

## PSYCHOLOGY TOMORROW: THE IMMEDIATE FUTURE\*

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A few days before leaving home, the telegram from Professor Miller arrived asking me to serve on this occasion. My only reason for confidence that I might be able to do the job at short notice was that anyone ought to be able to speak without warning at any time on almost any subject who had for many years been teaching an 8 o'clock class in physiological psychology (yes, 8 o'clock in the morning). I did not know, however, that the subject of my talk here was to be nothing or, at least, nothing that had happened as yet.

The task assigned to me is in some respects the most challenging in the symposium. The other speakers can range freely since very few of us will be around to check on the accuracy of their predictions. But almost all of us will be attending the next two International Congresses; and I am sure that my friends will not let me forget what I will have said on this occasion.

As Lashley once told me—somewhat peeved as I pressed him for a definition of instinct—in life one often has the opportunity to choose between being vague or wrong. On that occasion Lashley chose to be vague. Today I have chosen, instead, to take my chances with you and with being wrong. But in being specific, perhaps my predictions will become a challenge—not only to some of you but to myself.

Overall my prediction is that psychology will continue the cognitive course it has taken during this past decade. In summarizing the last International Congress at Moscow three years ago I stated: 'I believe that future generations will look back on this occasion to state that here in Moscow we witnessed the emergence of psychology as a complete [experimental] science. I say this not only because of the full representation of the biological with the social, developmental and individual branches of psychology, though of course this attention to the physiological aspects of our endeavour is especially welcome to me. No, I am referring to another matter: in the recent past, the historical development of our science has shown three important faces. The first of these was behaviourism, the second cybernetics and the third, just beginning, I shall call the true emergence of a psychological psychology.'

To achieve this wholeness, psychology has had to view its panorama from each of these directions. The Moscow meetings made clear to me, however, that a biologically oriented cognitive approach was the necessary ingredient that made the whole thing go. I quote again:

'In conclusion, let me suggest that a major lesson of this Congress is that the very presence of an active biological and especially neurological psychology makes possible the healthy wholeness of psychology which so characterized this international gathering. The study of brain mechanisms gives an independent entry into sets of variables that are not readily and directly obtained from study of the organism's behaviour and environment. These neural variables are the ones that allow the binding and even the reversing of time: thus allowing learning to be extrapolated into anticipation and experience to become creation.'

\*Dr Paillard, who was to have given the opening paper of the symposium, was unfortunately prevented from attending the Congress because of illness.

I am not alone in the view that a cognitive biology can fertilize psychology at this time. May I recommend to you a chapter by Konrad Lorenz in a forthcoming volume of Lowell Lectures given at Harvard University a few years back, which is appearing under my editorship. In this chapter Lorenz discusses life as a knowledge process—and what he has to say about adaptation and acculturation makes fascinating reading.

Nor has my attendance at these meetings here disabused me of my views. I had decided to talk to you about two and only two issues and these because they are very close to my heart. Both stem from my own research on the brain. Also, I found here at the Congress many suggestions that the extrapolations which I had made before arriving might not be too far off the mark.

Psychology can face inward to study man's mind or outward to engage his culture. One of the issues I will discuss involves the inward, the other the outward look. Let me begin where I left off at the last Congress by discussing the relationship of man's brain to the structure of his memory.

One of the facts of brain is the peculiar finding, made much of by Lashley, that poking holes into it does not seem to bother recognition or recall. A patient blind in half or more of his visual field can yet identify and recognize whatever he knew before. He does this with the remaining brain tissue which must contain sufficient information to allow reconstruction of the whole. Experimental analysis of this clinical observation has established beyond doubt that memory storage in the brain is distributed and redundant within the system involved.

Until recently there was no easily conceivable model of a distributed redundant memory which also fitted the anatomical construction of the brain. The puzzle was that the brain is wired in a very specific fashion—not at all like a random net—but the psychological functions of this structure demanded flexibility which only a distributed mechanism could provide.

The advent of holographic photography and the science of optical information processing has changed all this. Holography depends on precise and specific relationships to attain distributed and redundant storage. This is effected by coding not only the intensity but especially the spatial phase relationships, the spatial neighbourhood interactions among simultaneously occurring events. Most holograms, and I believe neural holograms are of this type, result when waveforms initiated by a source reach their destination by two or more routes so that patterns of interfering wavefronts become established.

Holograms have marvellous properties. A small piece of holographic film will allow reconstruction of the whole image of the object photographed just as a small piece of brain will allow recognition to occur. When two or more objects have been photographed, transillumination of the film with light from one of the objects will give rise to ghost images of the others—true associative recall which can act as an active filter in information processing systems. Further, the useful storage capacity of holograms is phenomenal: already 100 million bits of memory have been stored in the space of one cubic centimetre. This capacity results from the fact that holographic patterns can be overlaid and each retrieved without affecting the others when the specific input which generated the pattern occurs.

I believe that holography, i.e. optical information processing and memory storage, will influence psychology during the 1970s much as computer technology has influenced our work during the sixties. The digital, sequential computer gave rise to ways of handling the programming of *symbolic* codes. The analogue, spatial hologram will give rise to ways of handling what I shall call *co-ordinate* coding. Co-ordinate transformations are powerful tools for content addressible,

parallel information processing, giving instantaneous cross-correlations when desired, and so speeding pattern recognition to orders of time compatible with those observed in biological organisms.

In physiological psychology the impact of holography is yet to be felt. Right now, feature extraction based on unit analysis with microelectrodes is the 'in thing'. Such feature analysis undoubtedly takes place and I believe that it provides the reference mechanism needed to establish the neural hologram. But, at best, feature analysis is limited to the appreciation of simple dimensions such as movement, colour and linear geometric attributes. It is a preprocessing mechanism, not the recognition device itself. In my laboratory we have found that only about 20 per cent of cells in the visual cortex of monkeys are engaged in such activity and a great number of these cells do not react to other than the most elementary geometric dimensions. The remaining 80 per cent of the neurones of the visual cortex appear to be uncommitted and their receptive fields are labile. This lability is just what is demanded by a holographic form of co-ordinate transformation.

Cognitive psychologists have puzzled about the nature of the memory store. I predict that more and more emphasis will be placed on co-ordinate transformations leading to distributed and redundant storage, accessed via a content addressible, parallel processing retrieval mechanism. This is optical-type information processing: IBM has already accomplished a computerization without optics and your brain and mine, I'll venture, have been working this way for years. Several papers at this Congress recognized the need for such imaging mechanisms, as have some published accounts in the literature.

Psycholinguists also will, I predict, begin to rely on co-ordinate coding and not exclusively on symbolic transformations. Already at this Congress several papers showed the necessity for imaging (i.e. co-ordinate transformation) if the mechanisms of semantic meaning were to be apprehended.

Both cognitive and linguistic psychology will find, I believe, a powerful device in the easy transformations that can be made between symbolic and co-ordinate codes. Such transformations are readily achieved if they go by way of holograms. Holograms are based on spatial Fourier transforms which have the characteristic that if applied twice in succession the original code is reconstituted. Even mathematical psychologists might again take heart in their field should they look at Fourier optics during the next few years. There is no question that stochastic and Markov models have about exhausted their usefulness.

pressing problems today are social problems -- problems that we have made for ourselves -- and their solutions will require us to change the way we behave in our personal and institutional contexts. Psychology, as one of the sciences of behaviour, should have much to contribute to such problems and so is more likely than some other sciences to be subjected to social pressures arising outside of psychology itself.

As I have listened to my colleagues on these planning committees I mentioned, it has become increasingly clear to me that one problem above all others lies at the heart of our present social distress. It is the problem of overpopulation. All our other problems are either caused directly or, at least, are seriously aggravated by the fact that there are already too many people in the world. It is not that we are slowly approaching some tolerable world population. Already people are starving in large numbers and by the mid-1970s it seems inevitable that there will be widespread famine of a kind I find difficult to describe, or even contemplate. It is not enough to slow our present rate of population growth; we must stop growing at all. Indeed, it is probably already too late just to stop -- we must reverse the trend and reduce the population of the world if we are to have any hope of satisfying the rising expectations of underprivileged peoples.

Unless this basic problem is solved on a world-wide basis, it is unlikely that the science of psychology will have any future worth talking about. I do not know what we can contribute to the problem of persuading people not to have children, but the consequences of continuing along our present path are almost too grim to contemplate.

Forgive me for imposing my personal feelings of despair on you, but I believe our world situation is truly desperate and that a realization of that fact is the proper context in which to set the following papers, all of which rest on the questionable assumption that civilized society as we know it will continue so that psychology may enjoy some future within it.

In arranging the programme for today the Programme Committee followed an interesting strategy. I have been told -- and for all I know it may be true -- that there was once a tribe of American Indians who followed a similar strategy. Whenever a prisoner escaped from their village they would send three runners after him. One was a sprinter, one a middle-distance runner, and one a long-distance runner. In order to get away the prisoner would have to outrun all three.

What we are trying to catch today, of course, is a glimpse of the future, and we have sent three runners out in pursuit of it. Our sprinter is Dr Pribram, who will consider the short-term future; our middle-distance runner is Dr Kay, who will look toward the year 2000; and our long-distance runner is Dr Toda, who will look as far ahead as he can.

To summarize this part of my prediction, I am stating that co-ordinate transformations will come to supplement symbolic codes in psychological analyses. I believe this is so because the precise tools to do so are available in Fourier optics and in the optical information processing software that has been derived therefrom. Further, the problems of psychology as stated so often here at the Congress have come to the brink of the insoluble with present techniques and cry out for just the sort of mechanism which holography can supply. The emphasis will therefore shift from an exclusive attention to programming, syntax and the grammar of behaviour to a more balanced concern which includes images, configurations and semantics. Especially interesting will be the working out of the relationships between co-ordinate and symbolic codes, relationships from which psychological meaning derives.

Let me now turn to the second major issue which my brain research has raised. This issue also deals with man's rationality but in a very different way. I am going

to discuss the problem of man's aggression against man and the culture he has created that tolerates such agonistic and agonizing behaviour. It is fashionable today, as it has been for some centuries, to speak of man's animal nature and the need for rational control over his bestiality. Man the naked ape, the carnivorous primate. Ethologists and psychoanalysts have worked hard to discover techniques to properly acculturate this biological wolf in couturier's clothing.

I have become concerned and alarmed at this generally held view of man because I know it to be false. Man's brain is just not organized the way Freud thought; nor as the early statements of the ethologists conjectured. True enough, there are deep within the core of the brain, structures (the reticular, hypothalamic and limbic formations) on which depend the regulation of the organism's internal economy. But these same core brain mechanisms have also been shown in monkey and man to be crucial to learning and remembering. The idea that these core brain structures, especially the limbic formations, are phylogenetically unchanged in primates is just not so. New accretions have been added which drastically alter the functions of the limbic core in man. Further, man's proudest possession, his frontal cortex, derives its function as well as its origin largely from the core and limbic forebrain.

What are these functions? My research has shown that these structures direct the organism's attention and behaviour towards what he feels to be right, away from what he feels to be wrong, and sets up the context within which these feelings of right and wrong occur. The feeling of rightness appears to depend on small shifts in the equilibration of the organism's brain such as those brought about by novelty and reward; the feeling of wrongness by the more drastic disequilibrations of punishment, frustration, etc.

Most of my research has been performed on monkeys and so I have to infer that my subjects have feelings much as astrophysicists had, until a week ago, to infer the composition of the surface of the moon. But just as the moon walk has provided direct evidence, so other research performed by colleagues in San Francisco has shown beyond doubt that man is clearly capable of sensing the states of his brain and even of learning to control these states much as do the Eastern mystics. Also, verbal reports given by patients who have had electrodes implanted in the limbic core of the brain confirm that moods and feeling states can be altered by electrical stimulations of these parts.

Such experiments have given some indication of another interesting fact. Within certain limits, the interpretation made by a subject of the pleasantness or unpleasantness of his brain state is flexible. There appears to be nothing sacred about the amount of disequilibrium which an organism interprets as right or wrong for him. Thus monkeys' active behaviour has been maintained by reinforcers which under other circumstances were proved punishing. In man, only the amount of feeling is determined by such disequilibrating agents as adrenaline; the interpretation, the labelling of the feeling, depends on prior history and circumstance.

Man's feelings and his emotional reactions are therefore subject to a great deal of experiential influence. There is nothing especially primitive or bestial about them. Quite the contrary, in fact. The nuances and range of feelings and emotional expressions of which man is capable far exceed those of animals. Have you known many horses who *hate*, cats who are really *angry*, or dogs who calculate the destruction of others?

These were the thoughts which I brought to this Congress. Imagine my pleasant surprise when Professor John Paul Scott and his colleagues here took up the same theme. Listen to Scott: 'About the only generalization one can make from all the

animal studies which have been done on agonistic behaviour is that individuals contiguous to each other will *interpret* discomfort as due to the other and so tend to drive him away'. The emphasis on *interpret* is mine. Animal psychologists, human psychologists and neuropsychologists have therefore all distinguished two classes of variables that determine aggression: dispositional and situational. As Hebb and many ethologically and psychoanalytically oriented psychologists have often observed, the *same* disposition can be channelled into a variety of expressions. What we have learned recently is that even the interpretation of the disposition which the organism makes is dependent on history and situation, on set and setting.

Coming from California, I am made very aware of the many group enterprises which attempt to experiment with set and setting to alter man's interpretations of his dispositions. These groups, just as some of the experimenters who reported at this Congress, have found that the expressions of disposition have become *instruments* for social action and interaction and that the game played with the instruments begins to lead a life of its own. Nor are the instruments of expression always skilfully deployed.

My second prediction is based on these observations. I believe that psychologists whose interest runs to the social and cultural will more and more use the tools of the cognitive psychologist who has developed methods for the study of skills: motor skills; skill in thinking; skill in perceiving. A skill is a programme, a hierarchy of sets sensitive to input and controlling the operation under way. Interpretation of the game—in this instance the disposition—depends largely on the rules of the game, the specific programmes which control it. Disequilibrium on crossing a road occurs from the left in the States, from the right in England, and interpretation depends on whether one makes of these brushes with death an exhilarating sport or a frightening necessity.

I further predict that the way in which the psychologist will apply the cognitivist's tools will be the way a biologist goes about the study of his universe. The ecology of small groups will be described, individuals in such groups will be singled out for anthropological inquiry, stimuli will be varied systematically to determine the range over which they are effective in guiding behaviour and components of the behaviour will be detailed in order to analyse the structure of the skill involved.

My prediction is therefore that the current utopias in small group living will provide a rich source for research into the control of aggressive feelings and agonistic expressions. Since man's brain does not contain the beast by the rational, the rational itself must be to blame for our present circumstance. It is not man's irrationality that is doing him in, it is his *dysrationality*. War is a fiercely rational game. Once upon a time the labels pride, anger and hate served well to channel the dispositional disequilibria to which men are subject. Today they make for a sick society. Our youngsters have coined the phrase 'make love, not war' in the intuition that we need new ways of labelling our brain states, need new games to play. But we know so little about the skill of love: the strategies and tactics of making love recur and endure; this is the challenge to psychology's tomorrow.

To conclude. Psychology in the immediate future will become infused with a biological version of cognitivism—a new biological rationalism. Man's rationality, I predict, will turn out to be less computer-like and more imaginal than we had thought a decade ago. Man's rationality will, as well, be found not a constraint on bestiality but a skill to be developed to make life worth living.