appreciation

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Gibson conceived of a perceptual psychology very different from that taken by mainstream research work in vision over the past 30 years. Placing psychology in a biological and physical context and avoiding traditional disciplinary definitions, Gibson outlined a physics relevant to animate life. From this flowed his theory of affordances, his preoccupation with surfaces, and his interest in animal locomotion. Visual motion played a decisive role in rounding out these views. His work here was prophetic, anticipating neurophysiological discoveries on motion sensitivity and directly inspiring more recent studies on higher order aspects of motion encoding. Gibson scrupulously avoided mention of internal representation. Yet, those researchers interested in such internal processes remain deeply indebted to his enduring contributions.

I saw Gibson just once and immediately formed a negative impression. That was back in 1963. I was a beginning graduate student in physiological psychology at the University of California at Los Angeles (UCLA), eager to understand the mind and behavior in terms of brain function. I attended Gibson's lecture, aware only that he was a well-known psychologist. Other than some mention of slant perception, I recall little of the content. I had, however, an impression of a man impervious to new information, old fashioned, perhaps reactionary. But of course I was young and opinionated, I knew very little about perception, and I had just learned of the spectacular discoveries of Lettvin (Lettvin, Maturana, McCulloch, & Pitts, 1959), Hubel and Wiesel (1959), and others. Someone raised the issue of Lettvin's work during the question period, and I was struck by Gibson's uninterested, dismissive tone. Either he did not seem to understand the findings or, if he did, he thought them irrelevant. "Hmm," I thought to myself, "another traditional psychologist, old fashioned, maybe on the defensive, not able to keep up with things."

I walked out of the room somewhat puzzled. How could such a renowned person have turned his back to such amazing results? No matter. In the next several years, I was to follow my dream and set up a single-unit neurophysiology laboratory to map receptive fields and to try to link the behavior of single cells to visual psychophysics.

Just before leaving graduate school, I happened to come across Gibson's (1966) newly published book, *The Senses Considered as Perceptual Systems*. Since Gibson's lecture in 1963, I had not thought much about Gibson. I did have the uneasy feeling, however, that maybe I was missing something. Perhaps my original opinion needed reassessment.

I bought the book, and I remember I could not stop reading it. It was hard to place. It did not seem scientific, but it read more like a philosophical essay. Yet it really was not like contemporary philosophy; it was more broadly synthetic. The language was very plain, free from the usual buzzwords or scientific jargon. Initially, the ideas had a distinct sense of the everyday about them, a description of the earth below, sky above, certainly not revealing any obvious hidden "secrets" about vision, at least not then. Nevertheless, Gibson's views did not seem unreasonable, despite his claim to have a very radical position. It was his main point, the primacy of "perception" over "sensation" that was generally the most memorable, but I also recalled, in passing, the emphasis of the mobile observer and the accompanying change in the optic array. I remember conveying a very tentative enthusiasm to a perception graduate student at UCLA. By then I realized that I really did not know much about perception and wanted his opinion. He scoffed, "Oh Gibson, that mystical stuff, where are the experiments? No testable hypothesis, no quantitative predictions."

It was not until I became a postdoctoral student at the University of California–Berkeley that at least one of Gibson's ideas began to sink in. Intending to record from the lateral geniculate nucleus, I often noticed that above the nucleus (in a then uncharacterized extrastriate cortical area), it was very easy to isolate single cells and that virtually all the neurons there were insensitive to form yet were clearly sensitive to motion. I thought, "Perhaps Gibson is right, maybe the function of motion is much more than the mere registration of moving objects in the world, but is also used for the perception of space and self motion. There seem to be too many neurons just for the registration of moving objects." Not too long afterward, I had the pleasure of collaborating with Jack Loomis. We read Gibson again and made an effort to bridge the gap between his ideas and those of Barlow (1961), who suggested that visual neurons should code meaningful regularities in the environment, thus reducing redundancy. We postulated the existence of a class of velocity sensitive neurons that could obtain information about the boundaries of surfaces during observer locomotion (Nakayama & Loomis, 1974). Such was the beginning of a growing appreciation of Gibson's contributions and a recognition that, far from being old fashioned, his ideas about visual motion could provide the foundation for entirely new research directions. I sus-

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pected that I would do well to reread Gibson from time to time because it was apparent that buried in this deceptively simple prose were some of the most interesting thoughts on vision that I had ever encountered. I would just have to reread these books at intervals to grasp their full meaning.

Over the intervening decades, I have not been disappointed. This occasion to comment on Gibson's 1954 article, "The Visual Perception of Objective Motion and Subjective Movement," certainly gives me another opportunity to both hear him out and to urge the reader to do so. The strength of Gibson's short article is that it anticipates and brings together issues and questions that had been previously neglected and that have now become recognized as critical questions. However, it also appears that Gibson was severely constrained, having to write a piece to be both short and understood entirely on its own. So by itself it lacks the depth of some of Gibson's longer writings, acquiring more significance in the broader context of Gibson's more sustained thinking. Thus, to be fair to Gibson, I comment on his article in the larger context of his more systematic writings on perception, primarily his books.

In his *The Perception of the Visual World,* Gibson (1950) proposed a psychophysics of vision, a research program that differed markedly from the prevailing practice of visual psychophysics. Traditional psychophysics began with Fechner, who invented an approach to link elementary physical quantities to what he thought were the simplest mental events. The absolute and differential threshold provided an operational, objective method to establish a relationship between physical intensity and sensation. Later, the structuralists would attempt to understand perception and higher processes in terms of elementary sensations, as if to build mental molecules out of atomic sensations. Logical and reasonable as it may have sounded at the time, the search for a "mental chemistry" failed. A description of "elementary sensations" did not lead to an understanding of perception.

Although the specific enterprise of the structuralists did not succeed, a much more broadly based program, motivated by a similar desire to understand perception in terms of elementary constituents, has emerged in the past 30 years. Calling itself by various names, such as vision, visual science, and visual neuroscience, this program forms a large, vigorous, and growing interdisciplinary field embracing neurophysiology, anatomy, psychophysics, and perceptual psychology. It also reaches out to computer vision and cognitive psychology. It was boosted by Hubel and Wiesel's (1959) description of visual receptive fields at various anatomical loci. Their catalogue of receptive field types held out the promise of a hierarchical progression, where cells with simple properties would then go on to bestow succeeding cells with complex, then hypercomplex, properties simply on the basis of excitatory and inhibitory connections. Lettvin et al. (1959) implied that the successive logical operations of differentiation and generalization had the hallmarks of logical thought. Extending this attractive idea to link it to the everyday facts of perception, however, began to run aground fairly early. Hubel and Wiesel, wisely, sidestepped the issue as to the specific functional role of these cells and directed their energies toward anatomical investigations, using novel techniques to reveal the intricacies of cortical architecture with convincing detail. This was accompanied and followed with the important discovery that the posterior portion of the brain consisted of many maps of the visual field (Allman & Kaas, 1974; Van Essen, 1985; Zeki, 1978). However, this tremendous increase in knowledge has told researchers mainly about the "nuts and bolts" of the visual system, not about how visual perception itself might work or what its specific functions might be.

During this time, psychophysics became informed by these neurophysiological developments, and a parallel concept of an orientation selective spatial frequency channel emerged, one that provided a link to the receptive fields of cortical neurons (DeValois & DeValois, 1990). Such channels could explain simple detection and discrimination experiments, and some combination of channels provided some explanation of simple pattern discriminations as well as providing some foundation to understanding motion encoding and stereopsis. However, it was a far cry from everyday perception. Marr (1980), keenly sensing the crises in the playing out of the separate fields of physiology and psychophysics, articulated a synthetic view of how these findings might fit into a larger conception of visual function.

Meanwhile, Gibson appeared to all but ignore these developments. Early on he wrote, "The writer has elected to study psychophysics rather than psychophysiology because he believes that it offers the more promising approach in the present state of knowledge" (Gibson, 1950). Although using the term psychophysics, the psychophysics of Gibson was altogether different from the traditional variety just described. To review Gibson's psychophysics, I consider what he meant by each component—the physical first, then the psychological.

Gibson's Physics

All through his long scientific life, Gibson the psychologist would show a deep interest in physics, endeavoring to find a broad and more principled framework within which to place psychology. However, for Gibson it is a physics not recognizable to physicists, at least not then. Gibson's physics is the physics of the everyday on the scale of the everyday. It spans the distances traversed by animals, not those traversed by atoms or galaxies. It spans durations of the present, not infinitesimal instants or epochs. It deals with forces of the everyday and with its materials.

It is a physics more tied to macroscopic phenomenon, largely ignored by physicists. For example, against Eddington's (1928) *The Nature of the Physical World,* Gibson argued,

> Some thinkers, impressed by the success of atomic physics, have concluded that the terrestrial world of surfaces, objects, places and events is a fiction. They say that only the particles and their fields are "real." The very ground under one's feet is said to be "merely" the bombardment of molecules. (Gibson, 1966, p. 22)

Ground, the earth on which we stand, is physical and very real to Gibson and would become a cornerstone of his environmental physics.

Thus, Gibson's physics differed in at least two significant ways from conventional physics. It was a physics restricted to a scale comparable to the animal. In addition, it possessed a particularity not usually associated with physics, consisting of those physical features of our earthbound environment relevant to animate life. Thus, it consisted of a firm ground below, but with numerous and often dramatic deformations and outcroppings (terrain), air and illumination above, and large bodies of water (oceans, rivers, puddles, etc.). Even more specific and most emphasized in later work (Gibson, 1979) is the description of the physical world exclusively considered in terms of its potential functional relation to an animal's existence. The focus remained rooted in the physical world, but it now became fused with psychology because Gibson felt a need for an environmental physics defined specifically in relation to animate life. For this purpose, he developed his well-known theory of affordances:

> The affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill. The verb to afford is found in the dictionary, but the noun affordance is not. I have made it up. (Gibson, 1979, p. 127)

Gibson linked his ideas explicitly to evolutionary biology and behavioral ecology, indicating that a particular set of affordances comprised an "ecological niche" for that animal. Affordances and niches to Gibson had an objective meaning freed from mentalism and subjectivity: "The niche for some species should not be confused with what some animal psychologists have called the 'phenomenal environment of the species in which the species is supposed to live'" (Gibson, 1979, p. 128).

Surfaces for Gibson are one of the most important generic physical features of the physical environment:

> The surface is where most of the action is. The surface is where light is reflected or absorbed, not the interior of the substance. The surface is what touches the animal not the interior. . . . If a terrestrial surface is nearly horizontal (instead of slanted), nearly flat (instead of convex or concave) and its substance is rigid (relative to the weight of the animal), then the surface affords support. . . . If its surface of support with the few properties is also knee-high above the ground, it affords sitting. We call it a seat in general, or a stool, bench, chair. (Gibson, 1979, p. 23)

Thus, Gibson's physics is not about the physical world by itself, but only in its relation to potential physical actions of animals. Locomotion, a major focus of Gibson's 1954 *Psychological Review* article, constituted one class of actions common to all animals and was of major concern to Gibson. His interest can be separated into two components. First is the issue of how locomotion with respect to the physical environment is controlled, the issue of proprioception. Second are the consequences of locomotion for perception, the effect of a changing optic array. When considered jointly, they would provide a major source of new ideas about vision.

Gibson's Psychology of Information Pickup

Hand in hand with Gibson's very different approach to physics, his conception of perceptual psychology and the nature of the visual stimulus differed greatly from traditional psychophysics. Gibson's conception was to make a tight linkage between *his* physics and *his* psychology. As such, he rejected the traditional route on which most of researchers' current understanding of vision now rests. Referring to that tradition, he wrote,

> The visual exposition of the sense of sight begins with the anatomy of the eye. There follows an account of the visual sensations, with emphasis on color, brightness and form as they are related to the photosensitive cells of the retina. . . . The whole treatment is in terms of human vision. We shall begin, however, with the question of what eyes are good for. (Gibson, 1966, p. 155)

In short, for Gibson this meant getting information from the layout of surfaces and controlling behavior in this environment, particularly locomotion. So rather than light intensity, spatial extent, spectral content (all of the physical variables of interest to vision researchers in the past), Gibson would be concerned with surfaces in particular reference to the actions of animals.

Ignoring the conventional approach taken in perceptual psychology and psychophysics, with its preoccupation with visual angle in the two-dimensional retinal image and the needed reconstruction of the third dimension by means of binocular parallax, Gibson's space perception repudiates any scheme based on Cartesian coordinate axes:

> Visual space, unlike abstract geometrical space, is perceived by virtue of what fills it. . . . The surfaces, slopes, and edges of the world have correlates in the retinal image specifically related to their objective counterparts by a lawful transformation. If this is correct, the problem of the restoration of the lost 3rd dimension in perception is a false problem. . . . There is literally no such thing as the perception of space without the perception of continuous background surface. This hypothesis might be called a "ground" theory to distinguish it from the "air" theory. (Gibson, 1950, pp. 5–11)

Gibson thus saw light "itself," not as a stimulus but as a carrier of information about the surrounding environment of surfaces. Perhaps one of the most controversial ideas was that the pickup of information from surfaces was "direct," not mediated by some kind of synthesis or set of inferences. What led Gibson to this view was his notion of the higher order variable of the optic array, a variable of optical stimulation that if directly measured, would give an immediate and informative reading. Consider his well-known example of size. An object of a given size cuts x units of texture elements with respect to the surface that it sits on, no matter how far it is placed. No measurement of distance is necessary for an appreciation of equivalent size to be registered. To obtain the slant of a surface, Gibson saw the gradient of texture as particularly important, providing a direct measure of surface slant.

Thus, Gibson was concerned with obtaining information about surfaces in the world; he was not concerned with providing an exact copy between the information about surfaces and one's visual experience. Not requiring a replica, he went on to ask whether a psychophysical bottom-up approach to perception is possible:

> If, contrary to past teaching, there are exact concomitant variations in the image for the important features in the visual world a psychophysical theory will be possible. . . . The question is not how much it resembles the visual world but whether it contains enough variations to account for all the features of the visual world. (Gibson, 1950, pp. 61–62)

These views anticipate by over 25 years one of the most important tenets of computational vision, articulating the nature of the stimulus information required for vision (Marr, 1980).

As revolutionary and more immediately influential was Gibson's suggestion that spatial gradients of motion were sensed directly because in fact, these gradients of motion, like gradients of texture, could provide direct information regarding surface layout and extent. To appreciate the boldness of these assertions about motion, one has to understand the prevailing view of vision at the time. Then and even now, vision is seen in terms of the static retinal image, a set of light intensities across the photoreceptor mosaic, stimulating local retinal points, or "signs," from which perception must be built.

So sure was Gibson of his own views that as early as 1950, he could turn his back to this established thinking and calmly yet prophetically assert,

> Every photographer is aware that even a slight movement of his camera during exposure will shift the image on the film, for it ruins the picture. The same kind of shifting of the image on the retina occurs all the time during vision with the difference that vision is enriched rather than spoiled. (Gibson, 1950, p. 117)

The weight of the scientific tradition that Gibson had to repudiate is described by Lombardo (1987):

> Because the analogy between the retinal image and a static picture became popularized, the perceiver was not thought to be sensitive to optical change, a property of optical change or an invariant of optical change as such. Only those instantaneous properties of one given retinal image were thought of as stimuli. Perceived change, such as movement always required memory images, integration, inference, or some process of metatemporal organization. (p. 216)

For Gibson, the memory image of the immediately preceding retinal image was deemed unnecessary: The observer could directly sense change and the gradient of change.

Although the idea of a motion gradient did not receive an adequately precise definition by Gibson (it is more complicated than the usual gradient of scalar fields described by vector analysis), his basic intuitions have proved to be largely correct, at least mathematically. Evidently aware of contemporary ideas of mathematical invariance and group structure, and citing Courant and Robbins (1941) and Ernst Cassirer (1944) in his 1950 book, Gibson argued that a higher order variable of the motion field would be more explicitly informative about surface layout than motion itself. He also made the same claim for binocular disparity, suggesting that the gradient of disparity rather than disparity itself was more informative. In a highly influential set of mathematical articles in the mid 1970s, Koenderink and van Doorn (1976a, 1976b) examined the nature of motion parallax and binocular parallax fields and were able to show that a certain higher order component of the gradient of these fields was indeed more explicitly informative about surface orientation. Since then, Koenderink in similar spirit has gone far beyond Gibson, essentially creating a mathematics of vision, describing how images from surfaces either vary or remain invariant with viewer position.

Gibson's Impact: Relative Motion and the Control of Locomotion

For those younger scientists coming of age after the discovery of motion sensitive neurons, Gibson's ideas might not seem particularly startling until they realize that his detailed thinking about motion antedated the physiology. Only now has the physiology begun to catch up with and to address the class of questions asked by Gibson, and only now has the physiology begun to discover otherwise unforeseen properties of visual neurons that appear to vindicate his emphasis on motion and relative motion.

In my own case, I was very interested in whether neurons in the visual system of animals might analyze the moving image to pick out surfaces for the moving observer. As mentioned earlier, with Jack Loomis and directly influenced by Gibson, we postulated the existence of higher order visual neurons that would take differences in velocity between the center and surround of a receptive field, independent of direction. Such cells could highlight the boundaries of surfaces for a wide range of observer and eye motions (Nakayama & Loomis, 1974). Our analysis rested on the fact that the velocity fields created by observer translation could be mathematically distinguished from those created by observer or eye rotation. Later, in collaboration with Barrie Frost (Frost & Nakayama, 1983), we looked for cells that might generalize velocity differences between center and surround and indeed found neurons with spectacularly complex properties that were almost but not identical to those anticipated. Essentially, all cells of the pigeon optic tectum fired only when the motion of the center was in the opposite direction to that of the surround, generalizing this property over a wide range of motion directions. In detail, it became quite clear that such cells would not outline the edges of surfaces during motion, say flight, because they would be unresponsive if center and surround were both stimulated by motion in the same direction. Yet the eyes of the walking pigeon are mostly stationary with respect to the environment because of the head-bobbing reflex. As such, these neurons could well serve to address one of the key questions asked in Gibson's 1954 article. He asked how we can determine self motion from the motion of objects when both lead to image motion on the retina. These cells will distinguish the motions of small objects from large background motions at least during walking. Despite the highly specific and complex requirements for cell firing, the exact function of these cells, however, remains unexplained. Nevertheless, without the Gibsonian framework it is clear that we would never have looked for or found cells with such remarkable properties.

More closely related to our original idea of outlining surface boundaries, John Allman and associates found cells in monkey visual areas that preferentially responded when the velocities of center and surround were different (Allman, Miezin, & McGuinness, 1985). More recently, and echoing Koenderink and van Doorn (1976b), cells with higher order properties of the velocity field (divergence or curl) have been identified in monkey extrastriate cortex (Tanaka & Saito, 1989).

It is in the control of locomotion, however, that the most complete vindication of the Gibsonian outlook is evident, at least so far. In his 1954 article, Gibson asked about the visual perception of locomotion in a stable environment. Shortly thereafter, Gibson (1958) proposed that the focus of expansion, the point in the velocity field where all motion vectors originate, constituted an optical invariant that would identify for an observer his own heading, his direction of motion with respect to a visual environment. Although this is not true if the animal rotates his eyes during locomotion or moves in a curvilinear path (see Nakayama, 1982), one can conceive of isolating the focus of expansion from the added rotational component purely from operations of the velocity field itself or by taking account of eye rotations. Psychophysical studies have in broad outline confirmed Gibson's imaginative hypotheses, showing that observers can sense their own direction of motion in a computer simulated display (Warren & Hannon, 1988). For complex conditions where the eye does not undergo pure translational motion, the sense of eye position is also required (Royden, Banks, & Crowell, 1992). As yet, however, researchers have not gone beyond these psychophysical observations to show that humans or animals actually use this information to perform real locomotor tasks.

A more spectacular vindication of Gibson's approach concerns the timing of impending collision as one approaches surfaces or when projectiles are moving toward observers. Symmetrically growing images simulate a direct hit, a very primitive visual spatiotemporal pattern to which human infants are differentially responsive (Yonas, 1981). Building on Gibson's theory of invariances, Lee (1976) described the optical parameter *tau*, the angular extent of an approaching object divided by its first time derivative. This variable provides exact information as to the time when the target will collide with the observer (see also Hoyle, 1957). It is remarkable that this variable provides reliable information independent of distance or speed, thus providing not mediated but direct information of obvious behavioral relevance. Lee later found that this variable could account for the behavior of diving birds, who must streamline their wings just before plunging into the water at high velocities (Lee & Reddish, 1981). Most recently, in a very exciting set of physiological experiments, Wang and Frost (1992) found neurons in the pigeon visual system that fire at a fixed interval of time before an impending collision, independent of distance or speed. This sequence of remarkable studies is perhaps one of the most dramatic of the recent success stories emerging from the Gibsonian framework.

The Perceptual Primacy of Surfaces

For Gibson, surfaces were all important, both in the realm of the physics relevant to animate life and in the psychology of information pickup. Not surprisingly, the traditional approach of psychophysics and neurophysiology, with its preoccupation with visual angle, luminance, and spectral content, ignored surfaces. They were not forgotten, however, by perceptual phenomenologists, who created many demonstrations showing the importance of surface phenomena (Kanizsa, 1979; Metelli, 1974). Yet, so buried was this awareness of surfaces that Marr's (1980) theoretical formulation of the 2.5-dimensional (2.5 D) sketch (essentially a revival of surfaces) became a high point in his ambitious enterprise to "explain" vision. It is of interest to quote Marr directly: "For all these reasons, the emergence during the autumn of 1976 of the idea of the 2.5 D sketch, which first appeared in Marr and Nishihara . . . was for me the most exhilarating moment of the whole investigation" (Marr, 1980, p. 269).

Over the past 7 years and with the close collaboration of several colleagues, I have developed a very strong interest in surfaces. Our work, however, did not start from Gibsonian principles or outlook but began as a set of phenomenological explorations. Yet, a set of conclusions emerged from our work that I think show clear parallels to ideas promulgated by Gibson years earlier. First, we argued that the pickup of information about surfaces is more or less an autonomous process, accomplished before object recognition (Nakayama, Shimojo, & Silverman, 1989), which may begin as early as cortical area V1 (Nakayama & Shimojo, 1990a, 1990b). Second, and strongly echoing Gibson's philosophical views on the primacy of perception over sensation (Gibson, 1966), we showed that observers are more immediately responsive to surface properties in an image, not features. Thus, surface shape, not features, determines performance in visual search (He & Nakayama, 1992), visual texture segregation (He & Nakayama, 1994), and apparent motion experiments (He & Nakayama, in press; Shimojo & Nakayama, 1990). Finally, and more directly influenced by Gibson through Koenderink and van Doorn's (1976c) formal description of the sampling of images from different vantage points, we developed a theoretical framework to understand the perceptual learning of surfaces (Nakayama & Shimojo, 1992).

Locomotion in a World of Surfaces?

In reviewing Gibson and his successors, I note that two of his most persistent interests, locomotion and the pickup of information about surfaces, have been, in at least one respect, curiously isolated from each other. To my knowledge, the control of locomotion and the perception of a world of surfaces have not been considered together. Perhaps this is because the parameters relevant to control the direction of locomotion (the focus of expansion) and the estimation of the time of collision (tau) have been considered as image properties with only an indirect relation to the composition of surfaces. Furthermore, more recent analyses within the Gibsonian framework have identified other potential optical parameters that could control locomotion. For example tau-dot (the first derivative of tau) provides information to control braking (Lee, 1976; see Yilmaz & Warren, 1992); changing image orientation has been identified as an optical parameter for a pilot landing an aircraft on a straight runway (Loomis & Beall, 1992). In all of these cases, one might be drawn to the conclusion that locomotion could be controlled independently of a surface representation. To my knowledge, this supposition has never been explicitly raised or tested. Researchers need to ask whether locomotion in general must be considered within a world of perceived surfaces or whether there might be primitive processes of motor control, perhaps the ones cited here, that might be driven by image information alone.

Summing Up

It should be evident from what I have written that I hold Gibson in the highest esteem. I should. At critical moments in my scientific career, I have benefited immensely from his theoretical perspective. However, his influence of course is far broader.

In fact, for sheer breadth, incisiveness, originality, and influence, I cannot imagine anyone more qualified to be recognized as the most important perceptual psychologist of the last 100 years. Spanning many levels—philosophy, physics, behavior, specifics of the stimulus—the sweep is without parallel. Then there is the obvious originality: surfaces, texture, invariance, motion, the moving observer, and ecological optics, to mention a few. Moreover, I would argue that Gibson's influence in perception, psychophysics, neurophysiology, and computer vision runs very deep, although not always fully acknowledged.

That said, and aside from noting my own first impressions of Gibson, I have avoided one aspect of Gibson's views that have received the greatest criticism. Gibson and especially his followers have scrupulously avoided reference to any form of internal representation. Whether this reflects a defensible ideological position as articulated by his followers (Turvey, Shaw, Reed, & Mace, 1981), a pragmatic ordering of research priorities as indicated by Gibson himself (1950), or a fundamental naïveté as suggested by Marr (1980, p. 30), this almost blatant disinterest in the face of steady and often brilliant progress in the fields of neuroscience and psychophysics strikes me as a major limitation, particularly now. Nonetheless, I have turned a blind eye to this uncompromising stance because, early on, I decided that Gibson's ideas were just too good to pass up. For whatever valid reasons Gibson may have had against internal representation, the discovery of new and unexpected forms of internal representation have been the happy result.

So, Gibson's influence has had some paradoxical features. Throughout his career, he has more or less ignored internal representation, the very thing that most of us non-Gibsonians have been looking for. Yet, he has had quite a few admirers from within "our" ranks. Why should this be so?

The answer is apparent as soon as researchers realize that the search for internal representation cannot proceed in isolation, divorced from behavior or from an analysis of that which has to be represented. Recall that Marr (1980) outlined different levels of explanation required for complex processes like vision. They were (a) the computational level, (b) the algorithmic level, and (c) the level of implementation. In grudging acknowledgment, Marr noted that Gibson's main contribution was restricted to the computational level but faulted Gibson for underestimating the difficulties posed beyond. My own view is that even Marr, his followers, and most of contemporary visual science might be comparably faulted for underestimating difficulties at the computational—I prefer the word functional—level.

Whatever the faults or limitations of studies conducted at these various levels, those of us who have chosen to study vision are very fortunate in having such rich traditions from which to draw. As a field, we need to think hard about internal representation and to continue to look to physiological findings. We also need the approach advocated by Gibson: clear and original thinking about the nature and purpose of visual function linked to a rigorous analysis of the optical information required.

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P&C Board Appoints Editor for New Journal: *Journal of Experimental Psychology: Applied*

In 1995, APA will begin publishing a new journal, the *Journal of Experimental Psychology: Applied.* Raymond S. Nickerson, PhD, has been appointed as editor. Starting immediately, manuscripts should be submitted to

Raymond S. Nickerson, PhD
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The *Journal of Experimental Psychology: Applied* will publish original empirical investigations in experimental psychology that bridge practically oriented problems and psychological theory. The journal also will publish research aimed at developing and testing of models of cognitive processing or behavior in applied situations, including laboratory and field settings. Review articles will be considered for publication if they contribute significantly to important topics within applied experimental psychology.

Areas of interest include applications of perception, attention, decision making, reasoning, information processing, learning, and performance. Settings may be industrial (such as human–computer interface design), academic (such as intelligent computer-aided instruction), or consumer oriented (such as applications of text comprehension theory to the development or evaluation of product instructions).