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ABSTRACT

This paper presents a coherent account of affect based on the functional properties of the nervous system. The paper begins with a brief discussion of the nature of a structural theory and contrasts it with a functional view. Then the functional view is discussed in more detail. The following two assumptions of the functional view are described: emotions are created by the simultaneous activity of various components of the neuronal system and emotional structures persist only as long as the underlying neuronal elements remain in a state of functioning. Next, the paper demonstrates that traditional psychological research on affective variables is more consistent with a functional theory of affect as opposed to a structural theory. Finally, some of the empirical implications of the functional view are discussed in terms of the study of affective functioning. (RL)

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Technical Report No. 222

AFFECT: A FUNCTIONAL PERSPECTIVE

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Affect: A Functional Perspective

During the last four decades, dominant theories of comprehension and cognition--information processing theories, stimulus-response theories, and schema theories--have ignored affect. In a recent article, Zajonc (1980) points out:

> Contemporary cognitive psychology simply ignores affect. The words affect, attitude, feeling, and sentiment do not appear in the indexes of any of the major works on cognition (Anderson, 1976; Anderson & Bower, 1973; Bobrow & Collins, 1975; Crowder, 1976; Kintsch, 1974; Lachman, Lachman, & Butterfield, 1979; Norman & Rumelhart, 1975; Schank & Abelson, 1977; Tulving & Donaldson, 1972). Nor do these concepts appear in Neisser's (1967) original work that gave rise to the cognitive revolution in experimental psychology. And in the six volumes and the 2,133 pages of the Handbook of Learning and Cognitive Processes (Estes, 1975-1978), there is only one entry for affect and only one for attitude. It is worth noting that both of these entries are in Volume 3 in a contribution written by a social psychologist. In the last three volumes--those principally devoted to cognition--there are no references to affect whatsoever. (p. 152, Footnote 3)

This lack of attention to affective functioning is puzzling in view of the fact that several prominent authors have emphasized the indispensable role of affect and have studied it extensively (e.g., Bartlett, 1932; Berlyne, 1960, 1973; Festinger, 1957; Hebb, 1955; Olds, 1973; Schachter & Singer, 1962; Wundt, 1907). What is even more puzzling is that authors, from time to time, acknowledge the significance of affect but continue to devote little attention to it. For instance, Ginsburg and Opper (1969) write:

> Piaget recognizes that emotions influence thought, and . . . he repeatedly states that no act of intelligence is complete without emotions. . . . Nevertheless, Piaget's empirical investigations and detailed theories substantially ignore the emotions in favor of the structure of the intellect. (p. 5).

How can this paradox between what is preached and what is practiced be explained? There is one explanation, which may very well be the only major reason: Structural cognitive theories are not optimally equipped to deal with affect. This supposition is consistent with the fact that structural theories that study affect (e.g., Bower, 1981; de Rivera; 1977, Lehnert, Note 1) have primarily ignored the traditional research on affective functioning. What seems to be missing is a theoretical framework that is able to provide a basis for identifying and integrating important affective variables and for specifying the relation between affect and cognition in a parsimonious fashion. In an attempt to solve this problem, we have developed a coherent theory emphasizing the functional properties of the neuronal system. The principle aspects of structural models and their constituent conceptual metaphors have been discussed by Bransford, McCarrell, Franks, and Nitsch (1977), Iran-Nejad (1980), Jenkins (1977), and Iran-Nejad and Ortony (Note 2).

Iran-Nejad and Ortony also discuss how a functional theory differs from a structural approach. Other theories similar in spirit to the present functional approach are those developed by John (1967, 1972) and by Katchalsky and his associates (e.g., Katchalsky, Rowland, & Blumenthal, 1974).

This paper will first present a brief discussion of what a structural theory is like and will contrast it with a functional view. Then the functional view will be discussed in more detail. Next, we will demonstrate that traditional psychological research on affective variables, such as that of Berlyne (1960), Festinger (1957), and Schachter (e.g., Schachter & Singer, 1962), is more consistent with a functional, as opposed to a structural, theory of affect. Finally, we will discuss some of the empirical implications of the functional view for the study of affective functioning. We will discuss the functional view only insofar as it relates directly to the phenomenon of affect. The reader interested in other aspects of the functional theory, such as remembering, comprehension, and learning, is referred to the sources cited above.

The Structural Approach to Affect and Emotion

As an example of a structural theory, consider first de Rivera's (1977) theory of emotion. While de Rivera describes his views in terms of Piaget's Structuralism, his theory is also reminiscent of another slightly different structural approach, namely, the semantic network theories of long-term memory. In a network model, there is an abstract multidimensional space or network encompassing the entire spectrum of psychological patterning. According to de Rivera, affective structures (emotions) belong in such a psychological space. Each emotion is a schema in the Piagetian sense: a self-regulated, holistic system of transformations. In such a network, "each different emotion has a place in an overall structure of which it is a part" (de-Rivera, 1977, p. 36). The relative location of different emotions determines the extent of their psychological closeness.

Transformations are movements along dimensions of psychological space. Each type of emotion (e.g., anger, love) reflects different transformations. These transformations are not changes along intrinsic organismic dimensions, such as changes in the activity of the sympathetic nervous system (e.g., changes in heartrate); rather, they are internal representations (images) of overt or covert changes involved in the way the organism, as a whole, interacts with the environment (e.g., "digging a hole," "moving away from or toward others," etc.). They are internalized Piagetian action sequences. Finally, "the basic unit of emotional analysis is the dyad (the person and the other) rather than the individual" (p. 37).

The emotion of anger, for instance, involves the transformation of the "person" moving the "other" away from the "self." Fear differs from anger since it involves "the person moving away from the other." Similarly, love is "movement of person toward the other," and desire is the "person moving the other toward him." These transformations are manifested in our bodily movements. Love is a "giving" emotion (+ extension) and desire is a "getting" emotion (+ contraction). Anger does not involve extension (- extension) and fear does not manifest contraction (- contraction).

Like de Rivera's theory, the majority of structural theories of affect and emotion (e.g., Bower, 1981; Plutchik, 1962) are network models. Semantic network models were originally postulated to represent the meaning of words in the long-term memory (e.g., Anderson & Bower, 1973; Collins & Quillian, 1969). The most direct application of these models to the problem of affect was made in a recent paper by Bower (1981), who extended the network model to explain the state-dependent aspect of emotion. According to Bower, "each distinct emotion such as joy, depression, or fear has a specific node or unit in memory that collects together many other aspects of the emotion that are connected to it by associative pointers" (p. 135). Other structuralists, while not denying that structures have nodes or elements, emphasize that "the elements of a structure are subordinated to [structural] laws . . . not reducible to cumulative one-by-one association of its elements" (Piaget, 1968/1970, p. 7).

In spite of their differences, all structural models seem to share at least two global attributes. First, they are all <u>intralevel theories</u> (see Wimsatt, 1976): They assume that the holistic structures and their constituent elements are both mental in nature. Thus, they do not take into account the functional properties of the biological hardware; mental structures are characterized in terms of mental elements. Secondly, they assume that psychological permanence is an inherent property of mental structures and their organization. It is taken for granted that there exist long-term mental structures and relations. By contrast, the functional view is an <u>interlevel approach</u>. It assumes that at the mental level there are only unanalyzable wholes and no elements.[1] Elements, on the other hand, exist at the neuronal level; and it is the group functioning of these neuronal elements that results in the creation of holistic mental structures. Furthermore, the functional view assumes that mental structures are inherently transient; and psychological permanence is a reflection of the consistent and stable functional properties of neuronal elements.

Intralevel versus Interlevel Reductionism

While structural theories acknowledge that the mind is unanalyzable, they, nonetheless, proceed to dichotomize and dissect it. It is often claimed that mental structures possess characteristics that are unique to these holistic patterns. Consequently, any elemental analysis of the structures will destroy their properties. But since the notion of elements within a structure is unavoidable, the schema is defined as a collection of <u>mental</u> elements and <u>mental</u> relations (associations, rules--e.g., multiplication rules, and so on). Since a structure is a whole with "overall properties distinct from the properties of its elements," one must adopt "from the start a relational perspective, according to which it is relations among elements that count" (Piaget, 1968/1970, p. 79). Integers, for instance, have structural properties "which are quite different from the properties of number individuals" (Piaget, 1968/1970, p. 7); 35 is a nonprime number, while both 3 and 5, on the one hand, and 7 and 5, on the other, are prime.

What Piaget (1968/1970) argues against is intralevel reductionism, i.e., reductionism <u>within</u> the mental domain. "But there are at least two functionally distinct kinds of reduction which are so different in their functions . . . that one is led to doubt not only the unitary model of reduction but also the primacy of structure over function in its characterization" (Wimsatt, 1976, pp. 214-215). Wimsatt argued that the problems traditionally associated with reductionism are only applicable so long as one takes an intralevel approach. The alternative to an intralevel approach is an interlevel approach that attempts to specify the interface between the mind and the functional properties of the nervous system. Intralevel theorists often specify causal links directly between mental and behavioral states. For instance, Lehnert's (Note 1) process model is characterized in terms of affect maps that consist of affective units and links between them. These links are assumed to signify causalities of affect within and across characters. The interlevel approach, on the other hand, assumes that causal interaction cannot be specified strictly within the mental or behavioral domain without reference to the functional properties of the biological hardware. Rather, mental structures exert their causal influence on the functioning of neuronal elements, and the functioning of neuronal constellations, in turn, results in the creation of mental structures (see Dewan, 1976; Katchalsky, Rowland, & Blumenthal, 1974; Maturana, 1978; Sperry, 1976; Wimsatt, 1976). According to Katchalsky and his associates, the mystery in the old aphorism that "the qualitative whole is more than the quantitative sum of its parts" is in the word more. It implies something for nothing. However, if the "more" emerges as a consequence of the functioning of biological mechanisms, it is no longer obtained for nothing. This is because self-organizing dynamic properties of these mechanisms dissipate energy in order to achieve this.

Such arguments suggest that the solution to the parts-whole problem must be sought in the specification of the functional properties of the components of the biological system and in the way these components function to create mental structures. Mental structures themselves, on the other hand, must be studied only insofar as such investigation bears on the nature of the functional properties of the nervous system.

Structural theories of affect and emotion often postulate a set of basic emotions that mix to produce more complex emotions. Plutchik (1962) used the analogy of the color-wheel to illustrate the mixing of emotions. He argued that "it is necessary to conceive of the primary emotions as hues which may vary in degree of intermixture (saturation) as well as intensity, and as arrangeable around an emotion-circle similar to a color-wheel" (p. 109). Berlyne (1971) has drawn attention to a potential difficulty in such a direct analysis and synthesis of emotional structures:

> Attempts to list basic emotions are like attempts to divide the visible spectrum up into regions of similar color, with the possibility of adding to the number of hues by color mixture. The principle difficulty, with color as with emotion, is a lack of objective criteria, and thus of agreement, on where the boundary lines should be drawn. It has, for example, been established by the experiments of psycholinguists that the familiar seven "colors of the rainbow" are peculiar to our culture; members of other cultures divide up the spectrum quite differently. (pp. 73-74)

While there seem to be no universal criteria for dividing up the color-wheel into primary colors, it has been shown that the universals of color semantics can be explained in terms of the functional properties of the neuronal elements underlying the perception of color. Kay and McDaniel (1978) have reviewed the recent evidence on color-term semantics and argue that a "widespread belief in linguistics and the philosophy of language, challenged by the data reviewed here, is the doctrine that there exist ultimate semantic primes which are _discrete_ entities" (p. 611). As an alternative, Kay and his associates present a neurophysiological model indicating that "all the basic color categories of the languages of the world are based on the six fundamental neural response categories, whose structures are determined by the firing patterns of . . . cells in the visual pathway" (Kay, 1981, p. 64). Similarly, the functional view assumes that affect and emotion can be more readily explained in terms of the functional properties of the nervous system and not in terms of some abstract emotion-circle or network.

Functional Permanence and Frame Permanence: An Example and an Analogy

The second general characteristic of structural approaches is that they all place the locus of permanence at the mental level. They all assume that permanence is a property of mental structures, that there exists a long-term memory store or conceptual network, and that it is in terms of the structure and the organization of such a storehouse or network that psychological permanence must be specified. However, Bransford et al. (1977) and Jenkins (1977) have seriously challenged the permanent storage metaphor. They have argued that this is but one of the many possible alternatives.

With respect to permanence, affect has been treated vastly differently by different writers. For motivation theorists such as McClelland and his associates (e.g., McClelland, Atkinson, Clark, & Lowell, 1953), it is a stable and consistent instigator of action. For others (see, e.g., Ryle, 1949), it is little more than transitory "thrills," "pangs," and "glows" (e.g., a glow of pleasure).

The functional approach assumes that permanence is a characteristic of the biological hardware and is reflected in the consistent and stable functional properties of the components of the nervous system. Mental structures, on the other hand, are inherently transient.

The problem of permanence is a particular case of the more general problem of the preservation of form that goes beyond psychological phenomena. Consider an analogy from Miller's The Body in Question (1978):

> The survival of form depends on one of two principles: the intrinsic stability of the materials from which the object is made, or the energetic replenishment and reorganization of the material which is constantly flowing through it. The substances from which a marble statue is made are stably bonded together, so that the object retains not only its shape but its original material. The configuration of a fountain, on the other hand, is intrinsically unstable, and it can retain its shape only by endlessly renewing the material which constitutes it; that is, by organizing and imposing structure on the unremitting flow of its own substance. Statues preserve their shapes; fountains perform and re-perform theirs. (p. 140; italics added)

Thus, there are two types of structures: stable and unstable. And there are two types of permanence. Structural permanence is inherent in the structure itself. Functional permanence is inherent in the functional properties of the underlying system(s) that create and recreate the structures. These systems and their properties are permanent, to be sure, but are not the same sort of stuff as the structures they create. The engines, the pipes, the pressure, and the water are not isomorphic with the fountain they jointly create. Note that by specifying the components of the underlying system and how they relate, one can understand the way the fountain is created; but the latter (i.e., the created fountain) is not reduced to the former. This is the essence of an interlevel approach.

Structural psychological theories assume that permanence is an inherent property of mental structures. The functional view maintains that mental structures are inherently transient. They are created postfunctionally (see Iran-Nejad & Ortony, Note 2). They are formed as a consequence of neuronal functioning. And they last as long as this functioning is rehearsed by hundreds of autonomous neuronal elements each of which can, in principle, participate in the creation of an indefinite number of structures.

In accounting for the permanence of mental structures, therefore, it seems that a choice would have to be made between two different levels of analysis. One can assume the locus of permanence to be in the structure and attempt to specify long-term mental relations. Alternatively, one can assume that permanence is inherent in the functioning of autonomous neuronal elements and try to specify functional properties that would make it possible for these elements to permanently and consistently create and recreate transient functional structures. Since in affect and in cognition, as in the case of fountains, we have to deal with unstable and constantly varying structures, the functional view deserves serious consideration. It urges a shift in the locus of analysis in psychology, from a direct description of created structures to a description of the functional characteristics of the underlying systems. However, this does not mean mental relations must not be investigated. Rather, it means (a) that a formal theory of mental structures based on precise algorithmic analyses need not, and possibly cannot, be constructed, and (b) that investigation of mental structures must not serve toward an end goal of constructing a formal description of these structures; it must be done in subordination to the goal of specifying the functional properties of neuronal elements. Mental structures are analyzed only insofar as such analysis directly helps us understand "the style of the brain" (Arbib, 1981).

Structural theories are best suited to deal with permanent structures. This is probably why philosophical structuralism leads to such questions as whether or not the structure of a statue exists in the block of stone before it is carved, why psychological structuralism hypothesizes permanent mental structures in the head, or why many structuralists tend to hypothesize innate structures (e.g., Chomsky, 1980). According to the functional approach, permanent mental structures cannot exist; the latter must be created and recreated.

What then must a functional psychological (as opposed to an artificial intelligence) theory of affect do? Clearly, it must not build a long-term storage or a permanent structural network. Nor must it, as an end goal, construct a formal, algorithmic, representational system of such a repository or network that would be programmable into a computer. Instead, it must (a) specify how global affective states dynamically relate to localized components (e.g., distributed neuronal elements) of the nervous system; it must (b) provide a plausible account of affective valence and awareness; it must (c) present a plausible account of the concept of self; and, finally, it must (d) allow plausible definitions for affective variables (e.g., pleasantness/unpleasantness and interestingness). We hope this approach may place us in a better position to design experiments leading toward an integrated body of data on affective and mental functioning. Current research on affective functioning is carried out under a great number of "spot" theories. As Athey (1976) notes from the perspective of reading education, "the literature on affective factors misses the connecting thread of a good theory to make sense of the plethora of inconclusive and contradictory data" (p. 739).

Functional Properties and the Creation of Affect

Elements of a functional theory of cognition are evident in the work of Bartlett (1932), Bransford and his colleagues (e.g., Bransford, McCarrell, Franks, & Nitsch, 1977), Jenkins (1977), and Minsky (1980). These authors have also given special attention to the role affect plays in remembering. Bartlett draws attention to "the fact . . . that when a subject is being asked to remember, very often the first thing that emerges is something of the nature of an attitude" (p. 207). Similarly, Minsky maintains that "attitudes do really precede propositions" rather than the other way around:

> In this modern era of "information processing psychology" it may seem quaint to talk of mental states; it is more fashionable to speak of representations, frames, scripts, or semantic networks. But while we find it lucid enough to speak in such terms about memories of things, sentences, or even faces, it is much harder so to deal with feelings, insights, and understandings--and all the attitudes, dispositions, and ways of seeing things that go with them. . . . We usually put such issues aside, saying that one must first understand simpler things. But what if feelings and viewpoints are the simpler things? (p. 118)

In order to explain mental states, Minsky (1980) conceived of "the mind (or the brain) as [being] composed of many partially autonomous 'agents.'" He proposed that "no single one of these little agents need know much by itself, but each recognizes certain configurations of a few associates and responds by altering its state" (p. 119). In this section, we will try to demonstrate how a similar assumption makes it possible to present plausible accounts of such basic aspects of affective functioning as awareness and valence, as well as the notion of self.

Awareness

As Mandler (1975) has noted, "consciousness (awareness or private experience) . . . has generated some of the most extreme positions in psychological theory, varying from its denial by some behaviorists to an assertion of its exclusive dominance by some phenomenologists" (p. 12). While emphasizing the role of awareness as an important parameter in emotional functioning, Mandler also points out:

> Translating the private datum of consciousness into useful theoretical constructs remains one of the interesting tasks facing theoretical psychology. . . . We still tend to use ancient and philosophical interpretations of consciousness. The theoretical-analytic enterprise that properly dissects the ordinary language meaning of consciousness and construets theoretically meaningful terms and processes (and not just a single state or mechanism) is still to be undertaken. (p. 12)

The influence of the single-unit philosophical view of consciousness on neurophysiological research has been discussed by Luria (1978). The primary purpose of this research has been to identify a unitary neuronal structure whose stimulation would give the individual conscious experience and whose destruction would render the person unconscious. As an alternative, Luria proposes what he calls a <u>semantic and system-based</u> explanation of awareness, one that goes beyond the notion of consciousness as a changing state of wakefulness that results from the activity of the reticular formation. Luria emphasizes the contribution of other brain regions such as posterior and frontal cortical areas. He writes:

> Attempts to seek the material substrate of consciousness at the single-unit or synaptic level . . . thus begin to be seen as completely hopeless. The cerebral basis of man's complex, semantic, system-based conscious activity must be sought in the combined activity of discrete brain systems, each of which makes its own special contribution to the work of the functional system as a whole. (p. 31)

Mandler's and Luria's quotations seem to call for a distributed account of awareness. Similar suggestions have been made by Sperry (e.g., 1969, 1976) and by Restak (1979, 1981). According to Sperry (1969), "conscious properties . . . are directly dependent on the action of the component neuronal elements" (p. 534); and as Restak (1981) put it, it is possible "that the interaction between millions of neurons within the brain induces complex electric fields that are ultimately responsible for consciousness" (p. 19). However, the details of a distributed account of awareness have not yet been spelled out. This section attempts to present such an account.

The locus of the generation and perception of awareness. The central assumption of the present functional view is that there exist physically unitary and functionally autonomous neuronal elements that can function, in principle, independently of other neuronal elements and, therefore, can participate in an indefinite number of functional combinations. "One possible outcome of considering discrete systems embedded in a continuous system would be the subordination of obvious structural discreteness to a functional one: the spatially discrete elements could be brought to functional continuity . . . or the structurally continuous medium to functional (dynamic) discontinuity" (Rowland, reported in Katchalsky, Rowland, & Blumenthal, 1974, p. 78). The predominant principle that determines functional properties of neuronal elements is assumed to be <u>specialization</u> or <u>specificity of function</u>. This means that each neuronal element is specialized, or is capable of getting specialized, to function in a unique fashion and, thereby, to manifest some specific functional properties. One such property is the generation, by the element as a neuroanatomic system, of a unique feeling of awareness, a means of "communicating" to the global system that "I, the functioning element, am" in a state of functioning (activation or inhibition), either singly (explicit awareness) or in combination with other elements (implicit awareness). Conceptualized in this fashion, awareness can equip the overall system not only with a means of directly "monitoring" the activity of its components but also with a basis for distinguishing between them. This is, however, to speak metaphorically. In functional terms, the active element is assumed to be at the same time the creator and the perceiver of awareness. Awareness mediates the element-system relationship by means of two complementary mechanisms of simultaneous and independent functioning, which will be discussed later.

<u>Functional constellations and nonspecific awareness</u>. Functional properties of individual neuronal elements are <u>specific properties</u>; they can, in principle, be traced to a specific physical system, the element itself. However, it must be emphasized that neuronal elements do not represent particular emotions or ideas. The latter are created when a great number of elements function simultaneously. Such functional combinations have nonspecific properties, properties that cannot be traced to any one specific

physical system. Mental states and patterns, therefore, are nonspecific and unanalyzable in this particular sense, as are, by analogy, the physical (structural) properties of water. It is not clear what oxygen or hydrogen contributes to the physical properties of water; it is only possible to see that such properties emerge when the two gases combine. The functioning of the neuronal system and the generation and the experience of awareness can be conceptualized more readily by analogy to a light constellation. Imagine a constellation of lightbulbs in which each individual lightbulb is painted a unique color and, consequently, produces a unique pattern of light. In such a constellation, when a subset of lightbulbs is on, it creates a unique nonspecific light pattern. The pattern is nonspecific because its global properties (i.e., the overall color of the generated light pattern) are created by group functioning of several lightbulbs and can be traced only to the functioning constellation as a whole and not to any discrete (specific) element (i.e., to any one lightbulb).

An important consequence of this view of awareness is that changes in awareness occur as a function of changes in the functioning of underlying neuronal elements. At one extreme, abrupt changes mean sharp awareness of the changing elements. At the other extreme, no change in functioning generates no awareness. By analogy, changes in the overall light pattern generated by a set of colored lightbulbs can come about when new lights go on, old lights go off, and/or when some lights go brighter or dimmer, not by changing the resultant light pattern itself into a new form.

If the present view is correct, it means that, within certain specifiable constraints, the constellation of neuronal elements that are active at a given moment will combine to create a unitary functional pattern, and, consequently, a unitary feeling of awareness. Evidence for such combinatorial nature of awareness comes from the split-brain research carried out by Sperry (e.g., 1968) and others. This evidence suggests that "in the normal brain, the right and left hemispheric components combine and function as a unit in the causal sequence of cerebral control. In the divided brain, on the other hand, each hemispheric component gets its own separate causal effect as a distinct entity" (Sperry, 1976, p. 174); in the latter case, each separate hemisphere forms its own unitary functional combination; each hemisphere creates "a mind of its own."

Finally, the interface between the functionally autonomous neuronal elements and the nonspecific, postfunctional psychological patterns may be conceptualized by analogy with the concepts of genotype and phenotype as used in genetics. At the "genotypic" neuronal level, there are specialized neuronal elements that can, like genes, participate in an indefinite number of combinations. The psychological level itself, however, corresponds to the phenotypic level. In the same fashion that a particular combination of genes acts as a basis for the creation of a particular organism with particular phenotypic characteristics, a particular combination of neuronal elements acts to create a particular psychological structure. The analogy, however, breaks down as far as the relative permanence of phenotypic organismic structures, as opposed to the transience of psychological structures, is concerned. Grown organisms cannot be "undone" into their elementary genes, so the latter could each participate in some other organism. Psychological structures can, presumably, "uncombine," at the genotypic level, into their component neuronal elements.

The Combinatorial Aspects of Mental Functioning

What holds the system together? A system comprising functionally autonomous elements that interact via the establishment of transient postfunctional relations constitutes a fully dynamic system. In order to run, such a system would have to somehow resolve two problems, both having to do with how the complex system holds together as a unitary coherent entity. First, the component elements would have to have some way of establishing dynamic relations with the overall system and vice versa. Following Bartlett (1932), we believe that the mechanism responsible for such interaction is awareness; the active component element is the creator and the perceiver of a unique feeling of awareness, thereby catching, via its very functioning, the "attention" of the overall system by becoming itself the focal center of awareness in it. As Bartlett states, awareness gives the system a way of "turning round upon itself."

Secondly, the component elements would have to have some way of establishing dynamic relations among themselves. What sort of mechanism would render this interaction possible? The functional view assumes that the causal locus of element-element interaction must also be sought in the functioning of the specialized autonomous element itself. For instance, a functioning element can generate a unique pattern of physical energy whose presence in the system can, in turn, serve as a sufficient condition for another specialized element, or a constellation, to get activated.

Three types of functional relations may be hypothesized: consonance, dissonance, and irrelevance (Festinger, 1957). Two (or more) neuronal elements are consonant if they are specialized such that functioning of one element leads to initiation of functioning in the other. One way this could happen would be if the functioning of the first element resulted in the generation of a unique pattern of energy which would, in turn, serve as (sufficient) condition for the second element to begin functioning. The functional relation between two elements is irrelevance if functioning of one has no effect on the functioning of the other.

Functional dissonance arises when consonantly related elements tend to function in a direction opposite to the one required by their consonant functioning. Suppose the consonant relation between A and B is activation-activation and between C and B is activation-inhibition. Dissonance will arise if A and C tend to function simultaneously; since this will cause B to fluctuate in two opposite functional directions, namely, activation (due to stimulation from A) and inhibition (due to stimulation from C).

The simple system of postfunctional relations hypothesized here can provide a basis for explaining the creation and recreation of affective and cognitive patterns. Together with awareness, it also makes it possible to see how component-component and system-component interaction may take place.

The transient aspect of mental combinations. In a fountain, there is only one actual configuration, namely, the configuration of the (present) moment. Past configurations no longer exist; nor are they relevant. By analogy, the only actual psychological pattern is the schema-of-the-moment, the totality of the functioning neuronal elements--distributed in various regions of the nervous system. An emotion is a schema-of-the-moment in which the affective component is predominant.

Thus, emotions, as well as other mental structures, are transient phenomena and last only as long as the underlying neuronal elements maintain functioning, in the same fashion that the fountain lasts only as long as the underlying system runs. There is no need for storage of any mental frames or any other mental entity. (For a discussion of the problem of remembering, see Iran-Nejad & Ortony, Note 2.) Furthermore, beyond the functional constraints imposed by specialization of autonomous neuronal elements (e.g., consonant and irrelevant relations) there is no need for any underlying structural blueprints. As Arbib (1981) put it, "we can no longer think of a single localized schema for each familiar object in our environment, but we must rather imagine that the appropriate pattern of activity can be reproduced" (p. 33). This is especially true if we think of a concept as a transient pattern created by the activity of autonomous neuronal elements distributed across various regions (visual, auditory, tactile, olfactory, etc.) of the nervous system.

While mental structures are transient, duration of functioning in autonomous neuronal elements can vary. Some elements are always active or follow a regular functional rhythm (cycle). Elements involved in the concepts of self, of time, and of space are examples. Functioning of other elements is more transitory.

Initiation of functioning in neuronal elements takes place either endogenously or exogenously. One obvious example of endogenous initiation is the activity of those neuronal elements that are involved in the awakening of the organism from sleep. Another example is the activation of neuronal elements as a function of their logical or pragmatic consonance with other active elements in the schema-of-the-moment. Exogenous initiation occurs independently of the schema-of-the-moment; for instance, when neuronal elements get activated under the influence of external energy patterns (e.g., textual stimuli).

Resolution and Dissolution Aspects of the Schema-of-the-Moment

If neuronal elements generate energy patterns that provide sufficient conditions for other elements to get activated, how is it that upon the activation of the first element, all other elements subsequently related to it do not get activated in some sort of a chain reaction? The first reason for this is that particular elements (or constellations) often function in combination and, when they do, their characteristic energy pattern combines with that of other elements to form interference patterns (see Iran-Nejad & Ortony, Note 2, for a discussion). These interference patterns are different from specific energy patterns generated by individual components and, consequently, cannot serve as sufficient conditions for the activation of elements that they would otherwise activate. In other words, the generation of a characteristic energy pattern can activate other elements only if the element (or the constellation) functions independently of other elements. The second reason that a reaction chain does not occur is that internal energy patterns are not the only source of initiation. Often, elements that must enter the chain of activation, so to speak, have to depend on external energy patterns. For these and perhaps other reasons the development of the schema-of-the-moment is always constrained by the extent to which the problem of initiation of functioning in neuronal elements is gradually resolved. Consequently, the term resolution can more aptly describe the dynamic development of the schema-of-the-moment than combination.

A particular schema-of-the-moment can be either resolved, resolving, or unresolved. A resolved schema-of-the-moment is one in which all the elements function in a harmonious (consonant) fashion and, consequently, the global and local functioning go hand in hand. Completeness (closure) is another aspect of a resolved schema-of-the-moment. A resolving schema-of-the-moment is one in which all the local elements cannot yet function in a harmonious global fashion--because in order to do so, functioning of other as yet inactive elements is necessary. However, since consonant elements are constantly being introduced, the dynamic mechanism that moves the schema toward resolution is kept alive. An unresolved schema-of-the-moment is a (temporarily) "stalling" schema which cannot move in the direction of resolution because new consonant elements fail to get activated.

Not all schemata-of-the-moment can be characterized by resolution. The latter is a combinatorial mechanism. Any system comprising autonomous elements, must have some way of unbinding the already combined elements in order for the latter to be used in new combinations. This is accomplished by what might be called schema dissolution. Therefore, in principle, a schema-of-the-moment can also be dissolved, dissolving, or undissolved. A dissolved schema-of-the-moment is one that can maintain a coherent organization only to the extent that many elements dissonant with it can be inhibited. The global experience of the moment may be labeled as "unconvincing." A dissolving schema-of-the-moment is one that is in a state of crisis because, while the schema is not yet totally disrupted, dissonant elements are being introduced. An undissolved schema-of-the-moment is a "stalling" schema which cannot move in the direction of dissolution because further dissonant elements fail to get introduced into it.

Nonspecific Properties of the Schema-of-the-Moment

If one considers the configuration of a fountain at a particular point in time, a set of unique global properties can be identified--the particular shape, the silverish beads or spray, the diffused movements, the sound, and so on. These are nonspecific properties because, while the fountain consists of a great number of specific springs, the properties of the whole fountain cannot be traced to any discrete underlying component; they are the creation of the act of combination. Analogously, every schema-of-the-moment has its unique global properties. If the functional theory is correct, the relevant variables influencing the global properties of the schema-of-the-moment are such factors as awareness valence (positive, negative, or neutral), resolution/dissolution (resolved, resolving, unresolved, dissolved, dissolving, or undissolved), independent/simultaneous functioning (local or global focus), and change (gradual or abrupt). A resolved schema-of-the-moment can give rise to such feelings as coherence, completeness, meaningfulness, contentment, and so on. A resolving schema-of-the-moment may generate suspense, uncertainty, expectation, interestingness, and anxiety. Similar feelings of awareness may be associated with unresolved (e.g., incompleteness, discontent), dissolved (e.g., incoherence, senselessness, anomaly), dissolving (e.g., confusion, puzzlement), and undissolved (e.g., stress, restlessness). It is beyond the scope of this paper to discuss in any detail internal state concepts in the context of the functional approach. Therefore, we close this section with the hypothesis that factors governing the meaning, categorization, and use of internal state words (see, e.g., Hall & Nagy, 1979) may vary along the functional dimensions suggested here. Consider, for instance, meaning. Earlier, it was claimed that awareness is an indispensable aspect of affective functioning. If this is true, it must somehow be reflected in the meaning of internal state words. The unacceptability of (1a)-(1c) supports this claim:

(1a) I am angry but I am not aware of it.

(1b) Father Brown believes that God created the world in seven days but he is not aware of it.

(1c) I remember the name of my cousin but I am not aware of it.

In fact, if the functional theory is correct, there is nothing else to the meaning of internal state words than the transient state they refer to. This counterintuitive claim is in direct opposition to the notion that there exists a permanent representation for the meaning of every word in some alleged semantic network. The fact that (2b) is more acceptable than (2a) suggests that our intuitions contradict the pre-existence of such representations:

(2a) I know the meaning of the word structuralism but I have forgotten it.

(2b) I have Piaget's book called Structuralism but I have forgotten where I have put it.

If forgetting meant that "I have the meaning represented in my head but I fail to find and to access it," as some structuralists would put it, then (2a) would have to be as acceptable as (2b). Given the functional view, the term know can only be meaningfully applied to the transient phenotypic psychological level. It is often suggested that people might know something without being aware of it. The unacceptability of (2a) indicates that our intuitions contradict this. What we are not aware of is not (yet) what we know; and what we remember is not what we retrieve but what we conceive (create).

Mental Functioning and the Self

Traditional research bearing on the phenomenon of affect, especially the research motivated by consistency theories (see, e.g., Abelson, Aronson, McGuire, Newcomb, Rosenberg, & Tannenbaum, 1968), suggests a close interrelationship among the self, dissonance, and affective valence. The nature of this interaction, however, is currently unclear. Perhaps the major reason for this is that we know nothing about the self beyond the phenomenological, ordinary language notion of self, a unitary homuncular entity capable of performing essentially everything the individual as a whole can do. For instance, Puccetti (1981) speculated, on the basis of evidence from split-brain patients, that there are two "selves," one in each hemisphere. In her commentary on Puccetti's article, Churchland (1981) argued that the controversy over the number of selves and their location is like the dispute over how many angels can dance on the head of the proverbial pin. The self, like angels and demons, "is so ill-defined that we do not know how to begin to count or what to take as a reasonable estimate. In the absence of theory to provide principles for individuating, one man's considered judgment is another man's jest" (p. 103).

While the phenomenological ordinary language can easily lead to the notion of self in terms of countable homunculi, the functional view provides the concepts and the language for a plausible distributed account of the nature of self and its interaction with other aspects of affective functioning. It makes it possible to see how the phenotypic psychological level and the genotypic neuronal level might interact to create a unitary experience of self-awareness.

At the phenotypic psychological level, the totality of the functioning elements of the moment combine to constitute the unitary experience of the moment. We will refer to this unitary experience as the inherent self. That this global experience does constitute an (inherent) self has been suggested by Zajonc (1980). Zajonc cited evidence suggesting that "the self involved . . . is probably some global and general impression suffused with affective quality" (p. 167). In contrast with the inherent self, there is what might be called the acquired concept of self. This aspect of the notion of self involves the particular ideas about the self and is based, at the genotypic level, on active neuronal elements that, by themselves or in combination with other active elements of the moment, create our self-image, self-esteem, personal history, immediate or long-term concerns or goals, and so on. Under normal circumstances, the inherent self--the schema-of-the-moment--always includes an implicit concept of self. However, given the functional perspective, it must be possible for the inherent self to exist without an active concept of self. And indeed, this seems to be the case. It can happen, for instance, when, as a result of some dramatic life-threatening incident, a person forgets everything up to the moment of the incident. The permanently active elements creating the acquired concept of self somehow undergo inhibition. The inherent self, however, does not go away. Even though, the schema-of-the-moment may persist in a resolving state until everything is back to normal, the overall sense of unity is presumably never lost.

At the genotypic neuronal level, there are only functionally autonomous specialized neuronal elements, each of which generates a unique feeling of awareness. At this level, the categories into which the neuronal elements fall may have a bearing on the notion of self. For instance, it can be assumed (a) that all the specialized neuronal elements fall into three broad categories with respect to the valence of the awareness they generate--positive, negative, and neutral--and (b) that positive and negative elements somehow (e.g., via gross phylogenetic specialization) constitute two mutually inconsistent sets (or neural networks).

How do the phenotypic psychological aspects of self (i.e., the inherent self and the acquired concept of self) relate to the genotypic neuronal level (i.e., to the three categories of positive, negative, and neutral neuronal elements)? It may be plausibly assumed that only the negative elements are, via gross phylogentic specialization, "self"-dissonant. It would follow that both positive and neutral elements are self-consonant. Note that, given the notion of the inherent self, there can be no self-irrelevant elements. The acquired concept of self determines the long-term valence of the self and the inherent self is responsible for the transient valence of it. Thus, a person having a concept of self involving many negative elements (a low self-esteem individual?) would be ordinarily in a negative mood, even though, the inherent aspect of self may bring transient euphoric spells to the extent that positive elements are momentarily introduced and to the extent that the negative elements ordinarily involved in the concept of self get inhibited. Similarly, a predominantly positive concept of self (a high self-esteem individual?) may be caught in an aversive situation, if the inherent self is predominantly negative.

Thus, according to the functional view, there can be no homuncular self to reside in some location in the head. Self-awareness is a distributed phenomenon inherent in the very functioning of whatever specialized neuronal elements happen to be active. Thus, as long as the overall neural network remains functionally intact and some neuronal elements are functioning, they combine to create the inherent self. To the extent a particular portion of the network is disconnected (e.g., one hemisphere), integration between that portion and the disjoined portions (e.g., the other hemisphere) will be hampered. Thus, the distributed view of self-awareness is consistent with inter- and intrahemispheric unity. For instance, in a split-brain patient, one hemisphere may not know what the other hemisphere just did if it is separated from it. And since each hemisphere is in contact with an otherwise intact neural system, whatever neural elements are active in it will join to constitute a unitary self.

The distributed view of self also means that as long as some neuronal elements are active, the unity and the identity of the inherent self is preserved. Even in the most fragmentary dreams, we seem to somehow maintain the identity of a unitary self and the feeling that it is "me" and no one else.

<u>Attentional Consequences of Neuronal Functioning</u>

Global functioning, in which a constellation of elements function in a simultaneous and harmonious fashion, has the advantage of allowing the totality of the psychological experience of the moment to constitute a unitary feeling of self-awareness characteristic of a single individual organism or self. However, if organismic systems were only capable of global functioning, they would have (a) no way of becoming explicitly aware of the functioning of their constituents, and (b) they would have no control over them. Therefore, as Bartlett (1932) has noted, there must be some way for the individual component (consisting of one or more neuronal elements) to function independently in the context of the overall schema-of-the-moment. By independent functioning we mean that there should occur a change in the functioning of a particular component, compared to the global level of functioning of the schema-of-the-moment. When such independent functioning occurs, the particular component becomes the center (focus) of awareness (or attention) of the organism. Focusing or attention may be either local, if an element or a local constellation manages to function independently, or global, when the element or constellation functions in unison with the global schema-of-the-moment. Local focus leads to explicit awareness of the particular component, and global focus to implicit awareness of it. According to this view, independent functioning is simultaneously a mechanism responsible for attention (broad or focused) and for awareness (implicit or explicit). If a constellation of neurons do not change their (rate of) functioning, we will not be aware of them. If they change their functioning simultaneously with other groups of neurons, we will be implicitly aware of them. If they change their functioning as a single group by themselves, we become explicitly aware of them as a single unit.

The scope of independent functioning varies and may be constrained by the physical organization of the neuronal system. Consider a neuronal organization which is highly consistent with the known organization of the brain: Assume that the totality of neuronal elements divide into several grossly specialized (gross specialization being determined phylogenetically) local neuroanatomic regions--the visual cortex, the auditory cortex, the motor cortex, the pleasure/unpleasure areas and so on. Let us assume that further specialization of the neuronal elements within each of these areas occurs ontogenetically such that, at a given point in the life of the organism, each region contains its own repertoire or pool of specialized neurons. At the most global level, some elements within each and every area would be active, and all the active consonant elements distributed in all the areas would function harmoniously. This would create the most nonspecific experience of the moment--the global inherent self. At the next level, while neuronal elements in other areas are also in a state of functioning, some group of elements in one area (e.g., the visual cortex) manages to function independently, by changing its rate of functioning under exogenous or endogenous stimulation. The particular area becomes the focus of attention at that moment. Yet at another level of focusing, particular local elements in a given area can function independently of other elements in the same region and/or of elements in other areas.[2]

If this way of characterizing attention is correct, there must be two distinguishable aspects to attention on a given component. There must be an attention phase of short duration. This we will call the attention-catching aspect, and we believe it is determined by independent functioning. There must also be an attention phase of variable, and often longer, duration. This can be called the attention-holding aspect and must be determined by simultaneous functioning. This account of attention is consistent with the known neurophysiological and psychological data on attention. Pribram and McGinness (1975), who reviewed this data, concluded:

> Three neurally distinct and separate attentional systems--arousal [the short phase], activation [the long phase], and effort--operate upon the information processing mechanism. The presumed operation of these control systems is perhaps best illustrated as follows: The orienting reaction involves arousal but no activation; vigilant readiness involves

> activation but no arousal; the defense reaction involves arousal and activation; when neither arousal nor activation is present, behavior is automatic, that is, stimulus-response contingencies are direct without the intervention of any of the control mechanisms of attention. (p. 133)

An obvious difference between our account and that of Pribram and McGinness is that the present functional view does not allow neurally distinct mechanisms. On the contrary, the functional view implies that attention must be a <u>distributed</u> phenomenon; any neuronal constellation can become the focus of attention provided that it functions independently.

How about the "effort" aspect of attention? While independent functioning under the influence of external stimulation may take place in a more or less effortless fashion, endogenous independent functioning--that caused by internal sources of initiation--often involves the psychological experience of "effort." What functional conditions give rise to this experience? We believe it results when an inactive element or constellation must get activated under the influence of other already-active elements. In other words, active components of the schema-of-the-moment must be utilized as a source of initiation of functioning in inactive elements. This is possible because if a component of the schema-of-the-moment functions independently, it generates a characteristic energy pattern that, as we mentioned earlier, can serve as a sufficient condition for activating other elements; as might happen, for instance, when the schema-of-the-moment already contains an idea and we want to verbalize it. At times, this type of functional initiation may involve trial and error, and, as Bartlett (1932) has noted, it may be only possible through the mediation of awareness. It happens when the global structure manages to influence the functioning of local neuronal elements; when the overall system somehow manages to "turn round upon itself."

If the present account of attention is correct, the interface between the phenotypic psychological level and the genotypic neuronal level must form a causal loop. First in this loop comes initiation of functioning in particular neuronal elements. This can happen in different areas of the nervous system, under the influence of different internal or external sources of stimulation, and at different times--elements creating an idea need not initiate functioning at the same time. Next comes the combination of these elements, within themselves and with those that are already active, and the creation of particular ideas at the phenotypic level. When this happens, recognition and explicit awareness of the just-created idea occurs. The idea is conceived, so to speak. After this attention-catching phase, i.e., once an idea is created, it can become implicit in the schema-of-the-moment--the attention-holding aspect. This occurs through simultaneous or "choral" functioning of the genotypic neuronal elements, when elements come to function harmoniously with those participating in the schema-of-the-moment. Once an idea is implicit in the schema-of-the-moment, explicit awareness (discrimination) of it can occur only if the underlying neuronal element can somehow manage, endogenously or exogenously, to function independently (i.e., change its rate of functioning to a level different from that of the schema-of-the-moment). Finally, independent functioning at the genotypic neuronal level generates a unique pattern of energy that can serve as a sufficient condition to initiate functioning in other neuronal elements, and the causal loop continues during all waking hours.

Thus, the functional view provides the concepts for specifying the interface between the phenotypic psychological level and genotypic neur[...] functioning. It also makes it possible to specify the functional interrelationship among different regions (i.e., visual, auditory, motor, etc.) of the nervous system. For instance, at a broad level, the functional view is consistent with the notions of partial independence of affective functioning (Zajonc, 1980). Physiological evidence, such as gathered by Olds and his associates (see, e.g., Olds, 1973), suggests that there are areas of the brain, sometimes called the pleasure/unpleasure regions (Weil, 1974), that may contain the genotypic neuronal elements underlying what Zajonc (1980) calls the preferenda. At the genotypic level, it is conceivable, therefore, that initiation of functioning in the pleasure/unpleasure region can occur before, after, or even without such cognitive acts as recognition, discrimination, or awareness of an idea at the phenotypic level. This is because ideas are created and are, consequently, felt, recognized, or discriminated only when constellations of elements required to create them are fully, but not partially, in a state of functioning. The elements responsible for the liking of an idea, may be active long before the constellation responsible for its creation as a whole becomes functional and the idea is created.

The creation of the explicit awareness, as a discriminatory mechanism, resulting from independent functioning deserves to be mentioned again in closing this section. It is perhaps in reference to such coincidence of functional change and awareness that William James considered physiological changes (such as in heartrate or muscular activity) to be the same as emotions. It is only when our heartrate reaches above its normal rate that we become aware of it, or it catches our attention. And everyone has had the experience of "hearing" the clock only after it stops ticking.

The Functional Approach and Traditional Theories of Affect

Unlike current cognitive psychologists, several earlier authors concentrated on the study of affect. The present section will summarize this research and will argue that it is more consistent with a functional theory of affect.

Consistency Theories

Several psychologists have assumed that cognitive functioning tends toward consonance or consistency (Festinger, 1957; Heider, 1958; Osgood & Tannenbaum, 1955). Dissonance or inconsistency, on the other hand, gives rise to negative affect and, consequently, people try to avoid or resolve it.

By far the most influential consistency theory has been dissonance theory, developed by Festinger and his associates (Aronson, 1968; Aronson, Carlsmith, & Darley, 1963; Carlsmith & Aronson, 1963). Aronson pointed out in 1968 that the major strength of Festinger's theory is that it constantly generates research (see also Zajonc, 1968, p. 359). Today it continues to do so (see, e.g., Higgins, Rhodewalt, & Zanna, 1979).

In its original and still standard formulation, dissonance theory is primarily concerned with the dissonance between one's private beliefs and actions. Imagine subjects writing an essay in favor of a topic to which they are strongly opposed (e.g., the military draft). If they do so under conditions of internal justification (e.g., free choice, or insufficient reward), they will change their attitude in a more favorable direction. If, on the other hand, they do this under external justification (e.g., forced compliance, or sufficient reward), no such change would occur. According to Festinger, freely choosing to write a counter-attitudinal essay creates cognitive dissonance between the cognitions involved in:

1. I am opposed to the military draft, and
2. I am engaged in writing (suggesting to readers that I am) in favor of it.

As the number of elements consonant with #1 increases, the magnitude of dissonance will increase. Subjects may think that they are rightly opposed to the draft because American youths should not be forced to fight other people's wars in faraway lands. Similarly, if the number of elements dissonant with #2 increases, the magnitude of dissonance will also increase. The subject may think that he is being dishonest by arguing publicly in favor of what he is privately opposed to. Conversely, if the number of elements dissonant with #1 or consonant with #2 increases, the magnitude of dissonance will decrease. In the first case, subjects may think that the quality of American servicemen under the all-volunteer army has deteriorated and has placed the United States in a dangerously vulnerable position militarily. In the second case, they may think they are merely participating in an experiment and by writing the essay they are doing the experimenter a favor.

Increases in the magnitude of dissonance will result in cognitive effort on the part of the subject to reduce the dissonance. One way to do this is to change one's attitude towards a more favorable one. However, if there is external justification, then the latter in itself provides elements consonant with #2 and, to that extent, there will be no dissonance and, therefore, no attitude change.

Dissonance theorists have attacked several basic problems concerning affective functioning and its relation to cognition. The hypotheses most central to dissonance theory are that dissonance is an unpleasant state and that it is this unpleasantness that motivates (causes) its resolution. Several authors have also presented evidence bearing on such problems as whether dissonance situations are arousing (Kiesler & Pallak, 1976) or whether it is the arousal or the unpleasantness of dissonance situations that motivates dissonance resolution (Higgins, Rhodewalt, & Zanna, 1979).

For years dissonance research has been dealing with some of the more difficult problems of psychology. Perhaps because of the relative vagueness of the concepts involved, the research has not attracted the attention of many modern psychologists. Here, we have defined dissonance at the genotypic neuronal level as well as at the phenotypic psychological level. We have also specified its relationship with awareness valence and with the self. The original hypothesis of dissonance theory—that the negative valence resulting from the functioning of self-dissonant elements motivates the resolution of such dissonance--may indeed be an important aspect of the causal loop characterizing the interface between the mind and the brain.

Optimal-Level Theories

Optimal-level theorists concentrate on attempts to discover invariant relationships between external stimulation and mental functioning. Wundt (1874) was the first to propose a curve linking stimulus intensity and affective states. Stimulus intensity up to a moderate level was assumed to be pleasant, and beyond this optimal level, unpleasantness would increase with increments in intensity.

During the 1950's, evidence accumulated demonstrating that organisms often seek dissonance and prefer it (see, e.g., Berlyne, 1960). This evidence was difficult to explain in terms of the tension-reduction hypothesis of consistency theories. How could dissonance be pleasant and unpleasant at the same time? The optimal-level function seemed to provide an answer. Building upon Wundt's original formulation, psychologists hypothesized that in order to experience pleasantness, organisms would have to encounter something new (something different from what they were accustomed to) but not too new (e.g., Hebb, 1949, p. 323). Based on this formulation, dissonance or discrepancy, as it was called by Hebb (1949) and Haber (1958), was no longer exclusively negative. Rather, discrepancies up to an optimal level would be pleasant; those above it were assumed to be unpleasant.

While optimal-level theorists agreed that there was an optimal level, there was widespread disagreement "on the mechanism by which optimization proceeds" (Arkes & Garske, 1977, p. 149). Some argued that the individual tries to optimize the amount of arousal (e.g., Berlyne, 1960; Hebb, 1955). Some argued that the individual seeks an optimal degree of psychological complexity (e.g., Dorfman, 1965; Smith & Dorfman, 1975; Walker, 1973). Others argued for an optimal amount of deviation from the adaptation level (e.g., Haber, 1958; McClelland, Atkinson, Clark, & Lowell, 1953). And still others proposed an optimal level of congruity (e.g., Hunt, 1971).

The observation, made by optimal-level theorists, that organisms often seek external stimulation in the absence of any aversive biological or acquired drives and in the absence of any overt or covert goals is an important one. Important also is the realization that the explanation for this must be sought in the very functioning of the organismic systems, and not in the relational properties that hold abstract knowledge systems together. However, we do not find the optimal-level function very informative. We believe it is an artifact resulting from attempts to relate the organism to the world at the wrong level of specificity, to map external stimulation patterns to internal psychological patterns directly. This is probably why the optimal-level research, in spite of its relatively long history, has not managed to go beyond simple perceptual stimuli.

The functional view maintains that the locus of organism-environment relationship lies at the genotypic neuronal level. It is at this level that external energy patterns play their indispensable role of initiating functioning in the neuronal elements, elements that are phylogenetically or ontogenetically specialized to start functioning in the presence of such energy patterns.

Why do organisms seek external energy patterns? Without entering into much detail, we will mention the elements that are necessary for putting together an explanation in terms of the functional perspective:

1. Constant independent functioning of neuronal elements in the context of the schema-of-the-moment is absolutely essential if an internally consistent (i.e., positive) inherent self is to be maintained. Recall that the inherent self was the totality of the experience (or awareness pattern) of the moment generated by the functioning of neuronal elements throughout the neuronal system. According to this view, no simultaneous or independent functioning means no awareness experience, and consequently, no self.
2. Endogenous sources of initiation--internal energy patterns--are, by themselves, inadequate to keep the resolving schema-of-the-moment constantly alive. This is because some of the elements that must enter the "chain" of combination must depend on external energy patterns in order to become functional.

The functional theory, therefore, not only can explain why organisms seek external stimulation, but also implies that they must; that is, if the inherent self is to survive.

Psychophysiological Theories

Like many optimal-level theories, psychophysiological models suggest that affective functioning is mediated by the activity of the autonomic arousal system. William James (1884), the famous American psychologist, and Carl Lange (1885/1922), the Danish physiologist, defined emotions in terms of perceived changes in the activity of the sympathetic and motor systems. They suggested that we are angry because our legs start to shake and our hearts start to pound.

Evidence in support of the James-Lange theory comes from the research with paraplegic or quadriplegic patients. These patients report feeling less emotional after the damage to their spinal cord (Hohmann, 1966). They are only capable of getting thinking mad or afraid but not shaking mad or afraid.

In 1927, Cannon leveled several arguments against the James-Lange theory. He noted, for instance, that the same physiological changes in the rate of functioning of the sympathetic or motor systems (rapid heart rate, etc.) occur during a variety of emotional experiences. Any theory based on merely these changes will fail to distinguish different emotions. Cannon hypothesized that the origin of emotional experiences must be sought primarily in the activity of the lower portions of the central nervous system.

According to a theory developed by Stanley Schachter and his associates (Schachter, 1971; Schachter & Singer, 1962), the functioning of the sympathetic arousal system and/or the activity of neurons located in the lower brain centers are not sufficient to account for various emotional experiences. Rather, the activity of other (cognitive) brain centers must also be considered. Based on this view, arousal is a general functional state that can be interpreted and labeled as different emotions depending on situational circumstances. Evidence for Schachter's psychophysiological theory comes from a controversial experiment conducted by Schachter and Singer (1962). In this experiment, the same physiological state of arousal, induced by injection of epinephrine, was interpreted by some subjects as "anger" and by others as "euphoria," depending on whether the subject watched a stooge act angrily or euphorically. Schachter's theory is consistent with the present functional view, maintaining that an emotion is a nonspecific functional state created by the totality of active neuronal elements of the moment, located at various sections of the neuronal network.

Empirical Overview

The theories discussed above can lead to one general conclusion: Affect (emotional experience) is a consequence of the functional interaction among various dynamic mechanisms of mental functioning. The functional approach argues that the causal loci for this interaction are physically unitary, functionally autonomous, and distributed neuronal elements. Simultaneous and independent functioning of these elements are responsible for the creation and unitization of transient mental structures.

Among the advantages of the functional perspective is its explanatory power. With only a few basic assumptions, it plausibly brings such psychological phenomena as attention (broad or focused) and awareness (explicit or implicit) under the control of the same mechanisms, namely, simultaneous and independent functioning. Plausible solutions can also be offered to traditionally controversial problems. As an example, consider the question of localization of mental functions in the brain. Early investigators tried to locate separate neural centers for such complex behavior as reading English or French (Hinshelwood, 1900). Lashley's (1929) classic experiment with rats demonstrated that it was the amount of brain tissue destroyed, and not so much the destruction of specific areas, that correlated with the animal's behavior. This led to the conclusion that the brain acts as a mass and all areas are equipotential. More recent neurophysiological research (e.g., Heath, 1964; Heath & Gallant, 1964; Olds & Milner, 1954) has provided evidence supporting finer localizations.

If the functional view is correct, there can be no isomorphism between mental or behavioral structures and neural structures, in the same fashion that one would not expect to find individual genes or unique gene combinations for whole bodily organs such as the lungs, for instance. Even the simplest psychological patterns are created by the functioning of many neuronal elements located at various areas of the brain. (For a discussion of how "remote" communication among neuronal elements can take place, see Iran-Nejad & Ortony, Note 2.). This indicates that removal of a particular element or a particular local group of elements cannot be expected to eliminate any specific behavior and only that behavior. Rather, removal of brain tissue should have a gross effect on a host of behaviors.

Finally, for the sake of illustration, we will discuss some empirical implications of the functional approach for research concerning the nature of intrinsic motivation. Many psychologists have maintained that affective valence (pleasantness/unpleasantness) is the primary motivational factor. Consistency theories, for instance, believe that resolution of inconsistency is motivated by the unpleasantness that it generates. Optimal-level theorists, like Berlyne, have suggested that the activity of some unitary arousal system is the primary motivational factor by virtue of its effect on the functioning of the pleasure/unpleasure system. The functional view, on the other hand, implies that the primary source of intrinsic motivation must also be sought in the simultaneous or independent functioning of distributed neuronal constellations. This is because such functioning is the causal origin of awareness valence, attention, the inherent self, and the acquired concept of self.

First, independent functioning, together with simultaneous functioning, is the sole perpetual creator of the inherent self--the totality of the awareness experience of the moment. Without independent functioning the inherent self ceases to exist; that is, the organism goes to sleep. The only time this can happen is when endogenous and exogenous conditions are right for the organism to do so. Otherwise, independent functioning (i.e., activation of positive or self-consonant constellations and inhibition of negative or self-dissonant constellations) must take place to keep the inherent self alive and "happy." And, since endogenous sources of initiation of functioning are often inadequate for continued promotion of independent functioning, the only other real option for the organism is to engage in active or passive exposure to external sources of initiation.

Secondly, it is through independent functioning that the organism can become explicitly aware of the components of the acquired concept of self (i.e., the immediate or long-term concerns and goals). Recall that it is through independent functioning that interaction between the system as a whole and its components (including those involved in the acquired concept of self) is possible (see the section on the combinatorial aspect). No independent functioning of a particular component would mean no explicit awareness of it and, consequently, there would be no way of "determining" the extent to which that component is, for instance, consonant or dissonant with the self. Thus, independent functioning is essential for the maintenance of both aspects of the self. It is, therefore, reasonable to assume that it is the primary motivational mechanism.

If independent and simultaneous functioning are as important as the functional view implies, then they must somehow manifest themselves in mental experience. Are there any psychological experiences that could be assumed to correspond to them? Surprise, excitement, suspense, curiosity, and interestingness seem to be candidates, depending on the type of schema-of-the-moment (i.e., resolved, resolving, etc.). There may also be others such as the so-called "click" of comprehension. All of these seem to possess the attention-catching/holding quality they are expected to have. Furthermore, they all seem to correlate with awareness as independent or simultaneous functioning would necessitate. Therefore, they may indeed be psychological manifestations of the functioning of distributed neuronal elements.

If interestingness, for example, is to be defined as an inherent consequence of biological functioning, such a definition must be consistent with what is known about the concept of interestingness. For instance, it is generally agreed that both positive and negative experiences can be interesting. To the extent that this is the case, one would expect manipulations of independent functioning to be interesting regardless of whether they involve positive or negative components. We have recently gathered some data that support this hypothesis.

The actual framework uses passages which consist of two parts: a stem and an ending. Subjects read the stem, which contains/does not contain, implicitly or explicitly, events that follow in an ending. In this fashion, it is possible to present subjects with endings that are totally expected (at one extreme), because they are also stated in the stem ("no" independent functioning), totally unexpected (at the other extreme) because the stem does not allow subjects to entertain the idea of the events in the ending (abrupt independent functioning), or lie somewhere in between (gradual independent functioning). Subjects can, then, rate their experience on various affective scales immediately after they finish reading the ending.

Included among the rating scales were several measures of valence, an interestingness scale, an empathy scale, and several measures of dissonance (incongruity). A preliminary principle-components analysis showed that interestingness, valence, and incongruity loaded on three separate factors, indicating qualitative differences underlying judgments of these variables.

How does the functional model specify these underlying differences? Incongruity differs from independent functioning in that the former involves dissonant functioning. Independent functioning of a constellation means harmonious (consonant) functioning of the elements of the constellation; and subsequent simultaneous functioning means consonance with the schema-of-the-moment. While dissonant (incongruous) functioning means just the opposite. It is this harmonious functioning that allows the attention catching/holding aspect that seems to be the basis for the judgment of interestingness. In dissonant functioning attention fluctuates among the dissonant components and, consequently, results in confusion.

How does interestingness differ from valence? Consider a particular local component of the schema-of-the-moment, say, a constellation in the visual cortex. Independent functioning of this constellation means a change in the visual cortex in the functioning of this constellation as compared to the functioning of other components of the schema-of-the-moment in other regions of the brain. There are two aspects to this change. There is the attention catching/holding aspect: The very act of independent or simultaneous functioning results in focal or broad attention and, consequently, in the judgment of interestingness. The second aspect is the awareness that the act of functioning is assumed to generate. This is the basis for the judgment of valence. Thus, while attention (hence, interestingness) is common to all instances of independent and simultaneous functioning, awareness (hence, valence) is a property of the particular functioning constellation.

By providing the basis for identifying and plausibly defining a host of factors and mechanisms that are assumed to figure centrally in affective functioning, we have presented a plausible characterization of affect. These factors and mechanisms (e.g., valence, independent and simultaneous functioning, specialization, resolution and dissolution) are independent of particular knowledge structures and are, therefore, candidates for (or manifestations of) domain-independent universal principles. This functional view of cognitive/affective universals may be contrasted with the structural approaches that hypothesize domain-specific universals such as universal story schemata (e.g., Mandler, Scribner, Cole, & DeForest, 1980). To be sure, people from different cultures may share some sort of a schema for stories, in the same way that people from most modern cultures may share a schema for vehicles. However, we believe such domain-specific structures are not suitable candidates for cognitive universals. People who lived more than a hundred years ago had a perfectly normal cognitive system without schemata for such novelties as the television, the telephone, or modern vehicles. By contrast, pathological conditions could be suspected if the components of an individual's neuronal system were incapable of demonstrating independent or simultaneous functioning at the genotypic neuronal level, or if a person were unable to experience curiosity, suspense, or awareness at the phenotypic psychological level. It might be argued that pre-existing schemata or plans are necessary for the experience of curiosity or suspense. But such psychological experiences can be explained at least as clearly in terms of the internal consistency of the components of the schema-of-the-moment, determined by the functional properties of the participating elements.

Finally, we must say something about the role of structural analysis in a functional model. In recent years, significant achievements have been made in the analytical approaches to language and knowledge structures. The direct goal of this research has been to develop structural representations, consisting of frames and transformations.

The functional approach assumes that attempts at the analysis of cognitive structures with the aim of building structural representations of psychological validity can serve only at the expense of operating at the wrong level of specificity. Knowledge structures are unanalyzable and cannot be specified to the extent that a finite set of precise algorithms (of the nature of multiplication rules, for instance) would require in order to allow the construction of a formal structural description. This is especially true of global affective structures.

In the functional approach, structural analysis is only an intermediate tool. It takes the form of semi-arbitrary, heuristic, rather than precise, algorithmic analyses. While such heuristic rules may even have indispensable practical value, they are never attributed psychological status. Their value is determined to the extent that they serve to clarify the nature of independently specified functional properties of the nervous system. Functional analysis and structural analysis go hand in hand, but the former comes first.

Summary and Conclusions

This paper presents a point of view on affect that starkly contrasts with structural theories of emotion. The functional view maintains that emotional experiences must be described in terms of functional properties of underlying neuronal elements and not in terms of properties of abstract emotional structures.

Structural theories have been particularly slow in dealing with the problem of affect. We argued that this may very well be because they cannot do so. This argument was supported by the fact that the majority of existing theories of emotion are essentially functional and by the fact that the recently emerging structural theories of affect often choose to ignore this rich wealth of theoretical and empirical knowledge.

While few psychologists would doubt that the nervous system is the actual site and the creator of our thoughts and emotions, there is a great deal of reluctance in psychological theorizing to become involved with concepts bearing on the nervous system. It is often argued that we do not know enough, or we must solve simple problems first. But how do we know when we know enough or what is simple? In 1884, William James criticized psychologists for ignoring affect, pointing out "that the matter lay for them among the problems of the future, only to be taken up after the simpler ones of the present have been definitely solved" (p. 188). In 1980, Minsky found it necessary to warn again that "feelings and viewpoints . . . [may actually be] the simpler things" (p. 118).

We feel that what currently separates psychological and neurological concepts is the absence of a plausible language to bridge the gap. We think the functional approach has the potential for providing this language.

Reference Notes

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Footnotes

[1]The analyzability of mental structures has often been called into question. Polanyi (1958) has argued that (tacit) knowledge can almost never be formalized, and Bartlett (1932) states that affective structures are "very hard to describe in more elementary psychological terms" (p. 206). Similarly, Huey (1908) points out that "the consciousness of meaning itself belongs in the main to that group of mental states, the feelings, which I regard with Wundt as unanalyzable" (p. 163; also see Minsky, 1980, p. 118 quoted below).

[2]The limit on such independent functioning or focusing is the individual neuron, when some single neuron manages to change its rate of functioning singly. Though the latter is in principle possible, it presumably never occurs. In reality, several (hundred) neurons function at any given time to create an idea and/or to focus on a certain aspect of it in a particular region of the brain; ideas are not created locally, while images probably are. Neuronal elements creating a particular idea or meaning are distributed in various areas throughout the nervous system.