UNIVERSITY COLLEGE LONDON
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PSYCHOANALYSIS AND THE NATURAL SCIENCES:

THE BRAIN-BEHAVIOUR CONNECTION FROM FREUD TO THE PRESENT

Inaugural Lecture: Energy and Entropy in Psychology

Presented on the Occasion of the 100th Anniversary
of Freud's Birth

KARL H. PRIBRAM
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I gratefully acknowledge the help with the concepts in physics which I received from discussions with my son John K. Pribram, Illy Prigogine, Elizabeth Rauscher and especially Geoffrey Chew, David Bohm and Basil Hiley. Of course, I am solely responsible for the views set forth in this essay, for I may have interpreted their remarks in ways which they themselves would find inappropriate.

THE ISSUES

John Bowlby in this series of Freud Memorial Lectures points out that 'From 1895, when Freud made his first attempt to sketch a theoretical framework for psychoanalysis, until 1938, the year before he died, Freud was determined that his new discipline should conform to the requirements of a natural science. Thus in the opening sentence to his "Project" he writes: "the intention is to furnish a psychology that shall be a natural science . . ." (SE p.294); whilst in the "outline" we find a passage in which he asserts that once the concept of psychical processes being unconscious is granted, "psychology is enabled to take its place as "a natural science like any other," (SE23 p.158)'.

Bowlby goes on to point out that 'nevertheless, despite Freud's unwavering intention, the scientific status of psychoanalysis remains equivocal'. Still, as noted by Marie Jahoda (1972) in a provocative address to the British Psychological Society some years back, 'Freud won't go away' despite the disenchantment with many of his views by the psychological community. Jahoda suggested that this is due to the fact that Freud's ideas have continued to capture our interest because he raised critical questions. She also noted that neither psychoanalysis nor social and clinical psychologists have as yet adequately answered these questions.

Perhaps the problem lies in the limited focus that has come to characterise these sciences. Freud and Bowlby are correct in their aim: after an initial descriptive phase, answers to questions must be framed in a larger context if they are to *remain* scientific. By this I mean that observations must not only be reliably confirmed (descriptions do not vary overly much from time to time and place to place) but the observations must become validated by tightly coupled relationships to observations made with alternative techniques. Only then are the observations truly sharable and shared. This is the way not only of common science but of common sense (where observations in the visual and auditory modes are validated against each other and against the tactile).

Freud was of course the epitome of a natural scientist at his best. Validation of observations came naturally to a member of the Fin de Siecle Viennese intellectual community. Allan Janik and Stephen Toulmin in *Wittgenstein's Vienna* (1973) declare that this community presented in microcosm most of the important ideas that were to shape the course of history in the 20th century. Validation was sought not only within the natural sciences but with the broad sweep of philosophical thought. It is significant therefore that Freud took several courses with Brentano, the philosopher of Act Psychology and 'intentional inexistence' (intentionality) who has often been coupled with William James as a forbearer of American Realism. There is reason to believe (see e.g. Raymond Fancher, 1971) that psychoanalysis is indeed indebted to this tutelage. I shall return to this topic in my second lecture.

In addition to Brentano, there was of course Wittgenstein, and, more important to Freud, Ernst Mach and Morris Schlick who planted in the soil known as the Viennese Circle, seeds which, in the hands of Gustav Bergman, Rudolph Carnap, Herbert Feigel and Hans Reichenbach would sprout the formal gardens of positivist and linguistic philosophy.

Freud himself was an avowed Machian. He attempted to place the neurology and psychiatry which he had learned from Meynert, Charcot and Hughlings Jackson (whose works he translated from English to French) into the positivist framework that Mach believed could unify the natural sciences. To read Freud's work in this context makes it possible to take the seminal issues with which he dealt and examined them from the standpoint of developments in the natural sciences during the intervening century. The theoretical frames which Freud developed can usefully be grouped into two major categories: the clinical and the metapsychology (Gill, 1975). I will deal in these lectures only with the metapsychology which Freud defines as the set of mechanisms that operate to produce both normal and clinical manifestations. These mechanisms were conceived by Freud as both neural and social and are therefore at the heart of the brain/mind issue. Taken in this light, the problems raised in the psychoanalytic metapsychology are as pertinent today as they were in the nineteenth century. And I believe we have in the laboratory and in theoretical work made some considerable progress in the last 100 years. It is my purpose to address these problems once again and to compare Freud's treatment of them with currently tenable views. I begin with the most fundamental of these -- the concept of energy.

ENERGY

In this section I wish to make a case for 'dematerialising' energy and to neutralise it with respect to psychological processes as well. The natural science definition of energy is given in terms of a potential to perform, or an actual performance of work. In turn, work is defined as the production of a constructive change in a system or the maintenance of a system in the face of destructive influences. A system is any configuration of events whose totality is more simply described as a unit than as a summation of its components. Constructive is synonymous with systematic; destructive with breakdown into components. There is a precise relationship between material systems (masses) and energy, a relationship summarised by Einstein's famous equation: energy equals mass times the speed of light squared ($E = mc^2$).

Further, Einstein, A. Lorentz and H. Minkowski applied this equation to quantum mechanics where they made explicit the relationship between momentum on the one hand and space and time on the other. This relationship is given as $M = X^2 - t^2 c^2$ (in which $X = x,y,z$) the three components of space and the component of time, t, are related once again by the velocity of light squared. Because of the fact that no material object can exceed transmission at greater than the speed of light, Einstein's theory of special relativity denies physical matter access to the coordinate system M (a Minkowski enfolded conceptual space). Many quantum and relativity physicists have for this and additional reasons (such as the observer effect which produces Heisenberg uncertainty and Bohr complementarity) tantalisingly suggested that these higher dimensionalities might be identified as psychic or psychological (see e.g. Wigner, 1969). Such identification poses the danger of a panpsychism with which they feel uncomfortable. The dilemna is resolved if we simply view all such higher order abstractions as neutral with respect to the mind/matter duality especially since so much of the representation of these abstract 'spaces' is mathematical. Though mathematics is a psychological process, what is so startling is that it can describe the material world so effectively. But that does not mean that *all* mathematics necessarily describes matter. The example just given suggests that extramaterial (though not necessarily therefore psychic) 'entities' may be so described.

Note that according to this view the speed of light and therefore light itself may also be considered neutral with respect to the material/mental duality. Light is massless though its path (though not its speed) is altered by masses (i.e. by gravitational forces). Light is, in fact, conceived as 'pure' electromagnetic energy, a conception consonant with the view that it is neutral with respect to matter. That the pattern (or path) of a form of energy should change when in proximity to matter does not disconfirm such a view. The bending of light can be conceived to take place much as the bending of water or air waves by the configuration of obstacles. This is, in fact, the approach taken by Bohm, Hiley and Stuart (1970) in their analysis of the two slit experiment and their inferences regarding the quantum potential.

There is a tendency in psychology, including psychoanalytic psychology (where it is identified in English as cathexis), to use the concept 'energy' in a less well defined fashion. As McFarland (1971) has pointed out, this is not necessary: behaving organisms expend energy in doing work. There is no reason to restrict the energy concept to non-living systems: behavioural systems certainly are capable of doing work and the measurement of the quantity of energy expenditure should not be different for living than for non-living systems.

What then are we to make of 'psychic' energy? Could I not substitute 'psychological' for 'psychic' energy? And then equate 'behavioural' and 'psychic'? Aside from the fact that psychological processes must be inferred from observed behaviour and the two are therefore at different levels of discourse, not many of my behaviouristic friends would be happy with the deeper meaning of this syllogism; nor probably would those of you who are psychoanalytically minded. Why? Why shouldn't we as scientists *infer* psychological processes from the behaviour of organisms? Everyone else does.

Skinner (1971) has clearly stated the reasons for the behaviourist bias: psychological language – i.e. mental terminology – carries along with it much connotative excess baggage which makes it tedious and awkward to discern precise meanings. But this did not prevent Newton and other physical scientists from borrowing terms such as 'energy', 'force' and 'field' from popular discourse and successfully using them precisely in a scientific context. In fact, 'energy' and 'force' were primarily *psychological* concepts until the advent of Galileo, Kepler and

Newton much as colour, flavour and charm are primarily psychological concepts today — yet for nuclear physicists these terms are precise attributions that qualitatively describe hadrons and quarks.

My proposal is this: let $E = mc^2$ be the equation that relates space occupying matter to neutral (with respect to the mental/material dichotomy) 'moments' of potential energy and to time (via the speed of light). Then let us explore the possibility that potentials describing energy and time can be related by way of behavioural analysis to psychological, i.e. mental aspects in a similar fashion. To do this we must first agree that energy per se is neither material nor mental but can readily be transformed into 'matter' and 'mind' and that the transfer functions which describe the transformations can be precisely stated. We must also agree to the scientific definition of energy as a measure of a potential or actual performance of work.

ENTROPY

This section continues the exploration of energy related concepts. Entropy, a measure of the efficiency with which work is accomplished is such a concept. Inefficiency begets heat, as when we burn fuel or generate atomic power. According to the Einstein equation heat, which is infrared "light", introduces the time arrow into the material world. This allows changes to occur, changes which can be measured in terms of the amount of order or disorder which characterizes matter. For example, when waves are generated in water or air, the waves per se do not produce a new substance; rather they *additionally organise* the medium (water, air). These second order organisations need also to be conceptualised because they can produce or absorb additional work. The analysis of how efficiently they do this is the province of thermodynamics and the concept which captures the essence of these additional organisations is called entropy.

The first law of thermodynamics states that every energic reaction begets an equal and opposite reaction, i.e. the total quantity of energy within a system remains constant. It is the law of constancy which is one of Freud's two major postulates upon which he builds his metapsychology. (The other is the neuron doctrine from which he derives the organisational structure which deploys energy.) Given that the sum total of the quantity of energy in a system remains constant, how then can the work done by transforming liquid water to steam be accounted for? The answer lies in the second law: systems can be efficient in their work or they can be inefficient. When systems are inefficient a great deal of heat is generated; efficient energy use minimises heat loss (thus 'thermodynamics'). Where Einstein's equation relates energy to those organisations we identify as *matter* via light; thermodynamics relates energy to additional types of order via heat. These additional types of order are called *entropy* – although the term is used in the negative, i.e. to describe the absence of such alternate orders. Thus negentropy becomes a measure of order.

An important ontological question (a question of origin) is posed by the observation made above that waves and other such organisations arise secondarily in material organisations. The question is whether such negentropic orders could asie *independently* of matter. In Clerk Maxwell's day when an 'ether' was postulated to fill the universe, the answer might have been simply given. The Michaelson-Morley experiment which failed to demonstrate any ethereal drag on the earth's rotation did away with the 'ether'. But the universe is filled with evidences of electromagnetic energy; furthermore, light and heat radiate through this energy filled 'field'. Bohm and Hiley (see e.g. Philippides, Dewdney and Hiley, 1979) have recently proposed that, in fact, a vacuum is not a void but a plenum densely filled with potential energy – the quantum potential – and have drawn out in sophisticated fashion the consequences for microphysics of this proposal. So perhaps the relationship of *negentropy* to energy can be conceived to parallel that of *matter* to energy rather than to be intrinsically dependent on it. This would mean that electromagnetic energy per se could become patterned and this is not a completely unfamiliar occurrence. Our radio and television programmes depend on just such patterns. We speak of such programmes as communicating 'information' and Brillouin (1961) and others have detailed the correspondences between information and negentropy.

Thus entropy as well as energy can be considered neutral to the material/mental duality. But just as in the case of energy, negentropic organisation does depend on matter and/or mind to manifest – to realise. Prior to manifestation, such organisations are potential only: in short, it takes matter and/or experience (such as e.g. thinking) to manifest the potential energy and entropy as work. Manifestations occur especially at the boundaries of material systems and at interfaces between them.

The second law of thermodynamics states that in non-living material systems, negentropy tends over the long haul to decrease, entropy (i.e. disorder) to increase. Schrodinger (1944) has pointed out that living systems are characterised by opposing the second law: life begets order, at least temporarily. Prigogine (1980) has recently provided specific equations by which disorder is dissipated in living systems by virtue of the fact that they are characterised by temporary stabilities even though they are not in equilibrium (i.e. they do not show the constancy relationship of the first law). Further, Eigen (1977) has suggested that the chemical evolution which occurred even before biological evolution, is based on mechanisms that controvert the overall tendency of physical systems to degenerate entropically. Thus, counterentropic (information enhancing) processes characterise the living world, its precursors and many of its constructions, its capacity for phenomenal (i.e. mental) experiencing and its cultures. As is the case for energy, entropy does not easily fall into either pole of the material/mental duality. Energy and entropy are inferred and their existence is therefore paradoxically prior to matter and mind.

ERROR PROCESSING VS INFORMATION PROCESSING

The relationship between thermodynamic theory and information measurement theory has been detailed by Brillouin (1962), Prigogine (1980), and Weizacker (1974) among others. In technical, scientific usage, information is a measure of the organisation of a system on the basis of possible alternative aspects of that organisation. Thus a switch is a binary logic element; it can be either off or on – and a measure of the amount of potential information (this is also called uncertainty) describes the number of alternatives (two) provided by the switch. Computers are composed of switches and therefore can be utilised as information processing systems. Norbert Wiener (1948) and his colleagues, Warren McCulloch, Walter Pitts, and Jerome Letvin (see McCulloch and Pitts, 1943), compared the construction of computer binary logic with that of the nervous system

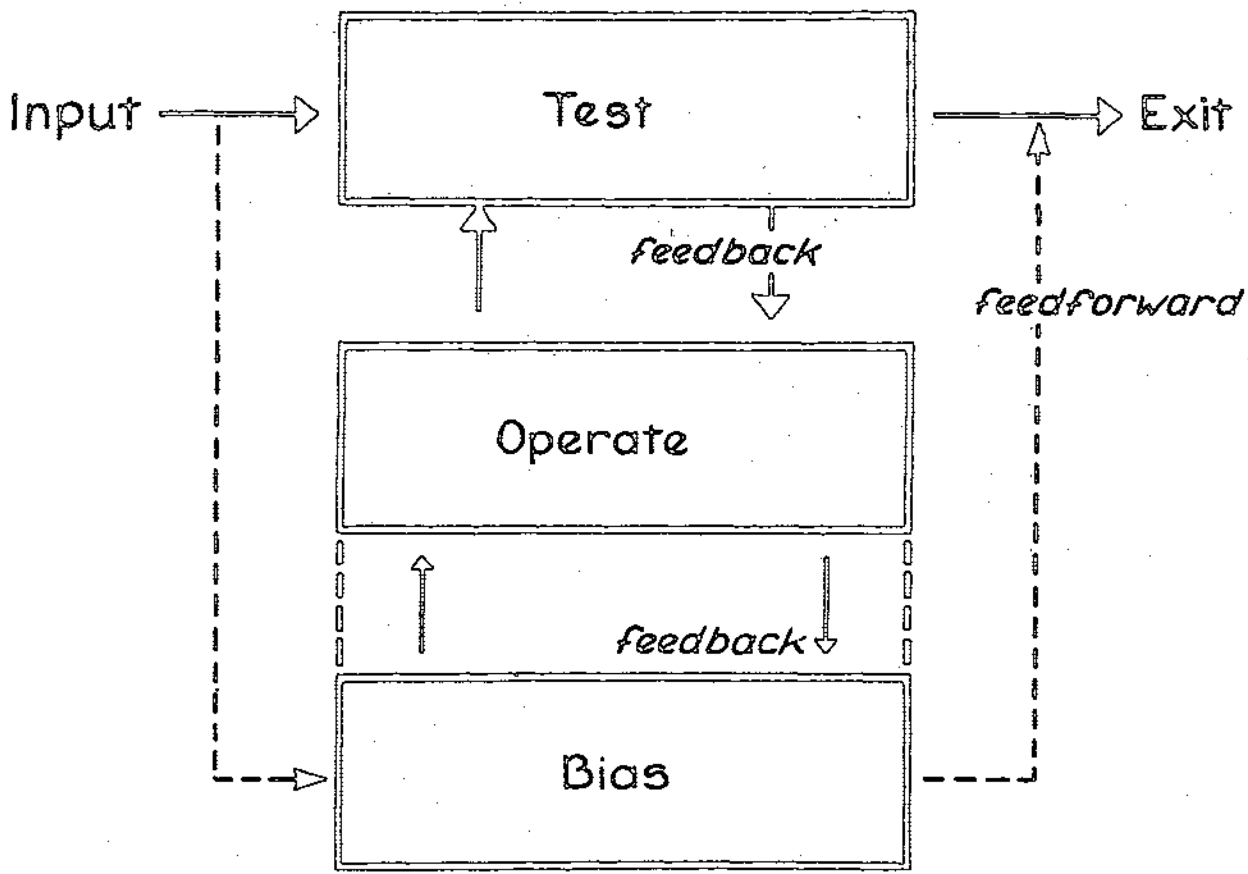
This comparison revealed that many parts of the nervous system operate in an entirely different fashion. Although the nerve impulses generated in axons give the appearance of simple switches, neurons in aggregate are spontaneously active and become organised into 'oscillators' and 'homeostates'. Oscillators behave like clocks in helping to synchronise the activities of the nervous system. Homeostats, often regulated by clocks, are characterised by feedback loops in which the consequence of the action corrects, when necessary, the process which produced the action. Homeostatic controls of the body's chemistry are of this nature; thermostats are familiar examples of such mechanisms which are constructed primarily to maintain constancy.

For many years feedback control mechanisms and information processing devices were considered together under the heading 'cybernetics' without clear distinction. For example, in *Plans and the Structure of Behaviour* (1960) George Miller, Eugene Galanter and I developed Test-Operate-Test-Exit (TOTE) feedback units which when hierarchically organised were conceived, in an unexplained fashion, to become information processing programmes. Von Holst and Mittlestaedt (1950) in their classical ethological contribution developed the principle of reafference which also failed to make the distinction between feedback and information processes. These early proposals failed to account for the active generative nature of organisms, their exploratory and creative aspects. Mittlestaedt (1968) and Pribram (1971) took heed of this failure, and others, as for instance Mackay (1966), Ashby (1963), and Teuber (1964), began seriously to search for a model that would allow for generative feedforward processing as well as feedback maintenance of constancy.

My particular solution to this problem, presented in *Languages of the Brain* (1971), was the development of a processing unit composed of *two* feedback units *connected in parallel.* This is essentially the mechanism used as an adjustable thermostat. The small wheel on top of the device adjusts the gap between two pieces of metal. This gap is at the same time also determined by the expansion (or contraction) of these pieces of metal due to the amount of heat in the room.

The paralleling of control has interesting consequences. In neurology and common discourse we call such controls 'voluntary'. For instance Helmholtz pointed out that if we voluntarily move our eyes about, the world remains still. But if we move our eyeball with a finger the visual world jumps. It is as if, in the normal course of seeing, the visual scene falls upon a 'screen' and our neural apparatus moves that 'screen' at the same moment and at the same rate as it moves our eyeball. In fact, Brindley and Merton (1960) have shown, when the eye muscles are artifically paralysed, the world moves when an attempt is made to move the eye – as if the 'screen' had been set in motion while the eyes remained paralysed. Teuber (1960) has labelled this 'screen-moving' mechanism a 'corollary discharge': of course no actual screen need be involved – only a signal that computes a corrective neural process simultaneous with or just ahead of the signal that produces the movement of the eyeball. Initiation of the movement can be attributed to the oscillatory nature of the components of the feedforward mechanism which, when they become synchronised, 'clock' the initiation. A prime example of this 'clocking' is the ability to awaken spontaneously at a preset time. Thus, feedforward organisations are not unique to vision – cerebellar control of voluntary actions of all sorts seems to work in a similar fashion (Ruch, 1950; Pribram, 1971). In fact, the technique of biofeedback which has become so popular in efforts to regulate ordinarily autonomous internal homeostatic processes apparently depends on producing a doubling of feedbacks: to the ordinarily operating internal homeostatic feedback and external feedback is added (Pribram, 1976). When the two feedbacks work in parallel *voluntary* control is achieved over a previously automatically stabilised process.

What then is the difference between the signals that operate 'closed' feedback loops and those that involve corollary discharges and 'open' feedforward loops or helixes? A feedback process is constructed to maintain constancy, to be repetitive, redundant. Ashby (1963) has noted that feedback controls involve the processing of redundancy *not* information in the usual Shannonian sense. Shannon in his original essay (Shannon and Weaver, 1949) describes feedback signals as 'bad' information – i.e. as indicative of *errors* rather than of alternatives. In short, there are two very different mechanisms to be distinguished: mechanisms that maintain constancy through error processing and mechanisms that process alternatives, i.e. 'good' information. There is, therefore, a distinction to be made between error processing and information processing. Error processing depends on feedback, closed loop mechanism; information processing depends on a higher order feedforward open loop (helical) mechanism that subsumes *alternative* feedback loops *connected in parallel* and thus transcends (brings under 'voluntary' control) the operation of any single feedback.


Input
Test
Exit
feedback
feedforward
Operate
feedback
Bias

As noted, feedback processes operate primarily to maintain constancy: neurophysiologically they have been shown to be load adjusting mechanisms. Changes in environmental load demand changes in the amount of work necessary to maintain, in the face of changing environments, posture, sensory adaptations and the homeostatic regulations of the internal environment. Recall that 'amount of work' is a measure of energy not entropy. Thus error (or load) processing feedback mechanisms are related to the first law of thermodynamics – the law of constancy, the law of amount of energy.

By contrast, feedforward mechanisms, because they involve alternatives (alternative feedback loops connected in parallel), are truly information processing mechanisms in the technical sense. Note that since feedforwards are composed of feedbacks, feedforwards are hierarchical to feedbacks. But note also that the composition of feedfordwards *must* be in parallel: Ross Ashby (1960) has shown, that simply multilinking feedback units with one another leads to hyperstability and thus to almost total resistance to change (i.e. the system cannot learn). As Ashby also noted, however, when joined in parallel, adaptive change is facilitated. Parallel control operations can be readily bootstrapped into lists so that structural programming by way of list structures becomes possible. (A list structure is a set of parallel alternatives that can be addressed serially as in most current computer programmes or simultaneously as in content addressable programming [Spinelli, 1970; Pribram, 1971].) Programming is concerned with the efficiency with which work can be accomplished: a good programme solves a difficult problem more rapidly at less cost and with less effort than a poor programme. Programming, i.e. information processing, thus concerns the second law of thermodynamics, the law of entropy.

PRIMARY VS SECONDARY PROCESSES

The psychoanalytic concept of cathexis is an energy related concept. In his 'Project for a Scientific Psychology' Freud defines biological energy as Q, a quantity probably of chemical origin, a portion of which, Q_n, can 'occupy' a neuron. This Q, in German 'Besetzte Potential' was translated into English as 'Cathexis' (see Pribram and Gill, 1976). Cathexis can be shifted about by producing action currents which are propagated along the axons of neurons but the shifts are impeded by resistances which characterise the junctions between neurons. Thus a qualitative Ohm's Law, $\text{Current} = \frac{\text{Voltage } (Q\eta)}{\text{Resistance}}$ of neuron function consonant with the electrochemical nature of the nervous system underlies Freud's conception of energy. (The psychoanalytic model has often been erroneously stated to be hydraulic because the hydraulic metaphor was often used in the nineteenth century by electrical engineers to describe electrical processes.) The law of energic constancy which provides Freud's first postulate is therefore modified by the operation of a second major postulate upon which to build the metapsychology: Freud, the observer of the agnosias (he is responsible for naming them) uses this Ohm's 'law' of neural function to organise gnostic, cognitive processes by way of a brain system that can transcend the order provided by the law of constancy. Cognition negates the entropic tendencies (to agnosia, disorder) inherent in physical systems.

One might ask whether this parallel between the foundations of the psychoanalytic metapsychology and those of thermodynamics are coincidental; to me, it seems unlikely that the seminal work of Boltzman in thermodynamics was unknown to Freud and his colleagues who were intent on creating a physicalistic psychobiology in the image of Mach and Hemlmholtz.

Intentional or not, the parallel exists. Freud, in the 'Project' clearly distinguishes two processes: one is reactive, the other more complexly organised and proactive. The reactive process can involve muscles, glands, or other neurons. Whenever energy is transferred to one of these tissues, a reaction ensues: muscles to environment back to organism; glands back to a sensitive nervous system; neurons back to neurons in junctional loops. These are the *primary* processes: discharge into the environment; the creation of an accruing chemical quantity which Freud calls the generation of 'unpleasure' – the basis of the pleasure principle; the formation of associative pathways.

Primary processes become organised into secondary, cognitive processes by virtue of (1) mechanisms which inhibit or delay the primary process; (2) reality testing procedures which compare the inputs from the senses with those from the primary processes; and (3) the evaluation, by means of these two mechanisms, of the consequences of actions.

By now you also are sure to see the parallel between feedback controlled error processing and Freud's primary processing systems on the one hand, and feedforward information processing and secondary, cognitive, processing on the other. Over the past decades there have been several suggestions (e.g. Holt, 1962; Peterfreund, 1971) that psychoanalysis abandon the energy concept in favour of more current information processing formulations. My feeling, based on the above analysis, is that this would be unfortunate. Experimental psychology has just recently begun to distinguish simple associative mechanisms from more complexly organised truly cognitive processes (see e.g. Anderson and Bower's [1973] horizontally vs vertically, hierarchically, organised associative nets, and Hilgard's [1977] work on dissociative processes). The experimental analysis of the neural mechanisms involved in motivation and emotion reviewed in the next section clearly argues for the importance of primary transformations of energy in the behavioural economy of living systems. At the same time these energy related processes can readily be distinguished from secondary negentropic ones which are dealt with in the final section under the heading of cognitive competence and the problem of limited span. The results of these experiments, especially those on attention span, make up an imposing body of knowledge which allows considerable refinement of the model presented in the 'Project' while remaining firmly within its scope.

MOTIVATION AND EMOTION AS ENERGY RELATED PRIMARY PROCESSES

Ordinarily when a person works consistently we infer that he is motivated to do so and perhaps interested in what he is doing. Whenever his application is inconsistent or inconstant we note that he is emotionally unstable, either because he is easily aroused, overly 'distractable' or 'blocked' i.e. he is either easily interrupted or has some 'hang-up'. Thus motivation and emotion are concepts that relate directly to the quantitative aspects of energy defined as the potential or actual performance of work. In a sense therefore, behaviourally or experientially derived concepts often encompassed by terms such as 'psychological' or 'psychic energy' are appropriately applied to these motivational and emotional aspects of behaviour and experience, especially as they involve biological 'drives' (Freud's Triebfeder) and the metabolic processes which they represent. However, in keeping with the theme set forth in this presentation the energy per se is not 'psychic' but neutral. We infer its existence from the biological and psychological work potentially or actually accomplished. Psychological work becomes manifest in changes in the complexity of organisation (i.e. in the structure of redundancy) and in the reduction of errors.

Neurobehavioural research has extensively seconded the relationship between biological energy metabolism on the one hand and the basic aspects of motivation and emotion on the other (see e.g. Grossman, 1967 for review). More interestingly, such research has also allowed a biological distinction to be made between motivation and emotion.

Let us begin with oral behaviour. Digestion of food and water practically ceases when a particular brain system is interrupted or chemically antagonised, e.g. the nigrostriatal dopaminergic system of fibers coursing lateral to the hypothalmic nuclei (Teitelbaum, 1955). By contrast, after disrupting another system (the ventromedial region of the hypothalmus) ingestion of food and water is slow to terminate, the animal is difficult to satiate (Mayér, 1963). Other factors such a filling the stomach, intestinal hormones, etc. appear to modulate these primitive 'go' and 'stop' brain mechanisms which are in reciprocal homeostatic balance. But more important in the present context is the fact that the 'go' and 'stop' systems are involved in a greater range of activities than oral behaviour. Thus, the basal ganglia in which the nigrostriatal 'go' fibers terminate, are well known to be critically involved in postural set, and by means of electrical excitation my colleagues and I have shown (Spinelli and Pribram, 1966, 1967; Lassonde, Ptito and Pribram, 1981) that receptive field properties of cells in the senory systems are altered as well: perceptual and postural readiness as well as motivation to eat and drink are controlled by these 'attitudinal' brain systems.

Similarly, when the medial hypothalmic 'satiety' mechanism is electrically stimulated, not only do eating and drinking cease but all behaviour is temporarily stopped. The animal alerts as if by some external distraction. The amount of alerting when of external origin has been shown to be related to the structure of the redundancy of the stimulus and not to the amount of information which it conveys (Smets, 1973). Similarly, when internal stimulation is increased, the animal first becomes alerted showing interest and exploratory behaviour, then, with a greater increase, distractibility, withdrawal and finally uncontrollable lashing out, the 'sham rage' described in earlier investigations of this region of the brain. Just as the nigral origin of the 'go' system has basal ganglia (striatal) components in the forebrain so does the medial hypothalmic 'stop' system: the nucleus accumbens and septal region on the orbital surface of the frontal lobe and the amygdala on the medial surface of the pole of the temporal lobe.

A model of energy-related mechanisms can be derived from these studies by accepting Brobeck's suggestion (1948) that the energy metabolism of the organism is anchored by temperature homeostasis. Both eating and muscle contractions tend to increase body temperature; breathing and drinking tend to decrease it. In keeping with this suggestion we found (Chin, Pribram, Drake and Green, 1976) that temperature discrimination is disrupted by electrical stimulation of the temporal pole and amygdala as well as the adjacent orbital region of the frontal lobe, not by stimulations of the parietal region where most somatosensory stimuli are processed. Others as well have found that parietal resections do not disrupt temperature discrimination.

In the spinal cord, temperature pathways are intimately interwoven with those of pain. From the experimental results described above for the hypothalmus and the many others which show an interference with aggressive and avoidance behaviour after amygdalectomy, septal lesions, and resections of the surrounding temporal and frontal lobe structures (see e.g. Pribram and Weiskrantz, 1957; Barrett, 1969; Bagshaw and Pribram, 1965) one may conclude that the pain pathways also contibute heavily to the 'stop' system. In fact, the discovery of the endorphins (see e.g. review by Snyder, 1980) has supported the Melzack-Wall suggestion (1965) that pain is subject to gating, making the regulation of pain a homeostatic process. Pain and temperature thus form the core of a quantitative dimension of experience which I have called the 'protocritic' (Pribram, 1977). The term protocritic was derived from Henry Head (1920) who distinguished between a quantitative 'protopathic' and a qualitative 'epicritic' dimension (characterised by 'local sign' -- i.e. by being located in time and space). It is the epicritic aspects of experience which are processed in systems which reach the cortex of the parietal lobe and other portions of the posterior cerebral convexity. 'Protocritic' (since the quantitative dimension is not restricted to pathology) processing involves the limbic forebrain (amygdala, accumbens, septal nuclei and the related cortical formations; Pribram and Kruger, 1954) and the anterior frontal cortex which, on the basis of much other research as well, can be considered as the intrinsic or 'association' cortex for these limbic structures (Pribram, 1954, 1958, 1959). It is this relationship of frontal cortex to the protocritic dimension which made frontal rather than parietal cortex the necessary choice for intervention in cases of intractable suffering.

Freud in the 'Project' delineated a primary brain system (Primär Gehirn – his ψ system) which has many of the protocritic processing attributes of the nigrostriatal and frontolimbic forebrain systems I have here described as the substrate of a motivation/emotion mechanism. Freud, on the basis of the work of Magendie (1822) in Paris and of Karplus and Kreidel (1909) in Vienna was cognisant of metabolic 'drive' stimuli (Triebfeder) which were regulated by 'key' neurons to maintain the constancy of the internal environment of the organism (Magendie's 'milieu interieur', 1822; Cannon's homeostasis, 1929). Freud anchored his core mechanisms around an adrenalin-like secretion by the mechanism of the 'key' neurons: 'according to our theory, it would, to put it plainly, be a *'sympathetic ganglion'*. (SE p.203). Pain was related to this system in the fact that the sympathetic system is triggered by actual noxious stimulation or threat thereof. Whenever the sympathetic system coped by maintaining constancy the organism felt comfortable; whenever the limits of constancy were exceeded the organism experienced pain and discomfort. When the limits of constancy were suddenly breached, affect was said to be generated; slower failures were experienced as 'unpleasure' (the basis of the pleasure principle) by virtue of the adrenalin-like secretions of the key neurons.

It is here that the model presented in the project gave Freud a great deal of trouble, much as it does today in any discussion which is based on an assumed buildup of 'unpleasure' or of 'psychic energy'. For Freud, as we shall see in the third lecture, conscious experience is based on qualitative i.e. organised, patterned neural processes, and he had a precise mechanism to account for it. The pleasure-unpleasure dimension, being quantitative and not patterned, should be inaccessible to consciousness. But we do experience pleasure and malaise (and also hunger, thirst, zest, nausea, appetite, lethargy, love, etc.). Freud wrestled throughout his life with the problem of how a quantitative energic mechanism could result in qualitative conscious feelings. For a long time, he settled for a single dimension 'pleasure-unpleasure' which reflected the quantitative homeostatic cycle – the action with equal and opposite reaction of the constancy principle, the first law of thermodynamics. He was terribly dissatisfied with this solution and attempted many alternatives. But not until the essays in *The Origins of Psychoanalysis* (1954) did he finally hit upon the correct solution: of course, to become available to consciousness, these processes must display patterns, despite the fact that they do not display local sign. The co-ordinates of the dimensions to these patterns need still to be established, they are not simply time and space. Much current research is devoted to analysing the complexity of neuro-chemical systems and their relationship to one another in the regulation of motivation and emotion and the feelings associated with these processes. This is perhaps the most active and promising field of research in the brain sciences. The basic homeostatic mechanisms reflected in the operations of various forebrain mechanisms become cognitively 'labelled' not only according to the relationships among internal states but also with respect to the environmental situation (Freud's exigencies) in which they become manifest (Schachter and Singer, 1962). It is this cognitive discriminative component which, as we shall see in the third lecture, makes the feelings conscious in the psychoanalytic sense (Matte Blanco, 1975).

COGNITIVE COMPETENCE AND THE PROBLEM OF LIMITED SPAN: GETTING THINGS DONE EFFICIENTLY

The central concept in current studies on behavioural efficiency relate to the observation that it takes effort to overcome limitations in processing span. Living systems show a variety of limitations in *span*: in memory span (e.g. Miller, 1956; Simon, 1974; Pribram, 1980a,b); in attention span (Broadbent, 1977; Kahneman, 1973; Pribram and McGuinness, 1975); and in executing what is intended (Miller, Galanter and Pribram, 1960).

William James (1901) originally developed the theme that overcoming the limitations of span distinguishes conscious experience and willed action from automatic behaviour. Constructively overcoming automaticity involves the expenditure of energy; a person may be considered highly motivated but incompetent. Only when automaticity is overcome efficiently is there an expenditure of 'will' or 'effort' as the term is used by William James and in this essay. Effort can thus be thought of loosely as an expression of 'psychic entropy' rather than 'psychic energy', provided that once again we keep in mind that energy and entropy are simply inferences neutral to the mind/matter duality. In short, we will use 'effort' or 'will' as terms which relate to the efficiency with which limitations in span (due to constraints imposed by neurobehavioural or environmental organisations) are overcome.

Daniel Kahneman (1973) has reviewed a large body of behavioural evidence regarding the limitations in span. In his review he equates attention, arousal, effort and the capacity to process – as do most experimental psychologists working on these problems. When, however, biological and especially brain variables are included in the experiments, a clear distinction between several of these concepts can be made and others are found incomplete and/or inaccurately described. Take for instance the idea that limitations on span are due to some fixed processing capacity which cannot be altered. True, there is a 'magical number' (Miller, 1956) of 'items' that can be processed more or less simultaneously, but true also is the fact that by grouping, chunking and contextualising, what constitutes an 'item' can be radically changed in the direction of including many of the original 'items'. Experiments on the processing channels in the brain – channels made up of the sensory-motor pathways – show that as much as 98 per cent by actual fibre count can be dispensed with, without significant impairment in discrimination behaviour (Galambos, Norton, and Frommer, 1967). This is convincing evidence in favour of a sizeable pool of reserve capacity – thus limitations on span must be due to some factor(s) other than fixed capacity. A better candidate would be the efficiency or competence with which the sensory-motor channels are used: the way signals within them become grouped, chunked, and parsed. In a set of simple experiments some years ago, I demonstrated that the anterior frontal cortex of primates is critical to the development of such competence: by inserting pauses in a stream of items, a cognitive prosthesis was provided to monkeys with frontal resections so that they could perform tasks which they had hitherto failed to master. The prosthesis works much as do the pauses we use to distinguish words and phrases: Deerseatoatsanddoeseatoatsandlittlelambseativy is hard to decipher. Competencies are attained by appropriate pauses and punctuation and other forms of contextualising a stream of items (Pribram, 1980).

One major form of contextualising is through reinforcing contingencies. Behaviour is shaped by punctuating and emphasising certain consequences as if by placing an apostrophy at the end of a particular sequence of acts. Thus the sequence becomes fitted to a context – it becomes con-sequent. The process of reinforcement makes sequence of actions con-sequential (Pribram, 1964). Reinforcers increase (or, if deterrents, decrease) the probability of recurrence of the behavioural sequence (in keeping with Skinner's behaviouristic definition, e.g. 1969). As might be expected reinforcing (and deterring) contingencies (contexts) are relatively ineffective in guiding behaviour after lesions of the primate frontal cortex (as e.g. after frontal leukotomy, Pribram, 1959).

Additional experimentation showed that this deficiency is relating reinforcing contingencies to behaviour leads to a failure in arranging the behaviour according to the likelihood, the probability of occurrence of the reinforcing contingency. Time estimation is not impaired – a steady stream of behaviour (or of withholding behaviour) occurs until the occasion for reinforcement arrives. Most normal primates, whether human or non-human, tend, when reinforcements occur regularly, to take a respite after being reinforced and to gradually resume work in a crescendo which culminates (studying all night) just before the punctuating contingency (the exam). Not so after resection of their frontal cortex. The contextual boundaries which determine behaviour in probabilistic situations have become loosened (Pribram, 1969).

This is not the only aspect of efficient processing that has been related to brain function, however. Electrical stimulation as well as lesion studies have shown that the anterior frontal cortex and that of the posterior convexity are reciprocally related in influencing the receptive field of the cells in the primary sensory projection systems. Further, when the posterior cortex of the convexity (the intrinsic 'association' cortex which lies between the extrinsic sensory and motor projection systems) is bilaterally resected, monkeys fail to sample as many alternatives as do their controls (including those with frontal lesions [Pribram, 1959]). Recall that Shannon's measurement of the amount of information processed depends on the probability with which a potential alternative is sampled. It is the cortex of the posterior convexity which determines the sample size being processed while the frontal cortex determines the deployment of probability distributions (based reinforcing contingencies) across that sample. In short, competence in processing is dependent on a sampling parameter established by the posterior convexity; and a probability variable based on chunking, grouping and parsing due to the operation of the frontal cortex.[1]

CONCLUSION

As we have seen in this inaugural presentation, Freud deals with primary energic mechanisms in terms of motivations (which he calls wishes) and emotions (unpleasure and affect) based on associative memory structures and feedback organisations. We are now in a position to ask whether the entropic, secondary cognitive processes as described in 'The Project' bear any resemblance to the sampling parameter and probability deployment processes briefly described here. Specifically, we need to question whether the sampling parameter operates in a fashion similar to reality testing and whether the controls on the *probability variable, the parsing, chunking, an*d contextualising are in any way foreshadowed by some similar executive operations in the 'Project'. The answer to both questions is 'yes'.

In the next lecture I will review evidence from my laboratory which provides experimental data concerning these cognitive controls. Basic are studies which show that the primary process emotion/motivation systems bias the organism to risk and that this bias is countered by a bias to caution which is imposed by the secondary, cognitive systems, those which deal with overcoming limited span. Next, it is shown that working conjointly these brain/behaviour systems operate to construct personal reality; that when the systems are damaged, agnosias and neglect syndromes result. The third lecture draws out the results of a still higher order interaction: that between the systems involved in personal reality with those which construct extrapersonal or sensory reality to result in *consciousness*. Specifically, this lecture covers the various definitions of consciousness that arise in psychoanalysis, medicine and philosophy. A clarification of the conscious/unconscious distinction as used in psychoanalysis results.

The final lecture devolves on another set of high order interactions, these between the 'personal' systems and the *motor* systems of the brain that generate *behaviour*. Evidence is presented to suggest that these interactions give rise to the natural *languages* in man and also in such language-like cultural structures as music and mathematics. The neural nature of the procedures which operate to generate these representational structures is discussed as are the differences in emphasis that distinguish these procedures.

As noted at the outset, the intent of this series of lectures is to suggest that a neuropsychological theory as extensive as that presented by Freud in the 'Project' can be constructed on current evidence. The parallels which are drawn between the two theories indicate a reservoir of nineteenth century and twentieth century knowledge which is common to both. It is additions to this common reservoir that will lead to modifications of the theory and any practice that is based on the theory. The reservoir also provides a frame within which psychology, psychiatry, and psychoanalysis can conform to the natural sciences – the goal toward which Freud worked so hard.

FOOTNOTE

[1] The importance of the chunking process, the resulting size of the chunk and the contextual boundaries which are set was illuminated by a conversation with Professor Audley during the dinner following the inaugural lecture. Audley suggested this example: a pregnant woman is thinking about the sex of her impending offspring. She already has a son. If she has a grasp of the incidence of boy and girl births in a *large sample*, she will know that her chances of having a bou are roughly fifty per cent. If, however, she *restricts her sample* to the two children, one born, the other about to be, she may note the following: two children can be either O O; O O; or O O. Since she already has a son, the first possibility is ruled out, leaving O O and O O with a probability of having a boy roughly two out of three, or sixty-six per cent. She wonders whether, perhaps, there is something biological in her or her husband that predisposes towards boys.

ANDERSON, J. R. and BOWER, G. H.
Human Associative Memory. New York: Wiley and Sons, 1973.
ASHBY, W. R.
Design for a Brain: The Origin of Adaptive Behavior. New York: Wiley and Sons, 1960.
ASHBY, W. R.
An Introduction to Cybernetics. New York: Wiley and Sons, 1963.
BAGSHAW, M. H. and PRIBRAM, K. H.
Effect of amygdalectomy on transfer of training in monkeys. *J. comp. physiol. Psychol.,* 1965, *59,* 118–121.
BARRETT, T. W.
Studies of the function of the amygdaloid complex in Macaca Mulatta. *Neuropsychologia,* 1969, 7, 1–12.
BLANCO, I. M.
The Unconscious as Infinite Sets: An Essay in Bi-Logic., London: Duckwork and Company., 1975.
BOHM, D., HILEY, B. J. and STUART, A. E. G.
On a new mode of description in physics. *International Journal of Theoretical Physics,* 1970, *3*(3), 171–183.
BRILLOUIN, L.
Science and Information Theory, New York: Academic Press, 1961.
BRINDLEY, G. S. and MERTON, P. A.
The absence of position sense in the human eye. *J. Physiol.,* 1960, *153,* 127–130.
BROADBENT, D. E.
The hidden preattentive process. *American Psychologist,* 1977, 32, (2), 109–118.
BROBECK, J. R.
Food intake as a mechanism of temperature regulation. *Yale J. Biol. & Med.,* 1948, *20,* 545–552.
CANNON, W. B.
Bodily Changes in Pain, Hunger, Fear and Rage. New York: D. Appleton and Company, 1929.
CHIN, J. H., PRIBRAM, K. H., DRAKE, K., and GREEN, L. O. Jr.
Disruption of temperature discrimination during limbic forebrain stimulation in monkeys. *Neuropsychologia,* 1976, *14,* 293–310.

EIGEN, M.
The origin of life. In: *The Search for Absolute Values: Harmony Among the Sciences, Vol II*, Proceedings of the Fifth International Conference on the Unity of the Sciences, Nov. 1976, New York: ICF Press, 1977, pp 767–770.

FANCHER, R.
The neurologic origin of Freud's theory. *J. History of the Behav. Sci.*, 1971, 7, 59–74.

FREUD, S.
[1895] Project for a Scientific Psychology. In: *Standard Edition of the Complete Psychological Works of Sigmund Freud.* (J. Strachey, Ed. & Transl.) New York: Norton, 1950, Vol. I, pp. 281–397.

FREUD, S.
The Origins of Psycho-Analysis: Letters to Wiljelm Fliess, Drafts, and Notes, 1887-1902. New York: Basic Books, 1954.

GALAMBOS, R., NORTON, T. T. and FROMMER, C. P.
Optic tract lesions sparing pattern vision in cats. *Experimental Neurology*, 1967, *18*, 8–25.

GILL, M.
What is metapsychology? In: M. Gill and P. Halzman (Eds.) *Meaning and Mechanism in Psychoanalytic Theory.* New York: International Universities Press Psychological Monographs, 1975.

GROSSMAN, S. P.
A Textbook of Physiological Psychology. New York: Wiley and Sons, 1967.

HEAD, H.
Studies in Neurology. London: Oxford University Press, 1920.

HILGARD, E. R.
Divided Consciousness: Multiple Controls in Human Thought and Action. New York: Wiley and Sons, 1977.

HOLST, VON E. and MITTELSTAEDT, H.
Das reafferenzprinzip. *Naturwissenschaften*, 1950, *37*, 464–476.

HOLT, R. R.
A critical examination of Freud's concept of bound vs. mobile cathexis. *J. Amer. Psychoanal. Assn.*, 1962, *10*, 475–525.

JAHODA, M.
Social psychology and psychoanalysis: A mutual challenge. *Bulletin British Psychol. Society*, 1972, *25*, 269–274.
JAMES, W.
The Principles of Psychology. London: MacMillan and Company, 1901.
JANIK, A. and TOULMIN, S.
Wittgenstein's Vienna, New York: Simon and Schuster, 1973.
KAHNEMAN, D.
Attention and Effort. Englewood Cliffs, New Jersey: Prentice-Hall, 1973.
KARPLUS, J. P. and KREIDL, A.
Gehirn und sympathicus. *Arch. ges. Physiol. Pflugers*, 1909, *129*, 138–144.
LASSONDE, M. C., PTITO, M. and PRIBRAM, K. H.
Intracerebral influences on the microstructure of visual cortex. *Exp. Brain Res.*, 1981, *43*, 131–144.
MACKAY, D. M.
Cerebral organisation and the conscious control of action. In J. C. Eccles (Ed.) *Brain and Conscious Experience*, New York: Springer-Verlag, 1966, pp. 422–445.
MAGENDIE, F.
Experiences sur les fonctions des racines des nerfs rachidiens. *J. Physiol. Exp.* 1822, *2*, 276–279.
MEYÉR J.
Regulatory and metabolic experimental obesities. In M. A. B. Brazier (Ed.) *Brain and Behavior*. Washington, D.C.: American Institute of Biological Sciences, 1963, pp.273–318.
McCULLOCH, W. S. and PITTS, W.
Logical calculus of the ideas immanent in nervous activity. *Bulletin of Mathematical Biophysics*, 1943, *5*, 115–133.
McFARLAND, D. J.
Feedback Mechanisms in Animal Behaviour. New York: Academic Press, 1971.
MELZACK, R. and WALL, P. D.
Pain mechanisms: A new theory. *Science*, 1965, *150*, 971–979.
MILLER, G. A.
The magical number seven, plus or minus two, or, some limits on our capacity for processing information. *Psychol. Rev.*, 1956, *63* (2), 81–97.

MILLER, G. A., GALANTER, E. H. and PRIBRAM, K. H.
Plans and the Structure of Behavior. New York: Holt and Company, 1960.

MITTELSTAEDT, H.
Discussion. In D. P. Kimble (Ed.) *Experience and Capacity.* New York: NY Acad. Sci., 1968, pp.46–49.

PETERFREUND, E.
Information, systems, and psychoanalysis: An evolutionary approach to psychoanalytic theory. *Psychological Issues* Vol II, Number 1/2, Monograph 25/26, New York, International Universities Press, 1971.

PHILIPPIDES, C., DEWDNEY, C. and HILEY, B. J.
Quantum interference and the quantum potential. *Nuovo Cimento*, 1979, *52B*, 15–28.

PRIBRAM, K. H.
Concerning three rhinencephalic systems. *EEG and Clin. Neurophysiol.*, 1954, *6*, 708–709.

PRIBRAM, K. H.
Neocortical function in behaviour. In H. F. Harlow and C. N. Woolsey (Eds.) *Biological and Biochemical Bases of Behavior.* Madison, Wisc.: U. of Wisconsin Press, 1958, pp.151–172.

PRIBRAM, K. H.
On the neurology of thinking. *Behav. Sci.*, 1959, *4*, 265–284.

PRIBRAM, K. H.
The amnestic syndromes: Disturbance in coding? In: G. A. Talland and M. Waugh (Eds.) *The Psychopathology of Memory*, New York: Academic Press, 1969, pp.127–157.

PRIBRAM, K. H.
Languages of the Brain. Englewood Cliffs, New Jersey: Prentice-Hall, 1971 (2nd ed. Monterey, Calif.: Brooks/Cole, 1977).

PRIBRAM, K. H.
Self-consciousness and intentionality. In: G. E. Schwartz and D. Shapiro (Eds.) *Consciousness and Self-regulation, Vol 1.* New York: Plenum, 1976, pp.51–100.

PRIBRAM, K. H.
Peptides and protocritic processes. In L. H. Miller, C. A. Sandham and A. J. Kastin (Eds.) *Neuropeptide Influences on the Brain and Behavior.* New York: Raven Press, 1977, pp. 213–232.

PRIBRAM, K. H.
The place of pragmatics in the syntactic and semantic organisation of language. In *Temporal Variables in Speech: Studies in Honour of Frienda Goldman-Eisler.* The Hague: Mouton, 1980, pp.13–20. (a).

PRIBRAM, K. H.
Cognition and performance: The relation to neural mechanisms of consequence, confidence and competence. In: A Routtenberg (Ed.) *Biology of Reinforcement: Facets of Brain Stimulation Reward.* New York: Academic Press, 1980, pp.11–36. (b)

PRIBRAM, K. H.
The brain as the locus of cognitive controls on action. In: G. d'Ydewalle and W. Lens (Eds.) *Cognition in Human Motivation and Learning.* Leuven, Belgium: University of Leuven, 1980, pp.82–92. (c)

PRIBRAM, K. H. and GILL, M. M.
Freud's 'Project' Reassessed: Preface to Contemporary Cognitive Theory and Neuropsychology. London: Hutchinson Publishing Group, 1976.

PRIBRAM, K. H. and KRUGER, L.
Functions of the 'olfactory' brain. *Annals of the New York Academy of Science,* 1954, *58,* 109–138.

PRIBRAM, K. H. and McGUINNESS, D.
Arousal, activation and effort in the control of attention. *Psych. Rev.,* 1975, *82*(2), 116–149.

PRIBRAM, K. H. and WEISKRANTZ, L.
A comparison of the effects of medial and lateral cerebral resections on conditioned avoidance behaviour of monkeys. *J. comp. physiol. Psychol.* 1957, *50,* 74–80.

PRIGOGINE, I.
From Being to Becoming. New York: Freeman, 1980.

RUCH, T. C.
Motor systems. In S. S. Stevens (Ed.) *Handbook of Experimental Psychology.* New York: Wiley and Sons, 1951, pp. 154–208.

SCHACHTER, S. and SINGER, T. E.
Cognitive, social and physiological determinants of emotional state. *Psycho. Rev.,* 1962, *69,* 379–397.

SCHRODINGER, E.
What is Life? Mind and Matter. Cambridge: Cambridge University Press, 1944, pp.178.

SHANNON, C. E. and WEAVER, W.
The Mathematical Theory of Communications. Urbana, Illinois: The U. of Illinois Press, 1949.

SIMON, H. A.
How big is a chunk? *Science,* 1974, 183: 482–488.

SKINNER, B. F.
Contingencies of Reinforcement: A Theoretical Analysis. New York: Appleton-Century-Crofts, 1969.

SKINNER, B. F.
Beyond Freedom and Dignity. New York: Alfred A. Knopf, 1971.

SMETS, G.
Aesthetic Judgment and Arousal, Leuven, Belgium: Leuven University Press, 1973.

SPINELLI, D. N.
Occam, a content addressable memory model for the brain. In: K. H. Pribram and D. Broadbent (Eds.) *The Biology of Memory.* New York: Academic Press, 1970, pp.293–306.

SPINELLI, D. N. and PRIBRAM, K. H.
Changes in visual recovery functions produced by temporal lobe stimulation in monkeys. *Electroenceph. clin. Neurophysiol.,* 1966, *20,* 44–49.

SPINELLI, D. N. and PRIBRAM, K. H.
Changes in visual recovery function and unit activity produced by frontal and temporal cortex stimulation. *Electroenceph. clin. Neurophysiol.,* 1967, *22,* 143–149.

TEITELBAUM, P.
Sensory control of hypothalamic hyperphagia. *J. comp. physiol. Psychol.,* 1955, *48,* 156–163.

TEUBER, H. L.
Perception. In J. Field, H. W. Magoun, and V. E. Hall (Eds.) *Handbook of Physiology, Neurophysiology III.* Washington: American Physiological Society, 1960, pp.1595–1668.

TEUBER, H. L.
The riddly of frontal lobe function in man. In J. M. Warren and K. Akert (Eds.) *The Frontal Granular Cortex and Behavior.* New York: McGraw-Hill, 1964, pp.410–445.

WEIZSACKER, VON E.
Offene Systeme I. Stuttgart: Verlag, 1974.
WIENER, N.
Cybernetics. New York: Wiley and Sons, 1948.
WIGNER, E. P.
Epistemology of guantum mechanics: Its appraisals and demands. In: M. Grene (Ed.) *The Anatomy of Knowledge.* London: Routledge and Kegan Paul, 1969.

PERSONAL REALITY

PRIMARY PROCESSES

Energy, Work Related
Getting Things Done *Somehow*
and/or Being Hung-Up
Wishes, Dispositions

SECONDARY PROCESSES

Cognitive, Entropy Related
Getting Things Done *Efficiently*
Ego, Executive

BIAS TO RISK

Emotions	Motivations
Affects	Memory Store
(Limbic, i.e. Accumbens/Septal and Amygdala Systems)	(Nigrostriatal Systems)

BIAS TO CAUTION

Probability Structures	Image and Information Processing
Contextualising Chunking	Choice Among Alyernatives Processing Proportions and Ratios
(Frontal System)	(Posterior Convexity)

CONSCIOUSNESS		LOGIC/RATIONALITY
EXTRAPERSONAL SENSORY REALITY	**PERSONAL REALITY**	**EXTRAPERSONAL MOTOR**
Phenomenal	Protocritic	Behavioural
Epicritic	Intensive	Epicritic
Extensive	Context Determining	Extensive
Local Sign		Local Sign
Holonomic		Invariant
Spectral		Object Constancies
Correlational		Actions
Distributed		Communications