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Freud's Project: An Open, Biologically Based Model for Psychoanalysis

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Biological matters in psychiatry are perceived in several ways. For the most part, biochemical etiologies are called to mind, inherited individual differences are sought, or the effect of some psychological process (e.g., stress) on the physiology of the organism is evaluated. Generally in contrast to these "biological" and "organic" approaches are those which concentrate on the psychological and social determinants of mental health and illness.

There is another biology, however, a biology which shows a special kinship to just these nonorganic, seemingly nonbiologic psychologies and psychiatries. This other biology is *neurobiology*—the study of the organic system whose office it is to organize, to structure the psychological and social functions of such concern to nonorganicists. Paradoxically, it was this other biology that spawned today's nonorganic views. It is my opinion that advances in research methods make it probable that neurobiology can again contribute substantially to psychiatry if permitted, i.e., if readmitted for serious consideration.

I have pointed out elsewhere (16) that the psychoanalytic model from which much of today's psychological (20) and psychiatric (7) theory derives is fundamentally a *neuropsychological* model. The neurological aspects of the model were abandoned by Freud and therefore failed to motivate neurophysiological research. Despite this, many of the neurological conceptions

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contained in his model have a current ring to them—the technical advances of the past half-century make the neurophysiological hypotheses derived from the model now testable. Further, specification of the neurological detail of the model, by producing a “real world” referent, can considerably clarify issues hitherto limited to metapsychological analysis.

My proposal is that we take seriously the detail—in its *structured* combination of the neurological and psychological—with which the psychoanalytic model is replete. The richness which the model provides is lost as long as its verbal currency fails to be tested against experimental standards; and today's available neurophysiological, neurobehavioral, and experimental behavioral techniques leave no excuse for failure to make such tests.

CATHEXIS—AN EXAMPLE

Let me illustrate: Freud bases his construction on the concept of a unitary quantity of neural excitation and the tendency of nerve tissues to discharge this quantity—i.e., on the all-or-none characteristic of the transmitted nerve impulse. However, he recognizes (as did most other neurologists of the 1890's) that this is not the whole story. Nerve tissue shows local, nontransmitted waxing and waning—graded changes—of excitatory potential: in axons electronic phenomena occur; at synaptic junctions and in dendrites potential changes are preponderantly graded. These graded mechanisms of neural excitation have recently become the focus of a great deal of neuropsychological research as the tools for precise investigation have become available. It has become recognized that the graded mechanisms are intrinsically important—that they are to be viewed as more than subthreshold phenomena which, when summed, lead to nerve impulses. Bishop (3), a leading investigator of dendritic mechanisms, has gone so far as to suggest that the graded mechanisms represent *the* important functional states of the central nervous system, that nerve impulses merely transmit information about such states from one part of the nervous system to another. The psychoanalytic model recognizes graded, local excitations of neural tissue as cathexes:

If we combine this account of neurones with an approach on the lines of quantity theory we arrive at the idea of a “cathected” neurone (N) filled with a certain quantity ($Q'n$) though at other times it may be empty.¹

And further:

The principle of inertial finds expression in the hypothesis of a current passing from the cell processes of dendrites to the axone. Each single neurone is thus a model

¹Sigmund Freud, “Project for a Scientific Psychology,” *The Origins of Psychoanalysis: Letters to Wilhelm Fliess, Drafts and Notes, 1887–1902*, edited by M. Bonaparte, A. Freud, and E. Kris (N.Y., Basic Books, 1954), p. 358. Subsequent quotations from Freud identified only by page number are from this source.

of the nervous system as a whole, with its division into two classes of neurones—the axone being its organ of discharge.—(p. 359)

By implication dendrites (and somata) are the organs primarily responsible for cathexis.

Freud's 1895 model attributed delay to core-brain mechanisms—his nuclear "psi" system:

The system phi might be the group of neurones which receive external stimuli, while the system psi might contain the neurones which receive endogenous excitations. . . . And in fact we know from anatomy that there is a system of neurones (the grey matter of the spinal cord) which is alone in contact with the external world, and a superimposed system (the grey matter of the brain) which has no direct peripheral contacts but which is responsible for the development of the nervous system and for the psychical functions. The primary [primitive] brain gives no bad picture of the characteristics we have attributed to the system psi, if we may assume that paths lead directly, and independently of phi, from the brain to the interior of the body. The derivation and original significance of the primary brain is unknown to anatomists; on our theory it must have been neither more nor less than a sympathetic ganglion.

Further on:

In this way psi is cathected from phi with quantities which, in the normal course of things, are small. While the *quantity* of the phi excitation is expressed in psi as complexity, the *quality* is expressed topographically, since, in accordance with the anatomical relations, the different sense organs communicate only with particular psi neurones. But psi also receives cathexes from the interior of the body, and it seems reasonable to divide the psi-neurones into two groups; the neurones of the pallium which are cathected from phi, and the nuclear neurones which are cathected from the endogenous paths of conduction.—(p. 377)

Neurophysiological tests.—Cathexis and current are opposed in the model. Cathexis accounts for the process of delay, current for the processes of discharge. On the neurological level the concept "delay" has never been put to test. True enough, when excitation fails to produce nerve impulses, delay in discharge is what occurs. In an experiment by Gloor (8), for instance, stimulation within one limbic structure (amygdala) increased the graded potential changes recorded from another (the dendritic layer of the hippocampus), and no nerve impulses were generated there (i.e., there was no increase in discharge from the fornix, the major output system from the hippocampus); and Eccles (6) has found that excitation reaching dendrites of the hippocampus very often fails to generate sufficient depolarization to result in a propagated nerve discharge. These experimental results are compatible with the neurological rudiments of the psychoanalytic model, but experimental support for functional significance is lacking to date. Does the graded response mechanism really function to *delay* discharge, or is it merely an indication that discharge failed of achievement? The psychoanalytic

model demands "delay"; more ordinary neurophysiology is satisfied when it can be shown that graded response mechanisms, when appropriately integrated, do result in discharge. Techniques *are* available to test the delay hypothesis. Adey (1) and his collaborators have devised methods to study the impedance, and therefore the capacitance and resistance, of central nervous system structures in the awake, performing organism. What, if any, correlations can be demonstrated among changes in capacitance of a neural structure in situations that demand delay? Specifically, is the capacitance of cerebral tissue involved when the organism performs delay tasks, such as delayed reaction or delayed alternation, but not when simple discrimination choices are required? Already we know that removal of certain parts of the cerebral cortex selectively impairs performance of delay tasks, leaving simple discriminations uninfluenced (15, 19). Do removals of these areas alter cerebral capacitance?

Psychoanalytic formulation.—Taken seriously, therefore, the concept cathexis in the psychoanalytic model leads to some interesting neurobehavioral and neurophysiological experiments. Perhaps of equal interest would be a consequence that could be attained only by attention to the neural detail of the model. Psychoanalytic theory has had considerable difficulty with the concept of "binding," and here a neurological contribution to metapsychology could prove rewarding.

Freud meets the problem for the first time, because he has constructed a neurological model in which cathexis and discharge are opposed. Yet ordinarily, when two neurones are highly cathected, discharge between them is facilitated: "A process of this kind is termed 'summation.' The psi-paths of conductance are filled by summation until they become permeable. It is evidently the smallness of the separate stimuli that enables summation to occur" (p. 378). But now, more specifically:

Every psi neurone must in general be presumed to have several paths of connection with other neurones—that is, several contact-barriers (synapses). It is on this point that the possibility depends of the excitation having a choice of path, determined by facilitation. This being so, it is quite clear that the condition of facilitation of each contact-barrier must be independent of that of all the others in the same psi neurone. Otherwise, there would once again be no possibility of one path being preferred to another—no motive, that is. From this we can draw the negative inference as to the nature of the condition of "facilitation." If we imagine a neurone filled with quantity ($Q'n$)—i.e., cathected—we can only suppose that this quantity is uniformly distributed over all regions of the neurone, including all its contact barriers. On the other hand, there is no difficulty in supposing that, in the case of a quantity ($Q'n$) in a condition of flow (the nerve impulse), it will take only one particular path through the neurone; so that only one of the contact-barriers will be influenced by that quantity ($Q'n$) and acquire facilitation from it. Therefore facilitation cannot be based upon a cathexis that is retained. . . .—(p. 362)

Note that these passages again oppose cathexis and the nerve impulse, current in flow; and note also that facilitation of a current in flow is produced through summation of excitation in the psi *paths of conduction*. This does *not* mean that facilitation is produced by summation of excitation in psi *neurones*, since excitation retained in psi neurones (i.e., retained cathexis) does *not* lead to facilitation. Only when quantity is absorbed by the synapse (as a consequence of use) does facilitation result.

Our first idea might be that [facilitation] consists in an absorption of quantity ($Q'n$) by the contact barriers . . . we cannot yet tell whether any equivalent effect is produced by the passage of a given quantity ($Q'n$) three times and by the passage of a quantity ($Q'n$) three times as great once only.—(p. 363)

The result of the fact that quantity can be "absorbed" by the synapse suggests that it may be absorbed by the remainder of the neuron as well—that when this occurs, cathexes are retained—and this is later made explicit:

We must conclude that matters are so constituted that when there is a lateral cathexis [cathexis of a network of neurons in psi, tangential to, i.e., branching out from, the main paths of conducted discharge] small quantities ($Q'n$) can flow through facilitations which could normally be passed only by large ones. The lateral cathexis, as it were, "binds" a certain amount of the quantity passing through the neurone.—(p. 396)

Binding in Freud's original model is thus conceived as the major mechanism through which large quantities of excitation are prevented from immediately discharging through motor action. Binding of these large quantities makes possible selective, appropriately timed, discharge by *small* quantities much as charged condenser-resistor networks can be selectively activated by small quantities of electric current. The binding of excitation by neurons is therefore the mechanism basic to the secondary process. (The quotation above from p. 396 is preceded by the sentence: "Thus, *the secondary process is a recapitulation of the original course of excitation in psi, but at a lower level, with smaller quantities.*") Again, it must be emphasized that the *course* of excitation proceeds at a lower level, with smaller quantities—that this course is taken only when larger quantities are *bound* by lateral cathexis.

What then is nonbound, i.e., free, excitation? Freud repeatedly refers to shifting cathexes, displacement of excitation, and the like. Passages from a description of the development of the ego are illuminating:

The . . . nuclear neurones abut ultimately upon the paths of conduction from the interior of the body . . . continuously filled with quantity; and since the nuclear neurones are prolongations of these paths of conduction, they too must remain filled with quantity. The quantity in them will flow away in proportion to the resistances met with in its course, until the next resistances are greater than the quotient of quantity ($Q'n$) available for the current. But at this point the whole cathectic mass is in a state of equilibrium. . . . In the inside of this structure which constitutes the

ego, the cathexis will by no means be everywhere equal; it need only be *proportionally* equal—that is, in relation to the facilitations.

If the level of the cathexis in the nucleus of the ego rises, the ego will be able to extend its area; if it sinks, the ego will narrow concentrically. At a given level and a given extension of the ego there will be no obstacle to displacement taking place within the region of its cathexis.—(p. 427)

Now, what about this “displacement”? It occurs most readily in dreams: “. . . characteristic of dreams is *the ease with which quantity (Q'n) is displaced* in them and thus the way in which B is replaced by a C which is superior to it quantitatively” (p. 404). Displacement also occurs in psychopathology: “. . . only the distribution of quantity has been altered. Something has been added to A that has been subtracted from B. The pathological process is one of *displacement*, such as we have come to know in dreams, and is hence a primary process” (p. 407).

On superficial reading these passages may appear to be full of contradictions. The ego, an equilibrated mass of cathected neurons, makes possible secondary processes (such as thinking) which depend on paths being facilitated by small quantities of discharge. Yet within this same ego a primary process, *displacement* of quantity, can occur, albeit only during dreams and in psychopathology.

What is important to note is that displacement, a shift in quantity, is conceived to occur via a primary process, i.e., a process of sudden discharge. When complete discharge is restricted, as by the presence of a powerful ego (i.e., a set of neurons with ability to bind excitation), the result is the sudden displacement of quantity via nerve impulse activity from one neuronal pool to another. Cathexes have thus been shifted, but not in some mysterious way—shift has resulted from a circumscribed localized discharge to neighboring neurones.

ATTENTION AND REINFORCEMENT ANOTHER EXAMPLE

What then determines the difference between this pathological psi process and a normal one? Freud answers this explicitly: “. . . the mechanism of attention will regulate the displacement of ego cathexes” (p. 428).

Attention, in the psychoanalytic model, results from progressively developed comparison and feedback process which produce a match between an expectation and indications of reality. Again, the detail of this process is replete with neurological referents which can be directly tested with today's available neurophysiological and neurobehavioral techniques.

Comparison, which determines attention, results from the operation of a series of heirarchically arranged feedback loops which Freud calls the process of satisfaction—a fundamental mechanism in determining the construction of the individual:

The filling of nuclear neurones in psi has as its consequence an effort to discharge, an impetus which is released along motor pathways. Experience shows that the first path to be followed is that leading to internal change (e.g., emotional expression, screaming, or vascular innervation). But, as we showed at the beginning of the discussion [p. 357], no discharge of this kind can bring about any relief of tension, because endogenous stimuli continue to be received in spite of it and the psi-tension is re-established. Here a removal of the stimulus can only be affected by an intervention which will temporarily stop the release of quantity ($Q'n$) in the interior of the body, and an intervention of this kind requires an alteration in the external world (e.g., the supply of nourishment or the proximity of the sexual object), and this as a "specific action," can only be brought about in particular ways. At early stages the human organism is incapable of achieving this action. It is brought about by extraneous help, when the attention of an experienced person has been drawn to the child's condition by a discharge taking place along the path of internal change (e.g., by the child's screaming). This path of discharge thus acquires an extremely important secondary function—viz., of bringing about an understanding with other people; and the original helplessness of human beings is thus the primal source of all moral motives. [Cf. pp. 422-23.]

When the extraneous helper has carried out the specific action in the external world on behalf of the helpless subject, the latter is in a position, by means of reflex contrivances, immediately to perform what is necessary in the interior of his body in order to remove the endogenous stimulus. This total event even then constitutes an "experience of satisfaction," which has the most momentous consequences in the functional development of the individual. For three things occur in this psi-system: (1) A lasting discharge is effected, so that the urgency which had generated unpleasure in W is brought to an end. (2) A cathexis corresponding to the perception of an object occurs in one or more neurones of the pallium [p. 377]. (3) At other points of the pallium a report is received of the discharge brought about by the release of the reflex movement which followed the specific action. A facilitation is then established between these cathexes [2, 3] and the nuclear neurones [which were being cathected from endogenous sources during the state of urgency].

The report of the reflex discharge comes about owing to the fact that every movement, as a result of its collateral consequences, gives rise to fresh sensory excitations—of the skin and muscles—which produce a *motor* [or *kinesthetic*] *image*.—(pp. 379-80)

Note here that Freud attributes the origins of satisfying experiences to intervention by a care-taking person. Only by such intervention can wishes develop sufficient complexity; only by such intervention can the psychological structure become organized. As Strachey points out: "In none of Freud's later formulations of this idea has the present one [quoted above] been equalled or surpassed: it indicates the part played by object-relations in the transition from the pleasure to the reality principle" (p. 379).

According to this model wishes are the "residues," i.e., the memory traces, of satisfactory experiences (p. 383), and attention becomes possible when states of craving, having been, through experience, altered into states of wishing, become further modified into states of expecting—states that allow thinking and reality-testing:

This state of attention has a prototype in the "experience of satisfaction" [p. 380]

(which is of such importance for the whole course of development) and the repetitions of that experience—states of craving which develop into states of wishing and states of expecting. I have shown [Part 1, Sections 16–18] that these states contain biological justification of all thought. The psychical situation in these states is as follows. The craving involves a state of tension in the ego; and as a result of it the idea of the loved object (the "wishful idea") is cathected. Biological experience has taught us that this idea must not be cathected so intensely that it might be confused with a perception, and that its discharge must be postponed till indications of quality arise from it which prove that it is real—that the cathexis is a perceptual one. If a perception arises which is identical with or similar to the wishful idea, the perception finds its neurones precathected by the wish—that is to say, some or all of them are cathected, according to the degree to which the idea and the perception tally. The difference between the idea and the perception then gives rise to the process of thought; and this reaches its conclusion when a path has been found by which the discordant perceptual cathexes can be merged into ideational cathexes. Identity is then attained.—(pp. 417–18)

Neurophysiological tests.—Neurologically the model proposed by Freud the project is sophisticated: (1) Memory traces are conceived to be hierarchically organized. (2) *Each* memory is at least triply determined—events initiated within (drive stimuli), external to (sensory stimuli), and by (motor stimuli) the organism, compose each trace. (3) Operations (behavior and thought) are carried out by the organism as long as activated memory traces fail to be matched by current inputs.

There is a good deal of behavioral evidence in support of these propositions—e.g., see *Plans and the Structure of Behavior* (13). Neurological techniques are just beginning to allow an approach at this level. Doty (5) has produced evidence for the multiple determination of the engram, and Sharpless and Jasper (21) have shown that habituation involves changes in the neural apparatus which are highly specific to the inputs that have been experienced. Sokolov (22) in addition, has demonstrated that orienting occurs whenever there is a mismatch between an input and this habituated neural "model" of prior experience. His experiment is a simple one. He habituated persons to a tone beep of a certain intensity, duration, and frequency, irregularly presented. When habituation had occurred, as gauged by such physiological indices as the galvanic skin response, plethysmography, and alerting responses in the electroencephalogram, he diminished the intensity of the tone. Immediately the person again oriented. Sokolov reasoned therefore that habituation did not indicate some increased neural threshold or loss of neural sensitivity. He suggested that the habituated neural "model" served as a template against which inputs were matched. He tested his suggestion by again habituating his subject; then, instead of diminishing intensity, he *shortened* the tone beep. Orienting again took place—but now at the point when the tone ceased. In other words, the person oriented to the unexpected *silence*.

Habituation, then, can be taken as an indicator that specific changes are occurring in the central nervous system, changes that will influence subsequent reactions to stimuli. Yet these changes are not so simply brought about as these initial experiments would lead us to believe. Experiments performed in my laboratory (10) have shown that the probability of orienting is dependent on another set of variables which Lacey and Lacey (11) have related to the stability of the person's autonomic effector mechanisms. Further, some indicators of orienting (such as the galvanic skin response) seem to signal that a process is taking place which is not directly involved in alerting (as measured by the electroencephalogram): the galvanic skin response and electroencephalographic components of the orienting reaction can be dissociated by central nervous system lesions (9). These lesions do not alter simple discrimination learning or performance; some of the lesions do, however, interfere with tasks that involve delay, and others alter the ability to transfer what the subject has learned in one situation to another (2). The suggestion is that whenever a galvanic skin response is obtained a more complex registration of inputs is being achieved, a registration that allows flexibility in subsequent use beyond some simple match-mismatch mechanism necessary to discriminative performances. The studies have not proceeded to the point where the details of Freud's richly specified psychoanalytic model of reality testing can be brought under experimental scrutiny—but a direction of research has been spelled out which brings such an accomplishment within range.

Psychoanalytic formulations.—I have presented elsewhere (17, 18) a model based on the laboratory procedures used in experimental psychology. The suggestion was made that reinforcement (i.e., satisfaction) was a neural process which acted to progressively organize the more or less haphazard sequences of occurrences which make up the life of an organism. This neural process is rooted in habituation—inputs derived from within the organism, from its environment, and from its own actions form a neural model which is the context within which subsequent occurrences can provide *information*. Subsequent events thus become consequent—i.e., meaningful. The organism is learning. Consequences, in turn, are habituated, and, when this occurs, the context itself has been altered. Now events comparable to earlier ones no longer provide information; they match the model. However, these events may still guide performance (perceptual, motor, or thought); they *value* the execution of performance, they are part of the contextual matrix within which performance takes place. Other novel occurrences become informative, and the process is repeated. When information becomes organized through learning, satisfaction is experienced; when performances attain adequacy, gratification results (14).

This model is in some respects consonant with Freud's; it differs from the

psychoanalytic mainly in that it contains no prescription for precedence of drive, perceptual, and motor occurrences and in its emphasis of the distinction between learning and performance and thus between satisfaction and gratification. Some experimental psychologists have suggested that their data fit Freud's model even more closely (e.g., Dollard and Miller [4]). However, these similarities are apt to prove sterile if they do not point to specific lacunae in our experimental approach to the problem at issue. One such specification can be made: Both psychoanalysis and experimental psychology have for some time focused on the problem of learning. The problem faced in the clinic, and even in the laboratory, however, is often one that involves not learning but effective unlearning. Specifically, a patient or experimental subject must restructure, reorganize, the psychic set, i.e., the neural apparatus with which he approaches occurrences. Stated in terms of the model of the process of reinforcement, the task is not so much one of acquiring information as one of changing values. This can be accomplished through learning, but experience tells us that this is not the whole story. The learner must somehow be made receptive to a change in values which allows a greater amount of gratification to result from his actions. To date, although both learning theory and psychoanalytic theory are aware of this problem, neither has had much that is testable to say about it. Questions remain to be posed in experimental terms. For the most part these would center about the problem of extinction, which until recently has received only cursory development in the experimental literature (see Lawrence and Festinger [2] for a review of the main problem areas). How much true "forgetting" takes place? What factors determine the persistence of behavior (perception, thought) in the face of changed conditions? Does attention per se, as suggested by Freud's model, really alter the persisting behavior? What takes place in the central nervous system when input conditions change but performance remains the same? Are the neural antecedents to such actions indentifiably *unchanged*? Can changes be effected by focusing the subject's attention on the changed input conditions? And how is this most readily accomplished?

CONCLUSION

Even partial answers to these questions would take us a distance toward open understanding of the psychoanalytic model: today, knowledge often hinges on close acquaintance with a circumscribed theoretical system; scientific assurance cannot be given to those not so acquainted. The model basic to the psychoanalytic metapsychology is, as I have here suggested, an open one—free to be tested at the neurological level by modern neurophysiological and neurobehavioral techniques, and at the psychological level by the techniques of experimental (and social) psychology, and even by computer simulation. Tests must begin by focusing on basic functions understandable to a

variety of disciplines, functions such as delay, matching, and extinction; some patience will be necessary on the part of the sophisticated in every field such endeavors touch. We cannot, of course, hope to bring the entire secondary process to bay at once. However, the scientific community has devised its own form of "ego," a mechanism designed to usefully structure this necessary delay: namely, conferences and publications such as this one, since we are here dealing with a communicative network tangential to the main paths of our ingrained scientific and clinical pursuits. Do we not, as a consequence, return to these with freshly phrased expectations—perhaps a bit more appropriate to the task which confronts us? and do not these refreshments result in increasing our opportunity both for satisfaction and for gratification?

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