

SCIENCE

VOL. 78

FRIDAY, SEPTEMBER 8, 1933

No. 2019

Anticipatory Reaction: PROFESSOR RAYMOND DODGE 197
A History of the National Research Council, 1919-1933. IX. Research Information Service: DR. C. J. WEST 203

Scientific Events:

The Leverhulme Scholarships; Agricultural Reorganization in Mexico; The Southern California Rift Club; The Exhibit of the Bureau of Fisheries at the Century of Progress Exposition; Obituary ... 206

Scientific Notes and News 208

Discussion:

Observations on Forecasting Annual Changes of Crop Yields: DR. GEORGE W. HERVEY. Is Methylen-blue Anti-carcinogenic?: DR. MAURICE COPISAROW. Courses in the Literature of Botany: ELSA HORN. On the Audibility of the Aurora Borealis: CLARK M. GARBER. Professor Einstein and the Institute for Advanced Study: DR. ABRAHAM FLEXNER 211

Scientific Apparatus and Laboratory Methods:

A Method for Permanently Recording the Locations of Objects on Microscope Slides: K. E.

LOHMAN. Avoidance of Emulsification in Defatting Operations: A. E. RHEINECK and OLE GISVOLD 214

Special Articles:

Relationship of the Viruses of Vesicular Stomatitis and of Equine Encephalomyelitis: JEROME T. SYVERTON, HERALD R. COX and DR. PETER K. OLITSKY. A Respiration Coenzyme: DR. FRANKLIN E. ALLISON, SAM R. HOOVER and DR. DEAN BURK 216

Science News 6

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal
Lancaster, Pa. Garrison, N. Y.
Annual Subscription, \$6.00 Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

ANTICIPATORY REACTION¹

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ONCE in a while in the classical reaction experiment there occurred a disturbing phenomenon. Instead of trailing along in orthodox sequence the reaction occasionally came before the regular stimulus. What could one do with such a tactless event? As an experimental datum it couldn't be arbitrarily ignored. Yet it just wouldn't fit in with the other data. Like some other relegates to the scrap heap of science it might have suggested a reinterpretation of the stimulus-reaction schema, or at least some correction of its interpretation. Some of us at Yale believe that it does. "Oh, I see," you say, "the conditioned reflex is in the woodpile." But it isn't exactly that. If I may state the conclusions at the beginning I believe that there is abundant evidence that the doctrine of direct bonds between a specific stimulus and a specific reaction, instead of being the general plan of all

behavior, is either an artifact due to imperfect description or a special limiting case of laboratory experiment. In every-day human life, as well as in the laboratory, most specific reactions are selected phases of a complex flux of organic response evoked by a complex flux of stimulation and inhibition, some part of which is arbitrarily called the stimulus. This dual flux reaches into a more or less remote past and a more or less remote future. It shows a highly complicated system of present meanings in individual experience and appears as extensive ramifications or spread and systematization of impulses within neural tissue. In this flux the recurrence of identical set-stimulus-reaction sequences is highly improbable. The usual sequences are between more or less variable systems. They may be called for convenience the stimulus system and the reaction system, but in reality the relation is quite intimate.

In systems of irritable tissue the action of each part of the system often appears in a dual rôle. Central

¹ Presidential address delivered before the New York Branch of the American Psychological Association at New Haven, April 1, 1933.

tissue, at least, reacts to stimulation by some of its physiological neighbors, and it stimulates some to reaction. The same neural events in irritable tissue may be both a reaction and a stimulus. Both are really related or identical phases of organic systematization, expressions of the organism's capacity to react in a systematized way. The concept emphasizes two main points. Every so-called specific reaction is an arbitrary phase of a complex reactive adjustment flux. Every so-called specific stimulus of a tissue is an arbitrary phase of a complex flux of environmental changes without definite beginning and without definite end. The two may be, and often are, different functions of the same neural event, due to its different systematic relations within the organism.

The relationship is even closer. The flux of stimuli from the environment of the organism through the sense organs, through the nerve trunks and ganglia to the musculature and glands is paralleled by the flux of reactions. Changes in the environment are stimuli only when they evoke organic reaction. Reaction occurs only in response to stimuli. Each implies the other throughout. There is no neural stimulus without a corresponding neural reaction, no neural reaction without changes in the vital environment of the tissue that reacts.

In view of this fundamental biological relationship between stimulus and reaction a real anticipatory reaction is an impossible absurdity. It simply can not exist, yet somehow the impossible is actual.

It would be an unfortunate misunderstanding of the term "anticipatory reaction" to limit it to the occasional miscarriage of the traditional reaction experiment. Both Hull and I, from different approaches, have pointed out its wide-spread importance in the conduct of vital adjustments. Thurstone rightly held that anticipatory reaction is a real but strangely neglected measurable indication of intelligence. A large part, if not the largest part, of a rational person's life is spent in planning for events that may not occur.

It is generally recognized that there are two forms of reaction to circumstances. One is centrifugal and the other is centripetal. The one modifies the environment to make it livable, and the other modifies the individual to live in a given environment. Either centripetal or centrifugal reactions may be of one or the other of two types. The one type refers to events as they occur, making the best of what comes, whether bank failure, loss of fortune or any other more or less disturbing change in situation. Centrifugally it locks the door after the horse is stolen. Centripetally it exploits or utilizes events in the development of character and personality. It might be called the *nous pathetikos*. But there is another type of mental

activity that locks the door lest the horse be stolen. It is related to foresight and creative imagination. It aims to adapt to bad news or any other indication of future circumstances by developing beforehand certain resistances, inhibitions, philosophies of life. Moral education, stoicism and epicureanism represent phases of such adaptation. In it there is a certain creative evolution of the control by each individual, either of himself or of events. This is the *nous poetikos*.

While the two types seldom occur in pure form, the first is particularly apparent in infrahuman reaction. The second is more characteristic of man. It includes vital planning of all sorts, casual and systematic, immediate and remote, planning for the next dinner, planning for social contacts, planning scientific experiments, planning for family continuity or life work. It is involved in all orderly development of conduct. It appears in the predictive value of science.

Vital planning may occur in various frames, such as economic, social or moral. Economic planning involves all sorts of insurance against want and disaster, like automobile, fire, theft and accident insurance, life insurance, annuity. It involves the saving of surplus and its investment. The social frame of anticipatory reaction involves adjustments for the convenience, safety and welfare of society, from defensive arming of a nation to shoveling off snow and ice from one's sidewalk so that we, our neighbors and the casual pedestrian may not fall. Moral planning includes the general organization of life to definite ends according to our system of values and goal ideas. It runs the entire gamut of adjustment of our conduct to the moral susceptibilities and prejudices of individuals and groups, from watchfulness at street-crossings as we drive our automobiles to the ordering of our lives so that we may produce as little damage in the world, as little pain and as much good, as possible.

In all this planful activity the great mass of our reactions are anticipatory. It must be so if they would be useful. Biologically, security and even survival depend upon these anticipations. Failure to foresee accurately and preadjust adequately is not unusual, but it is regrettable and usually regretted. As I see it, one of the main tasks of education, and one of the main functions of science and common sense, is to achieve foresight. The rational conduct of life requires preparation for events before they occur.

The question at issue remains. How can the reaction anticipate the stimulus? Theoretically it can not, but practically it does.

The paradox is not an illusion, and it is far from trivial. On the one hand, it represents a serious discrepancy between the experimental science of mind

and the common-sense conduct of life. On the other hand, it represents a problem of the scientific synthesis of apparently contradictory facts. We conjecture that the answer lies not in the concept of the conditioned reflex but rather in the underlying fact of the spread of neural excitation and its systematization according to differential thresholds.

Under the traditional conceptions of specific reactions to specific stimuli from the environment of the organism the definition of stimulus in common life situations was often impossible and usually difficult. If the reaction flux desired by the traveling salesman is the act of buying goods, signing on the dotted line, paying for the goods, with the hope of recouping outlay by reselling, the sales stimulus flux is commonly more than handing across a well-linked fountain pen. It may include the personal habits of the salesmen as well as his line of patter and the sight of the goods in attractive containers. It may also include inquiry by a customer last week, the total financial situation, a fortuitous favorable bank balance and even an expected inheritance from a dead grandmother. In which case grandmother's death may be a very real factor of the stimulus flux and quite as important as passing over the well-filled fountain pen.

VARIETIES OF STIMULI

In our psychological tradition stimuli external to the organism are commonly classified according to the sensory end-organ which they specifically stimulate. This has a basis not only in convenience but also in sound physiology. Since, as we have seen, there is no organic stimulus without a reacting tissue the two are correlates. But it is equally justifiable to classify the stimulus-reaction process from the standpoint of the particular physical environment which finally evokes the reaction. Both references, however, have their disadvantages. From reference to the environment it has come about in the tradition that electricity, light, sound, contact, chemical action and rotation are commonly uncritically called stimuli and the special sense organs are often called receptors, though we know perfectly well that only certain more or less rapid changes in a limited range of these aspects of the environment act as stimuli and that the neural end-organs are specific reactors of specialized irritability instead of passive receptors. These more sensitive areas are really parts of extensive fields of sensitive reactors of less specific irritability. This is clear enough with respect to electricity, contact and rotation. It is fairly clear with respect to light and sound. The tips of the fingers and the lips are obviously high spots in a gradient of skin sensitivity; canals and cochlea, high spots in a gradient of sensitivity to contact and pressure. The entire body is more or less sensitive to elec-

tricity and chemical reactions. Light changes may affect any part of the skin in a relatively undifferentiated way. Sounds may be felt at the finger tips, and various inner parts of the body respond to sound vibrations which are too high to stimulate the cochlea. The terms receptors and receptor fields are still widely current and always misleading. The sensitive neural parts of the so-called receptors are not really receptors at all but primary reactors in the organic reaction flux.

The exact nature of neural stimulation and neural reaction is still largely a matter of conjecture, but enough is known experimentally to make it highly probable that both belong to the electrochemical series of physical events. Irritability of central nervous tissue is not necessarily different from irritability of peripheral tissue just because it lies in an organic environment. Changes in fields of force surrounding central nervous tissue are not necessarily different kinds of stimuli from changes in the fields of force surrounding peripheral neural tissue. The main point is that it can make no essential difference in the reaction of central nervous tissue where its stimuli ultimately derive from. Provided the stimuli evoke similar systems of neural reaction, it is a matter of relative indifference whether they originate in the organism or in its environment. A tissue can react only in accordance with its own reaction capacities to changes in its environment to which it is sensitive at the time.

This point is of great importance to us in the interpretation of anticipatory reactions in those cases which are unfortunately misnamed "conditioned reflexes." There are serious objections to the term, as has been pointed out frequently. To lump all reactions as reflexes doesn't aid description but confuses it. The term "conditioned reactions" would be a little less confusing in view of the widely spread specific connotation of reflex, and Miss Peak's functional discrimination between reflex and voluntary reactions. Moreover, since all reactions have antecedents which adequately condition them, even the term "conditioned" has no special descriptive value. In view of the general use of specific stimuli I could vote with those who would call the "unconditioned reactions" primary reactions and the "conditioned reactions" secondary. *Direct* and *indirect* seem to me still better. In view of the gradually arising belief that the conditioned reaction is never a reaction *de novo* and in view of Pavlov's own analysis it might be best to stick to the more simple descriptive terms reinforced and inhibited secondary reactions.

TYPES OF ANTICIPATORY REACTIONS

There sometimes seem to be three varieties of reaction which appear to anticipate the natural stimulus.

One emphasizes the systematization in the flux of stimuli, a second emphasizes the systematization of the overt reaction and a third emphasizes the systematization of both stimuli and reaction. However important these differences appear to be in practical life and in psychological thought, they are really more or less illusory. All known systematizations, both experiential and behavioristic, are within the organism. The illusion of extrojection, the projection of inner organic systems into an unknown outside is among the most persistent illusions known to psychology.

In the first mentioned type of anticipatory reaction, emphasizing the systematization of supposedly external stimuli, the reaction may appear to be quite indeterminate, varying from individual to individual, and from time to time in the same individual, not primarily according to the form and framework of the systematized stimuli, but rather according to the repertoire of the reactor. The type is well illustrated by the so-called defense reactions emphasized by Hull, such as the reactions of the dog to the snap of a whip. In some way or other in the experience of that dog, the snapping of a whip comes to be systematically connected with a possible blow. What the reaction shall be depends on the intervening spread of neural excitation, on the habits of the individual and his personality, or his surrogate for personality. Snap and blow may be stably connected in experience, while the reactions may be indeterminate accidents as far as the stimuli are concerned. The dog may cringe, may run away or bark, or his reaction may take any other form that corresponds with his constitutional or momentary set. Similarly in humans the threat of approaching danger regularly means that in some way or another there is a system of events in the experience of the individual which gives a meaning to each threat as it occurs. The threat of disease or financial disability, the threat of personal danger, the threat of assault, are well known in the experience of most of us. Such reactions are not "conditioned" in the sense that there is a specific substitute stimulus for a primitive reaction. The stimuli are systematized into a causal or temporal flux in which the oncoming event gives meaning to each of its predecessors. Overt reactions, like reactions of the dog, depend on the personality of the individual to whom the threat is made, his repertoire and the mood in which he happens to be. If the person threatened by assault is an athlete, an amateur boxer, a weakling or a coward, the reaction probabilities will be characteristically different. But the athlete may feel especially amiable that morning, the boxer cautious, the coward expansive.

Any number of analogous systematizations of experience will occur to my scientific colleagues.

The free association test represents this variety of

reaction fairly well in the psychologic tradition. Though the stimulus series is seldom fully organized, response series is still less so. The hope and expectation of the free association test is that it will expose the various dominant systematization tendencies of the individual tested.

A somewhat better illustration is the typical trial and error random response to experimental situations of discomfort, the restless activity in confinement, writhing reactions to pain and the chaotic spread of neural responses in reaction to any strong stimulus whatsoever.

Still better are the preparatory responses to stimuli that have acquired, or are acquiring, meaning. Such are the refixations of the eyes in response to peripheral stimuli. Attractive peripheral stimuli, as in reading, commonly become attractive through some systematic connection or connections with material in the field of attention. One may look to the right in a fairly well-ordered succession of reading eye movements in response to unclear peripheral words, the gradual unfolding of meaning and grammatical construction. As has been shown experimentally every unclear, prefixationally seen word adds something measurably important to the developing apperceptive processes which becomes more important in fixation. Every eye movement under such circumstances is more or less accidental, determined less by the characteristics of the prefixational stimulus than by its relations to the partially systematized flux of inner and outer stimuli. The eye movements in rereading the same text are never twice alike. The meaning may be essentially the same.

A second type of so-called anticipatory reaction emphasizes reaction systems without much reference to the adequacy of the stimulus. Almost any stimulus will revivify the fad of the faddist. Any point in the conversation may serve to remind him of his particular interests, and his reactions are determined by his systems of thought and behavior rather than by any specific bond between stimulus and reaction. The anti-prohibitionist needs no direct or specific stimulus to launch forth on the evils of prohibition; the religionist no specific stimulus to lead him to the contemplation of the all-importance of his relations to God and to related remarks and conduct. Such reactions are personal affairs and expressions of personality. The essentially moral person may be exposed for a long time to degrading situations and preserve his moral reactions. The essentially vulgar finds in every occasion opportunity for an expression of his vulgarity. The habitual offender, in spite of the best reformatory environment, may still remain an offender in his reaction to some social situation. The reformer knows no crushing defeat; beaten to earth he rises

with renewed strength to oppose the evils against which he has devoted his energies. In all these cases, and many more, the reaction might seem to occur apparently spontaneously. Any stimulus may operate to evoke the train of neural events which represent the personality of the reactor. This type presents the probable neural schema of the classical "conditioned reflex" of the salivary glands.

In the flux of systematized behavior most reactions lead somewhere. Each anticipates the oncoming act and prepares for it. As we have elsewhere pointed out, in the stratification of behavior there are no isolated acts, whether reflex, instinctive, automatic or voluntary. There is nothing but a more or less complex behavior flux with varying component factors in varying constellations. Each beginning anticipates an end, each end is also a beginning.

Some of these ends are quite unconscious, some are conscious only as premonitions, while some are fully conscious or are represented by surrogates. The knee-jerk is really complex, however simple it appears. Operating on a basis of psychophysiological set from previous stimuli it may begin with a quick lumbar reflex in a generally useful direction which develops, by the interaction of higher neural systems, toward such complicated adjustive acts as maintaining equilibrium or eliminating obstacles according to the direction of the central elaboration of the sensory data. There is no evidence that the adjustive act is a conscious end of the jerk which begins and in a measure anticipates it.

Preparatory reactions in which there is a premonition of the end are very numerous in every-day life. Every exploration—every sentence we speak or write—every step we take in walking—every corner that we turn in driving, belongs to a reaction system which includes more or less clear premonitions of the future. When we swing out our automobile to take a sharp corner the real stimulus to the swing is in the future. The reaction is an anticipatory reaction. There is evidence that rats which have learned to run a maze do much the same. We often call such future stimuli purposes and the anticipatory behavior purposive even when the purpose is nothing more than a premonition.

Long ago I stumbled across the problem of premonitions in ordinary speech. No one as far as I know has ever given them adequate description. The plain facts are that at the beginning of a sentence one prepares for its conclusion. This was especially obvious for me in the apparently complicated constructions of the German language, but it is more or less true in all languages. The real stimuli to the next word are not given alone in the previous word or sentence but in premonitions of the future, the ending of

the current sentence, its place in the argument of the paragraph and the total discourse. Every word is at once a fulfilment of the past and an anticipation of the future.

Similar premonitions occur in the understanding of spoken and written discourse. Many if not all of us have found ourselves ready to supply the unspoken word when the speaker hesitates. Rhyme and rhythm narrow the scope and vivify the premonition. Once upon a time I studied the measurable premonition effects of a prefixational vision in reading. It has been largely neglected in studies of the reading process by overemphasis on fixation points and the span of clear vision. But any one who tries to read the text from spans of clear vision fragments as are explicitly given by Judd and Buswell will realize their inadequacy. The right-sided hemianope for whom these prefixational premonitions are lacking either can not read at all or reads very slowly and imperfectly.

Analogous premonitions probably occur in the appreciation of music and in musical composition. Music in which premonition is an obvious certainty tends to seem trivial. In extreme cases, like the reported composition ecstasy of Mozart, premonition may become unusually condensed and vivid. He reported that on occasion he heard the composition not phrase by phrase as it was to be written, but in one great burst of sound. The whole psychology of premonition deserves experimental analysis and description. It is intimately connected not only with the problem of anticipatory responses and systematized reaction in speech and reading and music, but as Hull and others have pointed out, with such concrete experimental situations as maze learning and driving an automobile. It is probably also connected with wit, mental disease and the normal conduct of life.

Not essentially different, but only different in emphasis is a third variety in which both stimuli and reactions are systematized. This is exemplified in my experiments in the development of adequate pursuit movements of the eye. The first phase of such pursuit is a period of relatively uncoordinated approximations to pursuit, with inadequate pursuit reactions of the eye and long and frequent corrections. The second phase of such pursuit in response to an oscillating object is regularly much more nearly adequate with less extensive correction than the first. From then on stimulus and reaction are so systematized that the curves of pursuit are almost smooth. Much of our everyday adjustment to events as they transpire involves an exploitation of available behavior systems, corresponding to habits, in reaction to a systematization of stimuli, corresponding to experience.

In view of what we have said concerning the rela-

tion between stimulus and reaction we may now insist that all three varieties of systematization are equally neural. It is a fallacy to think of any known systematization as being external to mind. That is a naïve and uncritical philosophical assumption. The system of physical events that we naïvely think of as the external stimuli for the neural reactions of Mr. X is our own system and the extrojected product of our neural integration. But so is the system of Mr. X's reactions. Both systems depend on the integrating capacity of the same organism, namely, ourselves.

Available techniques for the experimental investigation of neural systems are quite inadequate. Gross extirpation can never settle the question of intranuclear systematization. It deals primarily with the interplay of the various neural levels. The problem of organization at each level calls for the further refinement and extension of such methods as those used by Hess, Dusser de Barenne and the Sherrington school. I believe it also calls for new techniques.

DIFFERENTIAL THRESHOLDS

Psychology is concerned with neural systematizations as they appear in the variable patterns of experience, behavior and personality. In many instances the psychological aspects are the only available indications of the neural systems. While references from a single indicator are necessarily indeterminate, we can say at least that the neural integrations must be adequate for the psychological systems. Further—certain analogues of peripheral and intranuclear organization probably extend to intranuclear systems. We have dealt elsewhere with the possible rôle of physiological barriers to repetition. Negative adaptation, relative fatigue, summation, facilitation, reinforcement, inhibition, rivalry and competition are all old stories. Our conjectures as to the consequences of these factors are capable of experimental investigation in connection with psychological systematization and resystematization. Some progress is fresh in your minds. On this occasion we would emphasize one more factor, the determination of spread in a group of vital reactors by their casual or persistent differential threshold.

We are still woefully ignorant of most of the details of how this principle cooperates with the others, and while hypotheses that grow out of ignorance are apt to be both tedious and trivial, there are certain reasonable expectations that grow out of experimental experience. First there is a well-documented doctrine of a differential and finally limited spread of neural reactions from any focus to physically and spatially remote areas of the central neural system. One comes to expect more or less extensive spread of neural re-

action to every stimulus from inside as well as outside the organism. Second, the spread of neural reactions tends to conform to systems more or less stable and more or less variable, according to the capacities of central neural tissue for persistent integration and reintegration. As the details of some of those spreads and systems are gradually coming to be known from clinical, neurological and psychophysiological data they appear in general to be vastly more complex than might be expected from the mere observation of overt behavior. Even the simplest overt acts, like the knee jerk, the lid reflex and the eye movements, give evidence of extensive neural stimulation-reaction spreads and complex systematizations or response. In many other cases the details are entirely lacking. In such cases explanatory conjectures seem to be quite out of place in any thought that aims to be scientific. Working hypotheses on the other hand, with possibilities of experimental test, are always in order and hypotheses summarizing the available facts tend to focus the outstanding problems.

So, entirely without specific neurological hypotheses, without presuming to have new information with respect to conditions or ultimate processes, we would raise a few suggestive questions with regard to the effects of a differential threshold on neural systematization and resystematization. If we inquire how any of the various modifiers of neural behavior become effective we must again answer honestly that we do not know the details, but that the only principle that fits in with our knowledge of the general physiology of living tissue is that they are all a part of a general plan, effecting some change in irritability of living tissue. The fundamental measure and expression of that irritability is the threshold. Each implies the other. Any natural or developed agreement in neural threshold must necessarily eventuate in a kind of neural system. Any change in a differential threshold must effect change in the relevant systems.

We know some such changes in threshold. They appear in normal sleep, fatigue and normal daily rhythm, in fever, in intoxication by various drugs such as ether, chloroform and alcohol, in lack of oxygen, in the effects of accumulated by-products of bacterial invasion, secretions of the ductless glands. There can be no extensive change of thresholds in neural systems without some change in consciousness or behavior, or both. Would not a general raising of threshold give rise to some such phenomena as we know in tolerance, negative adaptation, in apathy and hypo-excitability as well as in curtailed spread. If the change in irritability is uneven or skewed, systems must result which are lacking in some of the characteristics of normal reaction. Would not a gen-

eral lowering of the threshold eventuate in such phenomena as hyperexcitability, hyperactivity and increased variability; differential lowering, in fixed ideas, anancastic behavior, stereotypy and more serious disequilibrium?

One may also ask in passing what would be the effect of a low threshold of some natural system, such as sex or fear. I remember a patient for whom every situation was terrifying. She could give no adequate reason for being afraid in the staff meeting. "The doctors might torture me," but she didn't really expect they would. Their interested and sympathetic presence, like familiar street noises and less known situations, all indiscriminately evoked fear. The case, like most others, was perplexing enough in its details of diagnosis and treatment, but the main overt symptom was clear and clearly threatened a serious neurosis. If only there was available some specific drug that acted to raise the threshold of the fear system, that particular symptom might have been controlled. Instead, one must seek to control it and its reinforcing systems by some kind of reeducation, possibly with the aid of a general depressant of irritability.

As Freud and his pupils have pointed out, hyperexcitability of a specific sex system represents one of the most common sources of mental unbalance. But, exaggerated egotism and exaggerated feeling of inferiority, suspicion of infidelity, financial worry, hypochondria or any other hyperexcitable system may do almost equally as much harm in promoting unbalance.

Would not a general lowering of the threshold of the sex system tend to a spread of excitation to those systems from all sorts of remotely related stimuli with the definite expectation of such phenomena as fetish-

ism, promiscuity, Sadism, masochism, homosexuality and other abnormal systematizations of the sex life?

I am not suggesting any general principle of explanation but merely asking what would be the tendencies of abnormal excitability of any factor. The known tendency of neural excitation to spread to remote areas of the nervous system make it doubtful if any conditioned reaction represents an entirely new nervous connection. The commoner event probably is that directions of normal spread become emphasized and dominant, according to the principles of facilitation and inhibition that have been elaborately investigated by Pavlov and his pupils. The concept of emphatic or dominant neural bonds is not new. It dates back at least to Wundt's far-sighted analysis of the probable neural systems involved in speech. Recent psychoneurological experiments and clinical experience seem to confirm the soundness of his fundamental ideas.

The so-called anticipatory reaction now appears in a different light. Each case is really a phase of the reactive flux that arises from the systematic changes in threshold of some system leading to a spread of neural action to physiological neighbors before the suppositious specific external stimulus occurs.

This may follow the "conditioned reflex" schema. It may follow the plan of a neural short-circuiting of a series of external stimuli, as in Hull's analysis, but it is not conditioned alone by the sequence of external events. It may follow the course of logical or paralogical thinking or the invention of genius. It must follow the regular or irregular spread of neural impulse in central neural tissue according to the principle of a differential threshold.

A HISTORY OF THE NATIONAL RESEARCH COUNCIL 1919-1933

IX. RESEARCH INFORMATION SERVICE¹

By Dr. C. J. WEST

DIRECTOR

THE Research Information Service, in its present organization, is a committee of the Executive Board of the National Research Council, the main functional activities of which are: cooperation with the divisions of the Council through inter-office service, and the preparation of compilations which may be used as source books of a general scientific nature. Originally conceived as a war measure, it has passed through

several forms of activity, an outline of which will present briefly the scope of its accomplishments.

The following persons, under various titles, have been responsible for the conduct of the Service since its organization in 1918:

1918 —Graham Edgar, *Executive Secretary*
1919-1924—Robert M. Yerkes, *Chairman*
1924-1925—J. David Thompson, *Director*
1925-1933—C. J. West, *Director*

¹ This is the ninth of a series of ten articles prepared to describe briefly the nature of the activities with which the National Research Council has been engaged during the past fourteen years.

In December, 1917, by joint action, the Secretaries of War and Navy, with the approval of the Council