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MIND, IT DOES MATTER[1]

> Philosophy is akin to poetry, and both of them seek to express that ultimate good sense we term civilization. In each case there is reference to form beyond the direct meanings of words. Poetry allies itself to metre, philosophy to mathematical pattern.
>
> *Alfred North Whitehead*
> *Modes of Thought* ([27], pp. 237-238)

I

The title of this paper, 'Mind, It Does Matter,' is a variant on the old solipsistic saw: "Never mind, no matter." I have always been intrigued by this denial of the mind-brain problem but have found it untenable in pursuing neurobehavioral and neuropsychological research. The results of the research – and I am aware of the criticism that the results of brain research can have no bearing on ontological issues – have led me to a position best described as a biological constructional realism. As a biologist and a physician I can attest to the 'reality' of the psychological as well as the physical constructions that I face daily in laboratory and clinic. My realism is therefore neither naive nor physicalistic. In addition, it differs from critical realism in its emphasis on construction; critical realists are prone to accept their perceptions of the physical world as more or less veridical – the constructionalist is apt to emphasize the relativistic nature of consensual validation.

II. THE PROBLEM

I came to the present stance gradually and via many influences other than research results. Initially, the issue was opened for me when, as an opera-

S. F. Spicker and H. T. Engelhardt, Jr. (eds.), Philosophical Dimensions of the Neuro-Medical Sciences, 97–111.

tional behaviorist, I discussed with Lashley his presention, 'Cerebral Organization and Behavior,' at the Association for Research in Nervous and Mental Disease [14]. It was, it turned out, to be his last published paper. I accused him of having succumbed to mentalism. We argued a bit, and he then accused me of a naive realism. We both immediately realized that we had misjudged the other's arguments – Lashley was not a naive mentalist and I not a naive realist. But neither could we spell out where we differed from the 'naive' position.

I have since read Lashley's remarkable paper many times, and I recommend it as marking the watershed between the behaviorism of the early part of the century and the more encompassing cognitive psychology of today. After detailing some thirty years' effort in clarifying the mind-body problem operationally, Lashley characteristically concludes:

> I was forced to the conclusion that philosophers have been unreliable observers and that much of the difficulty of the mind-body problem is due to their incompetence as psychologists. The phenomena to be explained, as studied by psychologists, are mostly not what the philosophers have claimed them to be...
>
> The problems of mind suggested by the literature fall into two groups: first, the nature of the items, elements or things which are present in consciousness; second, the arrangement or patterns in which these items occur... The problem arising from these two aspects of mind are different. *The content of experience, the sensations and the like, constitutes all that is directly known*. It is the material which has most stubbornly resisted description in the space-time system of the physical sciences. The ordering is not so certainly to be characterized as mental. I shall deal with it first because *interpretation of the content of* experience is derived from the ordering.
>
> *Lashley* ([14], pp. 3-4)
> [Italics mine.]

Note that Lashley is making two apparently incompatible statements: (1) that the content of experience is all that is *directly* known and (2) that the content of experience is *derived* from its ordering. It is this apparent incompatibility which we both sensed and which mystified our discussion. Today, I would challenge Lashley to tell me which statement is, in his opinion, the more fundamental. Since I cannot do this, I can only present my own constructionalist resolution of the issue [21].

III. MENTALISM

But before detailing these observations on the issue of direct perception, some equally fundamental problems need to be faced. One of my original 'missions' in undertaking brain research was to excise mentalism from psychology as my forebears had excised vitalism from biology. The synthesis of organic urea from inorganic carbon, oxygen, nitrogen and hydrogen had sparked the development of biochemistry and the demise of vitalism. I had hoped that the study of brain-behavior relationships, by sparking the development of neuropsychology, would in a similar fashion dispose of mentalism. In a way I feel that my mission is now accomplished but in a completely unexpected fashion. Whereas vitalism proposed some vague 'vital principle' that differentiates the living from non-living, the proposals made by mentalists were of a different order. The richness of mind was not only detailed by professional observers but was experienced by all of us daily. That the phenomena of mind are as real as any other reality is impressed on every psychiatrist who sets out to deal with the social and psychological health of his patients. Mind is *not* vague – mind did not go away when its material 'components' were studied.

To William James is attributed the saying that a 'real' difference is a difference that makes a difference [13]. Mind – the sum of mindings, as Ryle [24] has defined it – matters by organizing the relationship between an organism and its environment. Today, we use the term 'attention' more often than 'minding' for this organizing process – but, mind you, without attention we would not be able to discern what matters.

In essence, I have come to feel that mentalism as an 'ism' will be supplanted by a psychology using definable mental terms of suitable variety. The problem of mentalism in psychology is not at all the same as was the problem of vitalism in biology, and therefore needs a different set of solutions. There is not one vague problem as there was in the case of vitalism; rather, there are specific puzzles such as existential subjective awareness; the projection of sensory events into the 'environment'; the definition of conscious states; the characterization of attention and perception; and of feelings of emotion, motivation and intention, to name just a few. I have also become convinced that behavioral specification of these mental states and processes is not only possible but critical. At the same time, however, such specification leaves unanswered the mind-brain issue with which this conference and my own work is primarily concerned.

IV. REDUCTIONISM, EMERGENTISM AND BEHAVIORISM

For me, the key to the problem lies in the fact that behavior ordinarily describes some organism-environment relationship. Specifications derived from observations of behavior thus assume the skin as a more or less arbitrary boundary. The specifications thus become enriched when the organismic and environmental variables involved can be precisely described. Vision is understood as different from audition when we can properly assign the roles of eyes and ears. Color vision becomes understood scientifically as a mode of perceiving a certain range of the electromagnetic spectrum with retinal receptors containing photosensitive pigments attuned to this range. Vision is a mental term – yet the contributions to the journal, *Vision Research*, would be difficult to fault for their 'mentalism.'

At this point my philosopher colleagues may query: Are not you simply stating a reductionist doctrine? You are confusing an understanding of the pieces with an understanding of the whole. My answer is that this *is* the way of science but – and it is a large *but* – the reductionism is tempered with emergentism. Scientists understand water as a combination of hydrogen and oxygen but stress that the particular organization, H_2O, results in properties which are unique and perhaps even difficult to predict from knowledge of the properties of hydrogen and of oxygen alone. Thus Sperry [26], as many before him (e.g., [12]), see the mind-brain issue in terms of mind as an emergent of brain organization. Our job, therefore, is to determine which brain organizations are responsible for which mental states and processes.

On the whole, I tend to go along with this approach, but as a behavioral psychologist, as well as a brain researcher, I hold that some organizations of psychological states and processes are more readily understood by recourse to their environmental organizers than by delving into the responsible brain organization per se. An analogy helps to clarify what I mean. It is usually easier to understand (i.e., specify the unique characteristics of) a program by studying the organizing 'software' that constitutes the input to a computer than it is by delving into the operations of the hardware switches that compose the working organization of the program per se.

V. INTERVENTIONISM

Reductionism tempered by emergentism and behaviorism thus appears to solve a great many of the mind-brain-behavior problems. But, of course, seemingly new queries immediately come to mind. Are the emergent properties epiphenomena? If so, do we take a dual stance and understand brain organization and the organization of mind to be parallel – in reality – or just parallel ways of talking about identities as becomes a monist? Or perhaps brain and mind interact in the sense that Sherrington [25] suggested: the motor cortex of the brain is where mental organization becomes effective, much as the piano keyboard is where a memorized concerto becomes actualized. The seemingly new queries turn out to be the old ones. The mind-brain issue is still with us even when we understand parts of the problem in terms of reduction, emergence and behavior.

VI. PHYSICALISM AND SUBJECTIVISM

There is yet another issue that is raised by the reductionist approach. Modern quantum and nuclear physics has had to come to terms with the fact that the observations of physical events cannot be excluded from the descriptions of the physical events (e.g., [11], [3]). Thus, if physical description entails observation non-trivially, reduction demands description of the observation and therefore of the observer. The elegant mathematical specifications that make up modern physics are the very mental activities emerging from the physicists' brains (when properly programmed). Physics thus 'reduces' to mathematics which is a mental process. But, as we have already seen, mental processes 'reduce' to brain processes which are physical and which therefore can in turn be reduced to mental...

We can either accept this circularity or go back to our philosophical speculations and laboratory manipulations, ignoring it all as too confusing. I would urge acceptance. Much of what we know comes to us from an ever-widening circularity, especially when the circle is entered from different vantages and with different techniques.

VII. CONSTRUCTIONAL REALISM

I have developed for myself a language that takes account of reduction, emergence, behavior, circularity. Central to that language is the fact that emergence results from particular *organizations* of the reductive constituents. My way of talking about these organizations is to say that, when they become 'realized' or 'embodied,' the emergent properties become manifest.

The concepts 'embodiment' and 'realization' are to be found everywhere in biology. The structure, i.e., the organization, of the genetic potential was found embodied in the DNA molecule. Further realization takes place by way of derepression, RNA, etc., until a viable offspring can be identified.

It may not be so different for an idea. The structure, i.e., the organization, of its potential may be implanted as a memory store in the relations among neurons (an engram). By way of derepression (differential reinforcement), RNA, etc. [18], further realization takes place until a viable manuscript can be identified.

Identification can be at several 'levels.' Thus I can take the offspring and study his behavior ("always yelling, just like his father") or his physical resemblance ("has his mother's eyes") or his brain waves or over the years other realizations of his potential. In like manner, the manuscript can be identified by its immediate effect ("is not this what Lashley meant?"), its physical organization ("a philosophical, not an experimental paper"), its spoken presentation, or its long-term influence.

VIII. EXTRINSIC AND INTRINSIC PROPERTIES OF REALITY

In all instances embodiment – realization – is the result of a process of interaction of one fairly immutable organization with those of a series of varying environments. The immutable organization provides the potential and is *extrinsic* to the medium in which realization takes place. The medium has its own *intrinsic* organization. Realization depends on a highly intricate meshing of these two organizations. I have elsewhere suggested that extrinsic organizations are akin to programs while intrinsic organizations are more likely to be holonomic (hologram-like) in character [19]. The distinction between extrinsic and intrinsic organizations is also similar to the concepts of extrinsic and intrinsic properties as delineated by Russell [23], except that Russell felt that intrinsic properties could never be apprehended. I would rather state that they are difficult – the World War II slogan of the U.S.A. Corps of Engineers is apropos here: "The impossible just takes a little longer." For me it is the intrinsic properties of a recording medium (be it a disc or tape or orchestra) that have to be mastered in laboratory or concert hall that test the patience of artist, engineer, and scientist when they try to realize the extrinsic potential that is the structure of a symphony.

IX. THE SPECIAL CASE OF DIRECT PERCEPTION

Perhaps by now I have either worn thin your patience or have pretty well made clear what I mean by a constructional realism. My realities are, for the most part, painstakingly constructed by me or by others. And you may, on the whole, agree – yet have one reservation. Ideas and thoughts may be constructed as may be physical reality. But what about the percepts which form the building blocks from which all constructions derive?

The issue of direct perception is a currently debated one, in part due to James Gibson's striking experimental demonstrations and refreshing interpretations [7].

Gibson's contribution has been to emphasize that perceptions are not constituted of 'elements' as Lashley (in the quotation at the beginning of this essay) had stated, but come whole and are directly perceived as such. Elements become differentiated as a result of perceptual learning [9]. Gibson further states that the environment 'affords' the organism with the 'information' to be perceived. This 'information' is different for different organisms and depends on the genetic endowment with which organisms scan their environments.

Gibson is not naive in his concept of what constitutes information – this need not be in any simple way isomorphic with the resulting perception. In discussions, however, he is adamant that even if we cannot specify it, the 'information' is present 'out there,' and that if it matches the 'affordances' of the organism, direct perception will occur. Thus Gibson is a realist, and his realism, as well as that of others such as Metzger [15], re-invigorated the position I had originally taken in the discussion with Lashley.

But differences also emerged in the discussion. If 'information' as such can only be perceived through scanning and other activities on the part of the organism (which Gibson calls 'affordances'), and these can change, as when patients with brain lesions are subject to macropsia or micropsia, how then are we to separate 'information' from 'affordance'? (Initially Gibson had no concept of 'affordance' – this was added as a direct result of the discussions – and he thus had a clearer, though, in my opinion, an obviously wrong view of direct perception: "This theory of vision asserts that perception is direct and is not mediated by retinal images transmitted to the brain" ([8], p. 226). I believe that organisms do separate 'information' from 'affordance' by consensual validation, by the mechanisms of projection (see [1], [19]) and by knowledge acquired through learning [10]. These are all constructional processes. In fact, we call a direct perception which does not fit what we know an 'illusion.' Many of Gibson's experimental effects are illusions, as in the centering of the origin of music between two stereophonic sources. Only when direct perception agrees with all we know can we infer that we have perceived the 'information' as it occurs. There is no question in my mind that the 'information' giving rise to a stereophonic effect can be specified, that there exists such 'information' and that the perception is due to that 'information.' I will argue, however, that what is *directly* perceived is on occasion at odds with that 'information' and that laborious search is often necessary to find out why. Direct veridical perception thus becomes a special case where apparent directness matches all we can learn to know about the 'information.'

Further, I claim that eye and brain are necessary to perception. Gibson in the quotation above does not deny this; he merely states that retinal *images* are not necessarily transmitted to the brain to constitute a perception. He prefers to think of the senses as scanners of their input – of the 'information' presented to them. I would argue that scanning is already a constructive operation – and whether one calls the result of such an operation an image (as on a television screen) or not (as in telephone communication) is irrelevant to the discussion.

The issues appear to be these. Gibson abhors the concept 'image.' As already noted, he emphasizes the 'information' which the environment 'affords' the organism. As an ecological theorist, however, Gibson recognizes the importance of the organism in determining what is afforded. He details especially the role of movement and the temporal organization of the organism-environment relationship which results. Still, that organization does *not* consist of the construction of percepts from their elements; rather the process is one of responding to the invariances in that relationship. Thus perceptual learning involves progressive differentiation of such invariances, not the association of sensory elements.

The problem for me has been that I agree with all of the positive contributions to conceptualization which Gibson has made, yet find myself in disagreement with his negative views (such as that on 'images') and his ultimate philosophical position. If indeed the organism plays such a major role in the theory of ecological perception, does not this entail a constructional position? Gibson's answer is no, but perhaps this is due to the fact that he (in company with so many other psychologists) is basically uninterested in what goes on inside the organism.

What then does go on in the perceptual systems that is relevant to this argument? I believe that to answer this question we need to analyze what is ordinarily meant by 'image.' Different disciplines have very different definitions of this term.

The situation is similar to that which obtained in neurology for almost a century with regard to the representation we call 'motor.' In that instance the issue was stated in terms of whether the representation in the motor cortex was punctile or whether, in fact, movements were represented. A great number of experiments were done. Many of them using anatomical and discrete electrical stimulation techniques showed an exquisitely detailed anatomical mapping between cortical points and muscles and even parts of muscles [4]. The well-known homunculus issued from such studies on man [16].

But other more physiologically oriented experiments provided different results. In these it was shown that the same electrical stimulation at the same cortical locus would produce *different* movements, depending on such other factors as position of the limb, the density of stimulation, the state of the organism (e.g., his respiratory rate, etc.). For the most part, one could conceptualize the results as showing that the cortical representation consisted of movements centered on one or another joint (e.g., [17]). The controversy was thus engaged – proponents of punctate muscle representation *vis-à-vis* the proponents of the representation of movement.

I decided to repeat some of the classical experiments in order to see for myself which view to espouse (reviewed in [19], chs. 12 and 13). Among the experiments performed was one in which the motor cortex was removed (unilaterally and bilaterally) in monkeys who had been trained to open a rather complex latch box to obtain a peanut reward [22]. My results in this experiment were, as in all others, the replication of the findings of my predecessors. The latch box was opened, but with considerable clumsiness, thus prolonging the time taken some two- to three-fold.

But the interesting part of the study consisted in taking cinematographic pictures of the monkeys' hands while performing the latch-box task and in their daily movements about the cage. Showing these films in slow motion we were able to establish to our satisfaction that no movement or even sequence of movements was specifically impaired by the motor cortex resections! The deficit appeared to be *task* specific, not muscle or movement specific.

My conclusion was, therefore, that depending on the *level of analysis*, one could speak of the motor representation in the cortex in three ways. Anatomically, the representation was punctate and of *muscles*. Physiologically, the representation consisted of mapping the muscle representation into *movements*, most likely around joints as anchor points. But behavioral analysis showed that these views of the representation were incomplete. No muscles were paralyzed, no movements precluded by total resection of the representation. *Action*, defined as the environmental consequence of movements, was what suffered when the motor cortex was removed.

The realization that acts, not just movements or muscles, were represented in the motor systems of the brain accounted for the persistent puzzle of motor equivalences. We all know that we can, though perhaps clumsily, write with our left hands, our teeth, or, if necessary, our toes. These muscle systems may never have been exercised to perform such tasks, yet immediately and without practice can accomplish at least the rudiment required. In a similar fashion, birds will build nests from a variety of materials, and the resulting structure is always a habitable facsimile of a nest.

The problem immediately arose, of course, as to the precise nature of a representation of an act. Obviously, there is no 'image' of an action to be found in the brain if by 'image' one means specific words or the recognizable configuration of nests. Yet some sort of representation appears to be engaged that allows the generation of words and nests – an image of what is to be achieved, as it were.

The precise composition of images-of-achievement remained a puzzle for many years. The resolution of the problem came from experiments by Bernstein [2] who made cinematographic records of people hammering nails and performing similar more or less repetitive acts. The films were taken against black backgrounds with the subjects dressed in black leotards. Only joints were made visible by placing white dots over them.

The resulting record was a continuous wave form. Bernstein performed a Fourier analysis on these wave forms and was invariably able to predict within a few centimeters the amplitude of the next in the series of movements.

The suggestion from Bernstein's analysis is that a Fourier analysis of the invariant components of motor patterns (and their change over time) is computable and that an image-of-achievement may consist of such computation. Electrophysiological data from unit recordings obtained from the motor cortex have provided preliminary evidence that, in fact, such computations are performed [5, 6].

By 'motor image,' therefore, we mean a punctate muscle-brain connectivity that is mapped into movements over joints in order to process environmental invariants generated by or resulting from those movements. This three-level definition of the motor representation can be helpful in resolving the problems that have become associated with the term 'image' in perceptual systems.

In vision, audition and somesthesia (and perhaps to some extent in the chemical senses as well) there is a punctate connectivity between receptor surface and cortical representation. This anatomical relationship serves as an *array* over which sensory signals are relayed. At a physiological level of analysis, however, a mapping of the punctate elements of the array into functions occurs. This is accomplished in part by convergences and divergences of pathways but even more powerfully by networks of lateral interconnectivities, most of which operate by way of slow graded dendritic potentials rather than by nerve impulses propagated in long axons. Thus in the retina, for instance, no nerve impulses can be recorded from receptors, bipolar or horizontal cells. It is only in the ganglion cell layer, the last stage of retinal processing, that nerve impulses are generated to be conducted in the optic nerve to the brain (reviewed in [19], chs. 1, 6, and 8). These lateral networks of neurons, operating by means of slow graded potentials, thus map the punctate receptor-brain connectivities into functional *ambiences*.

By analogy to the motor system, this characterization of the perceptual process is incomplete. Behavioral analysis discerns perceptual constancies just as it had to account for motor equivalences. In short, *invariances* are processed over time, and these invariances constitute the behaviorally derived aspects of the representation (e.g., [20]). Ordinarily, an organism's representational processes are called *images*, and there is no good reason not to use this term. But it must be clearly kept in mind that the perceptual image, just as the motor image, is more akin to a computation than to a photograph.

We have elsewhere presented the evidence that, for the visual system at least, this computation (just as in the motor system) is most readily accomplished in the Fourier or some similar domain. The evidence is that pattern perception depends, in part, on the processing of spatial frequencies. It is, after all, this evidence more than any other that has suggested the holonomic hypothesis of perception [19, 21].

The perceptual image, so defined, is therefore a representation, a mechanism based on a punctate connectivity that composes an *array*, which is operated upon by other lateral interconnections that provide *ambiences*, which in turn process the *invariances* in the organism's input. What remains to be understood is how such processing gives rise to our perceptions of an objective world separated from the receptor surfaces which interface the organism with his environment.

Von Bekesy [1] has performed a large series of experiments on both auditory and somatosensory perceptions to clarify the conditions that produce projection and other perceptual effects. For example, he has shown that a series of vibrators placed on the forearm will produce a point perception when the phases of vibrations are appropriately adjusted. When such vibrators are applied to both forearms and the subject wears them for a while, the point perception suddenly leaps into the space between the arms.

Other evidence for projection comes from the clinic. An amputated leg can still be perceived as a phantom for years after it has been severed and pickled in a pathologist's jar. A more ordinary experience comes daily to artisans and surgeons who 'feel' the environment at the ends of their instruments and tools.

These observations suggest that direct perception is a special case of a more universal experience. When what we perceive is validated through other senses or other knowledge (accumulated over time in a variety of ways, e.g., through linguistic communication) (see [10]), we claim that perception to be veridical. When validation is lacking or incomplete, we tend to call the perception an illusion and pursue a search for what physical events may be responsible for the illusion. Gibson and his followers are correct, perception is direct. They are wrong if and when they think that this means that a constructional brain process is ruled out or that the percept invariably and directly gives evidence of the physical organization that gives rise to perception.

As noted, there is altogether too much evidence in support of a brain constructional theory of perception. The holonomic model, because of its inclusion of parallel processing and wave interference characteristics, readily handles the data of projection and illusion that make up the evidence for direct perception. The holonomic model also accounts for the 'directness' of the perception: holographic images are not located at the holographic plane but in front or beyond it, away from the constructional apparatus and more into the apparently 'real,' consensually validatable external world.

I have spent some considerable time on this last point because so much of my own research, as well as that of other neurophysiologists, has over the past 25 years shown that the function of sensory receptors is as much under the control of the brain as it is sensitive to environmental input. It is this meshing of the extrinsic 'mental' with the intrinsic 'physical' which constructs reality. So, mind extrinsic, realized intrinsically, *does* matter.

X. CONCLUSION

In concluding, I repeat mentalism has lost its 'ism' to psychology, not to biology. Mental terms are being specified behaviorally. Some of this specification becomes enriched when brain mechanisms are taken into account. This does not mean that brain is ever irrelevant to mind, any more than computers are ever irrelevant to programs. However, programs can be understood, written, and realized on paper or tape instead of in a computer. Some mental processes – e.g., memory storage and retrieval – are also often realized in this fashion. Others such as feelings and perceptions appear to be more immediately brain-dependent for their realization and have therefore become the province of physiological psychologists. Here the mind-brain relationship becomes engaged in daily operations. It is the results of these endeavors which, I believe, are beginning to resolve the Cartesian dualism into a more manageable pluralism. Thus a variety of embodiments of biological organizations are admitted: some are classed as neural, others as behavioral, and still others as perceptual. There are those who would label the organizations themselves as constituting mind (does DNA have a mind of its own?). There are others who infer mind from the behavior of minding, as I have done here. And there are yet others who reserve for the mental, the subjectively experienced. But by verbal and non-verbal communication we come to know something of each other's subjective existence, much as we come to know the existence of the physical world around us. We accept the 'reality' of each, therefore, on pretty much the same grounds – i.e., constructions from patterns of sensory events. So why make more of the duality than there is? This view neither denies the duality nor makes it the rock upon which the unity of knowledge must necessarily founder. In fact, by precisely (even mathematically) describing the operations involved in each realization, a philosophy of mind – in the sense of Whitehead's definition of philosophy – is already in the making.

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NOTE

[1] This work was supported by NIMH Grant No. MH12970 and NIMH Career Award No. MH 15214 to the author.

BIBLIOGRAPHY

1. Bekesy von, G.: 1967, *Sensory Inhibition*, Princeton University Press, Princeton.
2. Bernstein, N.: 1967, *The Co-ordination and Regulation of Movements*, Pergamon Press, New York.
3. Bohr, N.: 1966, *Atomic Physics and Human Knowledge*, Vintage Press, New York.
4. Chang, H.T., Ruch, T.C. and Ward, Jr., A.A.: 1947, 'Topographical Representation of Muscles in Motor Cortex in Monkeys', *J. Neurophysiol.* **10**, 39-56.
5. Evarts, E.V.: 1967, 'Representation of Movements and Muscles by Pyramidal Tract Neurons of the Precentral Motor Cortex', in M.D. Yahr and D.P. Purpura (eds.), *Neurophysiological Basis of Normal and Abnormal Motor Activities*, Raven Press, New York, pp. 215-254.
6. Evarts, E.V.: 1968, 'Relation of Pyramidal Tract Activity to Force Exerted during Voluntary Movement', *J. Neurophysiol.* 31, 14-27.

7. Gibson, J.J.: 1966, *The Senses Considered as Perceptual Systems*, Houghton Mifflin Co., Boston.
8. Gibson, J.J.: 1972, 'A Theory of Direct Visual Perception', in J.R. Royce and W.W. Rozeboom (eds.), *The Psychology of Knowing*, Gordon and Breach, New York, pp. 215-227.
9. Gibson, J.J. and Gibson, E.J.: 1955, 'Perceptual Learning: Differentiation or Enrichment', *Psychol. Review* 62, 32-41.
10. Gregory, R.L.: 1966, *Eye and Brain*, McGraw-Hill Book Company, New York.
11. Heisenberg, W.: 1959, *Physics and Philosophy*, G. Allen and Unwin, London.
12. Herrick, C.J.: 1956, *The Evolution of Human Nature*, University of Texas Press, Austin, Texas.
13. James, W.: 1931, *Pragmatism – A New Name for Some Old Ways of Thinking*, Longmans, Green and Co., New York.
14. Lashley, K.: 1958, 'Cerebral Organization and Behavior', in *The Brain and Human Behavior* (Proceedings of the Association for Research in Nervous and Mental Disease), The Williams and Wilkins Co., Baltimore, pp. 1-18.
15. Metzger, W.: 1972, 'Critical Remarks to J.J. Gibson's Conception of "Direct" Visual Perception, i.e., of Revived Prephysiological Realism', in J.R. Royce and W.W. Rozeboom (eds.), *The Psychology of Knowing*, Gordon and Breach, New York, pp. 233-236.
16. Penfield, W. and E. Boldrey: 1937, 'Somatic Motor and Sensory Representation in the Cerebral Cortex of Man as Studied by Electrical Stimulation', *Brain* 60, 389-443.
17. Phillips, C.G.: 1965, 'Changing Concepts of the Precentral Motor Area', in J.C. Eccles (ed.), *Brain and Conscious Experience*, Springer-Verlag, New York, pp. 389-421.
18. Pribram, K.H.: 1966, 'Some Dimensions of Remembering: Steps Toward a Neuropsychological Model of Memory', in J. Gaito (ed.), *Macromolecules and Behavior*, Academic Press, New York, pp. 165-187.
19. Pribram, K.H.: 1971, *Languages of the Brain: Experimental Paradoxes and Principles in Neuropsychology*, Prentice-Hall, Inc., Englewood Cliffs.
20. Pribram, K.H.: 1974, 'The Isocortex', in D.A. Hamburg and H.K.H. Brodie (eds.), *American Handbook of Psychiatry*, Vol. 6, Basic Books, New York.
21. Pribram, K.H.: 1975, 'Holonomy and Structure in the Organization of Perception,' in *Proceedings of the Conference on Images, Perception and Knowledge*, University of Western Ontario, May 1974.
22. Pribram, K.H., Kruger, L. Robinson, R., and Berman, A.J.: 1955-56, 'The Effects of Precentral Lesions on the Behavior of Monkeys', *Yale J. Biol. & Med.* 28, 428-443.
23. Russell, B.: 1948, *Human Knowledge: Its Scope and Limits*, Simon & Schuster, New York.
24. Ryle, G.: 1949, *The Concept of Mind*, Barnes and Noble, New York.
25. Sherrington, C.: 1946, *Man – On His Nature*, Cambridge University Press, Cambridge.
26. Sperry, R.W.: 1969, 'A Modified Concept of Consciousness', *Psych. Rev.* 76, 532-636.
27. Whitehead, A.N.: 1958, *Modes of Thought*, 3rd ed., Capricorn Books, New York.