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Aesthetic Unity and the Role of the Brain

THE UNITY of the work of art, and the way in which it may be made up out of numerous contrasting, even conflicting, details, has been a problem of perennial interest to aesthetics. Thinkers from Plotinus through Coleridge to contemporary critics of the arts have speculated on how the parts of a work relate to the whole, whether the unity or the details are the more important aspect of art, and how we perceive unity when, as in music and literature, we make contact with the details only. The whole question poses interesting psychological as well as aesthetic problems. We often discuss the form of a work of art as though it were a readily accessible entity, something concrete that we could survey at a glance. Yet this is never really the case with a novel or a piece of music, although it might appear to be nearer the truth with a painting or sculpture. Reading a novel or listening to a symphony is rather a passage of experience extended over time, the reception of a moving stream of impressions. If we feel afterwards that the form of the work, the unity of the finished piece, is something real, however little we can look at it directly, then we must possess some faculty for building up a unified picture from the mass of passing impressions.

That we must possess some such faculty is particularly clear in the case of the work of art that is new to us. If all the parts of the work ultimately combine to give us the impression of unity at the end, some unifying process must be taking place in the mind during the reception of the work, even though we have no pre-existing memory of its form to guide us. If we consider any extended work of literature, from a Shakespeare play to a novel of Henry James, or any symphonic movement from Haydn to Stravinsky, this same underlying process always appears to take place independently of whether or not we possess a previous acquaintance with the work in question. It seems likely, then, that a major part of the artist's technique must be the ability to make all the many and contrasting parts of his work accrete into a unified whole.

It might be suggested that the artist's ability lies in selecting parts that will contrast, yet balance, each other, and solutions to the formal problem of art have been suggested along these lines by such thinkers as Arnheim and Berlyne. In this case the unifying principle must be concerned with the artist's choice of material and the structuring of it in an appropriate pattern. Creating a work of art, in this view, must be analogous to fabricating a building—selecting beams and blocks of the right size and putting them together so that all the forces balance in keeping the structure erect. A different kind of principle, however, is suggested by some recent advances in our understanding of how the brain appears to function, which focusses atten-

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tion not so much on the relationship of the parts of a work of art, but on the qualities of the parts themselves — how the unity of the whole "grows" out of the various parts, since these in themselves create a sense of unity and thus project or anticipate the unity of the completed work. The analogy in this case is to the plant, whose potential form is contained in, and grows from, the seed. The purpose of this paper is to describe some of the relevant research on the brain and to show how its conclusions can contribute to a new, "organic" model of aesthetics.

One advantage of beginning in this way in neurophysiology, is the establishing of a type of brain functioning which can then be applied to all the arts; it also bypasses the difficulties of attempting to deduce a theory directly from aesthetic or quasi-aesthetic material: first, the possibility that conclusions based on the material of one art form may not be valid for a different art form, and second, the problems attendant on the sheer complexity of any genuine aesthetic stimulus. A satisfying feature of the theory proposed in this paper, is that complexity is in itself seen to form the tissue of any extended aesthetic experience, and can be interpreted in a given work of art in a fruitful way with the help of the model of brain functioning described here.

If one considers the number of words in a novel or notes in a symphony, the complexity of the problem of relating the parts to form a unified whole is evident: the question must be how we are so often able to perform this task successfully. Memory, intellect, and emotion would all seem to be implicated. What kind of brain processes are there adequate for a task of such magnitude? Intellectual functions of a kind appropriate to the aesthetic experience can now be provisionally located in the frontal cortex — that part of the brain which lies directly behind man's forehead. Recent studies of this area, particularly of the kinds of intellectual and affective disorders or deficits which show up when part or whole of the frontal cortex is missing, reveal neurophysiological processes which seem directly relevant to the aesthetic problem of unity from parts. The parallels between the aesthetic experience and the problem-solving tasks which the neurophysiologists have used to probe the nature and function of the frontal cortex, are interesting and, I believe, illuminating. The conclusions of the neurophysiologists are particularly striking in that they point to the close links between the frontal cortex and the seat of the emotions in the brain — the subcortical structures, including the hypothalamus — thus suggesting the necessity of an affective component in *all* complex problem solving. It is this affective component that confers what is called "temporal stability" on the problem solving situation, where a constant shifting of response is required, and it enables us to understand how unity can be attained amidst the many and varied responses to a complex aesthetic stimulus.

The first part of this paper will therefore survey the theories of a number of workers who have been studying the frontal cortex in the last decade, together with the kind of evidence on which they are based. This leads to the second part, in which a model of aesthetic functioning is described, based on the kind of process which neurophysiology implies.

I

The function of the frontal cortex is a question which has been disputed by psychologists and physiologists since before the beginning of the century. In theory its function was generally described as that of "association," the place where simple stimuli came together to form memory traces. This hypothesis has since found no experimental support, and the concept of association has consequently been abandoned by many workers and considerably modified by others.[1] The problem of association as a part of behavior still remains, however, and recent work, mainly on the effects of frontal lobe lesions on behavior in animals and in man, has led to the problem being defined in a new way. Nauta[2] states the current position. The frontal lobe, he says,

> appears not to contain a single sub-field that could be identified with any particular sensory

> modality, and its entire expanse must accordingly be considered association cortex. It should, perhaps, not be surprising in view of this circumstance alone that loss of frontal cortex, in primate forms in particular, leads to a complex functional deficit, the fundamental nature of which continues to elude laboratory investigators and clinicians alike. (p. 167)

It was a consistent feature of patients with frontal lobe lesions that no clearly defined deficit was identifiable. It was remarkable that even when a large part of the frontal cortex was excised, no obvious change in the abilities of the patient resulted; this may be contrasted with the effects of a lesion in, say, the speech or visual cortex, where the deficit is obvious and measurable. The relatives of patients with frontal lobotomies claimed that in some way the patient seemed different after the lesion, but psychologists were unable to detect the difference using the normal tests, such as those on IQ and memory. It was not until some more sophisticated studies on frontal lesion patients were carried out in the 1960s that it became possible to draw certain tentative conclusions about the nature of frontal lobe functioning.

In his paper, Nauta describes an experiment by Luria and others in which a patient with a frontal lobe lesion was asked to draw a sequence of four simple figures in various combinations — a cross, two circles, and a triangle. It was found that the patient may simply draw, say, four crosses.

> This "inertia" may declare itself dramatically when the patient is asked to perform a task requiring an orderly sequence of separate steps. In such cases, he may perseverate an early phase of the action, but it is important to note that he may, instead, be sidetracked in a direction that could have been appropriate in the context of another task. (p. 170)

This behavior was described as "a deficit in matching of action carried out with the original intention . . .," and it was seen "as a central characteristic of the frontal-lobe syndrome." Even when the patient was able to verbalize the steps required by the experimenter, this had practically no effect on the patient's subsequent actions.

Milner[3] reports a similar phenomenon in patients put through the Wisconsin Card Sorting Test in which the task is to sort cards showing simple patterns according to changing criteria. Patients tended to "perseverate" a previous course of action after it ceased to be appropriate; again, verbalization of the correct requirement was of little avail. Patients tested on the stylus maze also exhibited perseveration and, significantly, seemed to have lost a measure of internal restraint following the lesion and were often unable to restrain themselves from rushing straight towards the goal in defiance of the "rules" of the test. Milner's formulation of the meaning of this behavior is extremely interesting and worth giving in full:

> In man, frontal lobe lesions are compatible with normal performance on many intellectual tasks. Nevertheless, it is possible to demonstrate a deficit after frontal lobectomy in situations that require a constant shifting of response to meet changing environmental demands. Under such conditions, the patient with a frontal lobe lesion seems unable to suppress his ongoing response tendencies, whether spontaneous or experimentally induced, or to rid himself of perseverative interference from previous sensory events . . . (p. 331)

> Normal behaviour is dependent on the simultaneous functioning of many complex sets, any one of which can take over the action system when the appropriate signals, verbal or other, arise. The effects of frontal lobe injury described . . . suggest a disturbance of this modulatory function, which may explain the coexistence of inadequate social behaviour and good achievement on many standard intelligence tests. (p. 331)

This inability to meet situations that "require a constant shifting of response" and the lack of "the simultaneous functioning of many complex sets," appears to agree well with the behavior of a patient who, having a paranatal bilateral frontal lobe defect, was observed over a period of thirty years.[4] This patient's behavior is described as "Stereotyped, lacking in novelty, imagination, initiative, follow-through."

A more complex hypothesis seeking to explain the neurological mechanisms behind perseverative and non-perseverative behavior is offered by Pribram, *et al.*[5] In this report a computer model, constructed to simulate human problem-solving, is described. The computer mechanism comprised a normal memory bank of separate items and "a hierarchically organized computer program composed of lists of items, each item capable of referring to another list." In the third type of problem simulated by the computer, the instruction is for the computer to search the different sections of the memory bank for a match to the successive sections of a problem presented in the program. But part of the instruction states:

> Shuffle, the *order* in which these items are to be tried in such a way that the instruction that has proved repeatedly successful is tried first, i.e., is placed first on the list." This is accomplished by temporarily storing the information about the outcome of previous searches . . . (p. 48)

This temporary storage must become a part of the actual instruction program and "must not take place in the computer's memory where it would do little good . . ." We are thus dealing with a special kind of short-term memory:

> These temporary instruction programs are called noticing orders; those that shift the order of the items on their lists on the basis of the outcomes of previous searches through their memories are known as flexible noticing orders. Noticing orders and the current problem program are kept separate from the computer's main storage facility in a "working" or temporary memory that is at all times accessible to the programmer and computer. (p. 48)

The loss of this "flexible noticing order" with frontal lobe lesion, takes place in the same kind of experimental situations with monkeys as those demanding a "constant shifting of response" in Milner's human subjects. The problems which Pribram, *et al.* found would show up the deficit in the monkeys with frontal lesions; all had in common

> the factor of change, not in the stimuli per se, but in the way in which the already experienced stimuli (e.g., cues and reinforcements) are compounded to form the new problem. The organism must react to those changes much as the computer program: it must reshuffle the order in which the stimuli are processed . . . (p. 49)

When a monkey with a frontal lesion comes up against such a problem, his behavior is observed to break down either into randomness or to exhibit perseveration.

> The suggestion is . . . that the frontally lesioned primate is defective in problem solving whenever a process that corresponds to a flexible noticing order is demanded. (p. 51)

The question thus centers on the mechanism of a shifting short-term memory during such problem-solving. How might this work in neurological terms? Milner, as we have seen, has postulated the existence of a "simultaneous functioning of many complex sets," a concept which would also seem to indicate the need for such a short-term memory during problem-solving. Pribram, *et al.* suggest their own hypothesis in terms which make apparent their shift away from the old association view of the frontal cortex:

> Earlier notions of the immediate memory process led to hypotheses about memory trace formation and decay, and to experiments aimed at uncovering reverberatory circuits in the brain. The concept of a flexible noticing order process within a working memory leads to tracking down the mechanism of temporary, flexible stimulus compounding, perhaps through the formation of readily shifted dominant neural foci. (p. 51)

Such "dominant foci" have apparently been located in other brain areas: an example of a focus in the motor cortex of the dog is mentioned, which proved amenable to "shifting" by Pavlovian conditioning. The difficulty inherent in "tracking down" such foci in the frontal cortex will be obvious. A neural event which is as temporary as the notion of dominant foci suggests, may (somewhat like Heisenberg's atoms) prove to be unmeasurable. This is not to dismiss the hypothesis: as I shall show, a concept of shifting dominant foci is of considerable value in helping to construct a neurophysiological theory of aesthetic behavior.

If direct evidence of the existence of dominant foci in the frontal cortex is unlikely to be obtained, what other evidence points to the possibility of their existence or of a similar mechanism? A paper by Teuber[6] proposes a somewhat different answer to the problem of the complex deficit produced by frontal lesion, which nevertheless suggests the existence of a mechanism similar to dominant foci.

When the eyeball is moved passively by, say, pressing a finger against the side, the world appears to move. In normal voluntary movement of the eye, however, the visual field remains still. Teuber suggests that in the voluntary movement a discharge from the motor to the sensory structure must be taking place which prepares the latter for the impending movement. When the eyeball is moved passively no discharge from the motor structure is being made. Teuber calls this the "corollary discharge," and maintains that its production is an important function of the frontal lobe. The inability of frontal lobe lesion patients to solve complex problems where a shifting response is demanded is, it is suggested, due to the loss of this "corollary discharge."

> . . . every "voluntary" movement has two neural correlates: a stream of impulses to the effectors and a simultaneous "corollary discharge" to central receptor structures, presetting the latter for those predictable changes of input that will be consequences of the particular motor output. (p. 439)

This indicates the possible importance of

> a more general form of sensorimotor coordination which may depend on the integrity of frontal structures and portions of the basal ganglia. (p. 439)

The old analysis of cortical function in terms of stimulus and response is therefore inadequate. "It is not in the reaction to incoming stimuli, but in the prediction of them, the presetting of them, that the significance of the frontal structures lies." In a given complex problem, a subject has to anticipate the likely course of events and also to be able to evaluate his own role in bringing those events about. It is in subjects with frontal lobe lesions that we often find

> an uncoupling of these two aspects. The patient is not altogether devoid of capacity to anticipate a course of events, but cannot picture himself in relation to those events as a potential agent. (p. 440)

The point to remember, then, is that corollary discharge flows to sensory receptors: its function is to preset them for impending changes: it is, as it were, predictive.

In his paper, Nauta, who points to the evidence for a close relationship between the frontal cortex and various subcortical structures (the "fronto-limbic" relationship), suggests an important extension of the corollary discharge hypothesis. The extensive connections of the frontal cortex with other parts of the brain, he says, "deserves particular emphasis, for it entails a need to view the frontal lobe at once as a "sensory" and as an "effector" mechanism." He urges that the frontal lobe syndrome is both a perceptual and an *affective* deficit. We have already seen, in the formulations of Milner and Pribram, *et al.* how the syndrome may be viewed as a perceptual deficit, i.e., one in which the patient is unable to make certain shifting evaluative responses. Teuber has indicated the degree of anticipation which may form part of this missing response, postulated by the hypothesis of corollary discharge with its predictive element. With his view of the frontal cortex as a senso-effector mechanism, Nauta is already able to speculate

> that the reciprocal fronto-limbic relationship could be centrally involved in the phenomenon of *behavioural anticipation*, and elucidate the "loss of foresight" that has so long been recognized as one of the most disabling consequences of massive frontal-lobe lesions. The normal individual decides upon a particular course of action by a thought process in which a larger or smaller number of strategic alternatives are compared. It could be suggested . . . that the comparison in the final analysis is one between the affective responses evoked by each of the various alternatives. The strategy ultimately elected would thus be one that has already passed censure by an interoceptive sensorium. (p. 183)

This introduces the important notion of the role affective criteria may play in making perceptual judgments on differing plans of action.

Nauta then suggests an extension of Teuber's corollary discharge notion to explain "the phenomenon of *temporal stability* in behavioral programs." Corollary discharge, as we have seen, postulates an effector function of the frontal lobe in presetting sensory mechanisms. But, says Nauta,

> it would seem possible to envisage a pre-setting not only of exteroceptive processing mechanisms, but also of those mechanisms dealing with interoceptive information. Such a pre-setting could be thought to establish a temporal sequence of affective reference points serving as "navigational markers" and providing, by their sequential order, at once the general course and the temporal stability of complex goal-directed forms of behaviour. (p. 183)

Corollary discharge, then, could be postulated as setting up not only the sensorimotor mechanisms consequent upon successful perceptual anticipation of events, but also a matching series of "affective reference points." This means that in maintaining any strategy for dealing with a complex sequence of behavior, not only must we perceive what anticipated events will be and how our motor functions will operate in bringing those events about, but the expected affective nature of those events must also be perceived, and both kinds of expected reaction must be temporarily kept on hand as a series of guiding reference points during the execution of the behavior. Nauta concludes that

> a plan for action cannot be kept in abeyance intact for any length of time unless it is represented in matching somatic and affective registries. If this were indeed the case, it would be readily understandable that loss of the frontal cortex as a major mediator of information exchange between the cerebral cortex and the limbic system is followed not only by an impairment of strategic choice-making, but also by a tendency of projected or current action programs to "fade out" or become over-ridden by interfering influences . . . it could even be suggested that the "frontal" animal has suffered a memory impairment after all, even though this loss affects the storage of its action plans rather than that of its external-perceptual images. (p. 184)

The essence of Nauta's hypothesis is the storage of a strategy for projected behavior. The parallels between his "somatic and affective registries" and the "dominant foci" of Pribram, *et al.* are striking. Both hypotheses are founded in numerous experimental observations of monkeys and human beings suffering from frontal lobe lesions during the presentation of complex problems; both, in an attempt to explain the behavioral deficit observed, arrive by different means at broadly similar conclusions. The dominant foci hypothesis proposes a purely intellectual mode of strategy; Nauta's hypothesis proposes in addition an affective element in strategy, and this is of great importance to our question of aesthetics.

Before discussing the implications of these hypotheses for the aesthetic experience, I should mention two attempts which have been made to formulate a neural model of cortical functioning, which have some points worth comparing with these hypotheses.

Lashley[7] in a paper on the "problem of cerebral organisation in vision," has suggested an interference pattern type mechanism, after the discovery of "a system of cross connections in the cortex which will permit the spread of excitation in any direction along the surface." It is possible to envisage two or more stimuli impinging on the frontal cortex setting up a series of waves, which will produce a number of polarization points across the surface; these might be compared with Nauta's reference points or the dominant foci. It suggests one mechanism by which the corollary discharge might set up a series of reference points, and one might speculate that the affective element of the reference point which Nauta has postulated might, in certain circumstances, give it a degree of stability causing it to persist after the original stimulus with its corresponding wave pattern, had ceased. It should be emphasized, however, that the evidence of cortical functioning is somewhat conflicting and does not necessarily support Lashley's view; the hypothesis offered here is thus entirely speculative.

Pribram[8] has himself offered a model of neural functioning which takes as its basis the photographic hologram. His model is something of a refinement of the interference pattern type theory, and I offer the following excerpt from his exposition without comment.

> The properties of the hologram are just those demanded by us to account for ordinary perception. I have already made the suggestion that arrival patterns in the brain constitute wave fronts which by virtue of interference effects can serve as instantaneous analogue cross correlators to produce a variety of moiré-type figures. Now, by means of some recording process analogous to that by which holograms are produced, a storage mechanism derived from such arrival patterns and interference effects can be envisioned. (p. 255–6)

I give these examples advisedly. I think they underline the fact that, even if we accept as a working hypothesis the notion of dominant foci or somatic and affective registries, the problem of explaining exactly what neural mechanisms could be involved in setting them up is still invested with immense difficulties. The extension of Teuber's corollary discharge notion offered by Nauta is purely hypothetical and does not in itself explain anything about the actual neural mechanisms involved.

II

I now propose to show, nevertheless, how the concepts of corollary discharge and of the kind of reference points postulated for a strategy of problem-solving, can be used to explain a number of the features of the aesthetic experience. At the risk of sounding repetitious, I will emphasize that the points to be borne in mind are that corollary discharge is essentially a presetting mechanism, a vehicle for expectations or prediction of events, and that the reference points it establishes to match against the course of anticipated events concern both somatic functions and, most important in the present discussion, affective functions.

In an experiment on eye movements, Khomskaya[9] found that the frontal cortex was most concerned with voluntary eye movements, in contrast to the occipital visual cortex, which was more concerned with reflex eye movements. In a study of voluntary horizontal eye movements, patients with frontal cortex lesions exhibited asymmetry, slowness, and irregularity in comparison with normals. This result provides an interesting analogy to the deficit in complex problem-solving behavior reported by Milner and others. It suggests that Khomskaya's patients were deficient in the somatic reference points postulated by Nauta. Of even greater interest, however, is an experiment on eye movements in "frontal" patients by Luria[10] where the stimulus object was aesthetic, i.e., a painting. In the eye movements of normal subjects exposed to a painting for several minutes, the eyes tend to fix most often on significant points in the picture, such as the eyes in a face, to trace important outlines, and, as might be expected, to make few forays into unimportant areas. The eye movements of "frontal" patients, however, showed little discrimination and wandered haphazardly over various sections of the painting, treating significant and insignificant features alike. What does this mean in terms of the frontal cortex mechanisms proposed?

Firstly, the aesthetic stimulus is attractive partly or wholly on account of its affective qualities. We may suggest that a normal spectator of a painting, on first being exposed to it, takes in the general outlines of the painting in a few quick sweeps of the eyes and discovers the principal points of significance more or less at once. If his interest is aroused a certain strategy for subsequent viewing of the painting becomes formulated at the same time. A series of corollary discharges takes place with each preliminary sweep of the eye. Some parts of the painting are more attractive than others: these parts, which elicit an affective response, set up equivalent affective and somatic reference points by means of the corollary discharges taking place. It is these reference points which comprise a strategy for viewing the painting. The affective reference points may arise from the significant features of the painting, such as the eyes of a face, or an area of indistinctness which at first has an intriguing effect, or a pleasing pattern of light and shade, or any kind of special feature which produces an affect on the first exposure of the painting. It is clear that unimportant areas of the picture will have no affective response and will therefore form no part of the strategy of reference points. In the subsequent viewing, then, the somatic reference points determine the course of the voluntary eye movements, while the affective reference points form a kind of prediction about what will be found pleasing. It is easy to see why patients with frontal lesions lacking the somatic and affective registries, and hence a strategy for viewing, would exhibit the haphazard voluntary eye movements that were reported.

A further attribute of the frontal lobe which can be deduced from some of its known afferent connections, is the ability to perceive both detail and the larger structure which contains the detail in the same instant. Nauta reports that

> whereas virtually no fibers to the frontal cortex appear to originate in the primary sensory fields, some can be traced from the immediately adjoining field (such as area 18 of the visual cortex) and a considerably larger number from the field "next in line" (e.g. area 19 of the visual cortex). It thus appears that the association of each of these three sensory systems (visual, auditory and somatic), although largely organized so as to involve a lineal sequence of intermediate cortical processing stations, includes some additional conduction lines originating in parallel from such intercalated way-stations. (p. 176)

This would seem to indicate that in any given instant of perception the main body of stimuli arriving at the frontal cortex are concerned with a reading of general form and outline, but that at the same time a smaller body of stimuli is providing a reading of particular items of detail. What this may mean in terms of different kinds of corollary discharge during the preliminary viewing of a painting may be envisaged; broadly speaking, there will be two kinds of reference point set up: one class concerned with form, the other with detail. In order to examine what this implies in terms of generating conflict, tension, and resolution, I propose to turn to another kind of aesthetic stimulus, music. Here the apprehension of successive items of stimuli is in a fixed order unlike the painting in which eye movement, and hence the order of presentation of stimuli, partakes more of a voluntary nature.

French has described the experiments which have led to the definition of association in a new way. He concludes that

> A growing body of data now leads to the conclusion that the dorsolateral anterior frontal cortex of primates may normally have a behavioural role that can be most felicitiously descibed in the language of association.[11]

In my discussion of the frontal cortex mechanisms involved in the viewing of a painting, it was not immediately obvious that association would be a problem. In trying to explain music in neurophysiological terms there is no escaping it.

In the presentation for the first time of a particular musical stimulus — say, a movement of a symphony — the various detailed items of stimuli are presented sequentially in a fixed order. There is no way in which the listener can "see" the form of the complete movement at the same time so that the items of detail can be fitted into place, as was possible for the viewer of a painting. Any perception of the movement's overall form which he may have acquired by the end of the movement will have been built up, as it were, brick by brick out of the individual items of detail. This is clearly a problem of association.

The problem presents itself at its most pristine in the case of a first hearing of the music. It is evident that a listener who is hearing the music for a second or third time will already possess some image of the form to help him place the details of what he is hearing in perspective. It is irrefutable, however, that one's perceptions at the first hearing of a piece of music very often make excellent sense. An explanation of why this should be in terms of affective reference points, solves not only the association problem but also shows how a piece of music is able to generate conflict, tension, pleasure, and resolution, and, in short, hold our interest.

As we listen to a piece of music its overall pattern invariably falls into a sequence of innumerable sub-patterns. In a large amount of Western music this will be apparent in the way music divides itself up into four and eight bar phrases. These are not the only kinds of sub-patterns however: others may consist of three or four chords which stand out by virtue of their loudness or softness, a particular patch of atmospheric coloring, a significant phrase of a few notes (such as the motto-phrase which opens and dominates the first movement of Beethoven's Fifth Symphony), or even a single note (a famous example being the obtrusive C-sharp in the finale of the Eighth Symphony). From the first bar of a movement which a listener is hearing, a stream of corollary discharges may be assumed to be taking place continually. Each of the many different sub-patterns will set up its own corollary discharge and result in the setting up of an affective reference point. But the essence of such reference points, as we have seen, is that they are predictive. In complex, problem-solving behavior, Nauta has postulated that the "navigational markers" of such reference points provide "at once the general course and the temporal stability" of the organism's response throughout the behavior. It would not, I suggest, be an inappropriate extension of this hypothesis to suggest that the same predictions about the general course of the musical stimulus which is being presented, are provided by a series of affective reference points. When it is remembered that each sub-pattern is setting up its own predictive reference point, the potential of this system for generating conflict and tension will be apparent, since it may be postulated that each such predictive reference point will to a greater or lesser extent differ in its prediction from all the others. This system, unlike the behavioral sequence of reference points, will thus create a degree of instability, so generating conflict, tension, and interest.

In the first place then, in the situation I have envisaged of a listener hearing a piece of music new to him, the opening sub-patterns will be setting up differing predictions as to the future content and course of the movement. These predictions need not be apparent to the consciousness of the listener — most likely they will not, in the same way that the frontally intact subjects dealing with a complex problem do not have to visualize the whole strategy at once in order to solve a particular step in the problem; but they provide a number of affective reference points against which the subsequent patterns of the music will be matched as they materialize. A level of tension will be set up both between the various reference points and according to how far subsequent patterns exploit or resolve the expectations which reside in the affective registries.

This neural mechanism explains one aspect of the association problem: incoming stimuli are matched with a range of various predictions about what the pattern of those stimuli are expected to be. At the same time, music is flowing past; a particular sub-pattern is an incoming, current stimulus for only a few moments, then it is completed and falls into the past, to take its place with all the other sub-patterns which have already been presented up to that point since the music began. This series of completed sub-patterns which are now lying in the past can be seen to be fulfilling three related functions. Firstly, each past sub-pattern is now available to be matched against each comparable future sub-pattern as it materializes; secondly, the whole series becomes a kind of functioning sub-pattern in its own right, making its own corollary discharge and setting up its own predictive affective reference point; and thirdly, this new sub-pattern with its own reference point will be existing in competition, as it were, with predictive reference points already present, creating new sources of tension and also, it may be assumed, modifying those reference points.

Once a piece of music has got underway, therefore, current, incoming sub-patterns will be matched both with predictions about what is expected to happen in the movement, and retrospectively with what has already taken place. This will give rise to a sense of perspective in the listener; again, the potential of this neural system for generating conflict, tension, and resolution must be apparent. In the mobile, kinetic situation of constantly varying sub-patterns, it is clear that the registry of affective reference points will not be static: a continual process of association, modification, mutation, and creation will be taking place. Most important, the sub-pattern of past stimuli will be constantly growing in size and dominance until by the end of the movement it has built up into the pattern of the whole movement, so that the skill of the composer lies in his ability to resolve the tensions and conflicts, and satisfy the expectations that he has set up. Good form, in the final overall pattern, consists of no more or less than this.

In this analysis I have worked with the assumption that all the expectations will arise out of the piece of music itself. This may often be the case. In much classical Western music, however, listeners would often bring certain more or less rudimentary expectations with them into the concert hall, and it is clear that these may have had a guiding effect on the setting up of the affective registry. Most first movements in symphonies and sonatas written throughout much of the eighteenth and nineteenth centuries, for example, were cast in sonata form. A listener would therefore expect to hear an exposition, containing contrasting first and second subjects, a middle or development section, a recapitulation repeating the first and second subjects, and a coda. The composer might conform to the rules of this plan or he might use his listeners' expectations that he will conform to it, to generate new sources of tension and interest. He might, for example, use the same material for the second subject as he used for the first, as Haydn often did in his later symphonies; he might telescope the sequence of events in the recapitulation, or extend the coda unexpectedly into a second episode of development, as Beethoven does in the Third and Ninth Symphonies.

It is possible to envisage how this neurophysiological analysis could be extended to all types of complex aesthetic stimuli — painting, literature, and poetry, since all depend to some degree on setting up expectations and patterns of tension and resolution. A word, finally, needs to be said in explanation of why aesthetic stimuli may be repeatedly presented without eliciting a dulling of the response, or, to use the correct term, habituation. Why is it possible to continue listening to, say, the same Beethoven symphony on numerous separate occasions, without becoming bored by it? The answer lies in the complexity of the stimulus and of the consequent affective registries set up. It may be assumed that each time the work is repeated, even if it is the same performance on a gramophone record, subtly different reactions to many of the sub-patterns will be elicited in contrast to previous occasions, partly due to the complexity of the sub-patterns themselves, but also to the different light in which they may be seen due to the listener's knowledge of the overall form. This will lead to the creation of subtly differing affective registries on each presentation of the stimulus. This is corroborated by the introspective comments of people who may know a work well, but say they still continue "to see new things in it."

III

It will be noticed that my analysis of frontal cortex functioning deals with the patterns and sub-patterns of form. As I have explained, a sub-pattern may consist of a very small piece of material indeed, even on occasion a single note of music. I have tried to show how, neurally speaking, such sub-patterns come to be related to each other and to the overall structure of a piece of music. What my analysis does not explain is why certain sub-patterns evoke an affective response apart from the affective significance of their structural relationships. Why is a certain melody, say, pleasing in itself? There are many melodies lying in symphonic structures which one could point to, which are perfectly satisfying and affect-eliciting entities when extracted from their context. The model offered above does not suggest any answer to this problem, unless it is possible that all such melodies in absolute (non-programmatic) music could ultimately be explained in terms of their form. I raise the point simply in order to draw attention to the limitations of the aesthetic model offered in this paper.

Other parts of the brain are obviously implicated in the aesthetic experience besides the frontal cortex. The mid-brain hypothalamic region has already been mentioned as providing the affective component. The reticular system probably modulates the level of arousal and the degree of attention to the aesthetic stimulus. There is undoubtedly also a large memory element involved, since we bring a range of pre-expectations to bear on any aesthetic object which may radically modulate or affect our reception of it; no one brain structure has so far been identified with memory, although there is a degree of experimental evidence for siting it in the temporal lobe. Most of the trans- and subcortical connections that would be required between all these different parts of the brain to enable it to act as a unity are already known to exist, although their precise functioning in this respect during aesthetic behavior has yet to be demonstrated.

It would be to claim too much for neurophysiology that by its aid we are now ready to arbitrate on certain critical questions concerning art. While one is undoubtedly justified in postulating a neurological event at the root of each and every experience — and this applies to aesthetic experience as much as to any other category of experience — whether such an event can be discovered or measured and, if so, what it means, is another matter. That the faith of the physiologist hoping to discover something about art has at times led to excesses has been noted by the critics Wimsatt and Beardsley. "The most resolute researches" of physiologists, they remark caustically,

> have led them into the dreary and antiseptic laboratory, to testing with Fechner the effects of triangles and rectangles, to inquiring what kinds of colors are suggested by a line of Keats, or to measuring the motor discharges attendant upon reading it.[12]

The neurophysiological theory offered here cannot be used to decide between the values of two different works of art, or why one produces one effect and one another. Such questions are better decided by the normal tools of the art critic. The kind of aesthetic analysis which follows from the theory, dealing with matters such as form, balance, prediction, and surprise, is perhaps a commonplace to art criticism; the recent findings of neurophysiologists however do suggest — one puts it no stronger than that — why a certain class of art may "work" better than another.

[1] See G. M. French, "The Frontal Lobes and Association," in *The Frontal Granular Cortex and Behaviour*, eds. J. M. Warren and K. Akert (Hightstown, N. J., 1964), pp. 56–72.

[2] W. J. H. Nauta, "The problem of the frontal lobe: a reinterpretation." *J. Psychiatric Res.* 8 (1971), 167–187.

[3] B. Milner, "Some Effects of Frontal Lobectomy in Man," in *The Frontal Granular Cortex and Behaviour*, pp. 313–331.

[4] S. S. Ackerly, "A Case of Paranatal Bilateral Frontal Lobe Defect Observed for Thirty Years," in *The Frontal Granular Cortex and Behaviour*, pp. 192–215.

[5] K. H. Pribram, A. Ahumada, J. Hartog, L. Ross, "A Progress Report on the Neurological Processes Disturbed by Frontal Lesions in Primates," in *The Frontal Granular Cortex and Behaviour*, pp. 28–52.

[6] H. -L. Teuber, "The Riddle of Frontal Lobe Function in Man," in *The Frontal Granular Cortex and Behaviour*, pp. 410–441.

[7] K. S. Lashley, "The problem of cerebral organisation in vision," in *Brain and Behaviour* 2., ed. K. H. Pribram (Baltimore, 1969), pp. 235–251.

[8] K. H. Pribram, "Some dimensions of remembering; steps toward a neuropsychological model of memory," in *Brain and Behaviour* 2., 252–258.

[9] E. D. Khomskaya, "O Korkovoĭ regulyatsii dvizheniĭ hlaz" (On the cortical regulation of eye movements) *Voprosy Psikhologii 3* (1963), 64–72.

[10] A. R. Luria, *The Working Brain* (Baltimore, 1973), p. 216.

[11] French, p. 57.

[12] W. K. Wimsatt, *The Verbal Icon* (London, 1970), p. 31.