© The Institute of Mind and Behavior, Inc.
The Journal of Mind and Behavior
Autumn, 1985, Volume 6, Number 4
Pages 469–514
ISSN 0271–0137

Awareness I: The Natural Ecology of Subjective Experience And the Mind-Brain Problem Revisited

Mark W. Ketterer

Oklahoma College of Osteopathic Medicine and Surgery

The purpose of the present paper is to review methodology, phenomena, principles and strategies germane to the empirical study of the subjective world as it exists during day-to-day life. Advances in neurobiological technology and the growing consensus in the behavioral and brain sciences on a dual-aspect monist position (Russell, 1921) for the mind-brain problem are making the "black box" increasingly available to examination. The primary determinants of entry of psychoneural events to the subjective field appear to be: the structure of the nervous system; the figure-ground phenomenon in attention; and overlearning/automatization.

It frequently seems as if science is not so much a means for answering the fundamental philosophical questions of life as it is a way of recasting them in an ever more precise manner. One often has the frustrating impression that, although progress has been made, the ultimate goal has receded. No better example exists than the area of consciousness. Science, like all human endeavors, rests on the idiosyncratic experiences of an ill-defined group of people labeled scientists (Kuhn, 1962; Mahoney, 1976; Polanyi, 1958). Apparently a fair amount of consistency exists across the subjective worlds of these people, for they are able to communicate, with no small degree of precision, methods and outcomes of complicated sequences of activity. But the means of communication are often inexact and require corrective feedback following unsuccessful attempts to replicate one another's results. Unfortunately, no scientist can directly know another's experience when he/she is conceptualizing, planning, observing, etc. It is this ever changing, ever present, inexactly communicable set of phenomena that constitutes a scientist's understanding of science. This subjective world is the foundation of all formal "knowledge," no matter how difficult such knowledge sometimes is to articulate (Polanyi, 1958). As Ritter (1979) notes:

> . . . science requires conscious experience as its empirical base. One wonders how the epiphenomenalist position could ever be empirically verified, since whatever observations

The author would like to acknowledge the encouragement and comments of Drs. L.R. Derogatis, R.A. Coursey, J. Gastorf, M.L. Pollak and R.A. Steinman. Requests for reprints should be sent to Mark W. Ketterer, Ph.D., Center for Behavioral Medicine, Oklahoma College of Osteopathic Medicine and Surgery, 2345 Southwest Blvd., Tulsa, Oklahoma 74107.

> are required would of necessity be conscious experiences. But if conscious experience is not causal, then such observations could have no effect on subsequent brain activity and ensuing thought. Epiphenomenalists will have to devise a new theory of knowledge which is not based on experience.
>
> In this regard, I often have the impression that scientists forget what is fact and what is theory. The frequency of light waves, for example, has been associated with the experience of color. Some scientists seem to think that light waves constitute the real world and the conscious experiences of color associated with them some kind of unreliable, shadow events. But it is the light waves which are hypothetical (no one has ever seen them). Color is a fact. Scientific theories are held with varying degrees of confidence, and an essential tenet of science is that theories can in principle never be entirely proven. Such is not the case with conscious experience. That we experience color is not an idea to be held with varying degrees of confidence: it is a fact of human existence. Indeed, all conscious experiences are facts and represent the only things we can be certain of. (p. 208)

Within the euroamerican scholarly tradition, little in the way of systematic investigation of immediate experience was accomplished until the end of the last century. It gives one pause to wonder why such endeavors were so long in arising. Perhaps the Zeitgeist of a triumphant science and technology was required. Or perhaps some initial success in demonstrating the illusion of the strong mind-body dichotomy position was needed. Certainly the "anchoring" of the phenomena of the mind to a bodily organ has promulgated technologies and theories that are increasingly amenable to empirical method. The mind, conceptualized as a nonphysical entity, could hardly be subject to serious empirical scrutiny. For whatever combination of reasons, the mind, by the end of the 19th century, was increasingly accepted as a product or process of the brain (Boring, 1950; Broad, 1925; Pribram and Gill, 1976). This conceptual revolution is still resisted by some today (Eccles, 1980; Robinson, 1976). Indeed we cannot, as yet, prove that all aspects of mind are explicable in terms of brain processes. But a large number of mental processes have been localized to reasonably discrete brain regions (Davidson and Davidson, 1980; Uttal, 1978). Given the successes of the search for neural concomitants of psychological events, continuing use of the working hypothesis of "psychoneural equivalence" (Uttal, 1978) seems more than warranted.

One could ask why the behavioral and brain sciences have been so hesitant to use the data of the experienced world as a means of studying neural processes. This hesitancy is grounded in an historically well-founded fear of "speculative mentalism." This fear reached its zenith in the paradigm of radical behaviorism (Watson, 1913). However the birth of—and wide acceptance of the rationale for—radical behaviorism occurred in an era when both our behavioral and biological methods were primitive by today's standards. Unfortunately, the assumptive residue of radical behaviorism still impedes the study of human consciousness (Epstein, Lanza and Skinner, 1981; Rachlin, 1980). As noted by an early critic of the more zealous forms of behavioral psychology:

> ...early behaviorism made an error, the consequences of which still disturb the psychologist's work. It is quite true that, in natural science, all observation of systems is

> observation "from the outside." But does it follow that, when the psychologist deals with human subjects, he must always use the same procedure? Must he also restrict his observations to behavior as watched from the outside? Why should he not be interested in mental life as experienced by himself or others? If a certain scientific enterprise which we admire has unfortunately only one kind of access to its material, why should psychology, which has two, refuse to make use of them both? In the meantime, the behaviorists themselves have discovered that, when a physicist observes his systems from the outside, the content of his observations as such consists of certain perceptual facts, mostly in his visual field, and that the same holds for the behaviorist's own observations of animals and men. But perceptual facts belong to the mental world, the world of experienced phenomena, and it therefore follows that such phenomena play a decisive role in any scientific enterprise. Hence, modern behaviorists no longer maintain that the phenomenal world has been invented by the metaphysicians. What is left, however, is their preference for observation from the outside, which under the right conditions yields clear quantitative results, in contrast to phenomenological procedures, which in this respect are generally inferior. In this methodological sense, most American psychologists now seem to be behaviorists. Under the circumstances, not only details but also most impressive aspects of the phenomenal scene are often ignored in the psychologist's work. Their admiration of method, of precision, prevents them from paying attention to phenomenological evidence even when this evidence could hardly escape the simplest observation. Naturally, the psychologists' sin of omission makes them incapable of contributing to the solution of the mind-body problem in its most serious form, in which it refers to the relation between the phenomenal scene and the characteristics of events in nature. Once more, one cannot study the relation between two groups of facts without knowing the facts in each group per se. (Köhler, 1960, p. 64)

There are those who assert that nothing can be gained from the study of consciousness that is not more objectively and reliably available in the study of behavior (Skinner, 1974) and/or neurobiology (Kandel, 1979). This stance may be defensible if one views the nature of humankind as an object of curiosity and external manipulation. However, if one wishes to communicate such wisdom to others less schooled in the behavioral and brain sciences, there is a compelling need to study and explicate the behavioral and brain processes that are the equivalent of conscious experience. For the sake of curiosity about ourselves and others, and for the enhancement of our ability to understand and control our own behavior and well-being in the context of our daily lives without use of surgery or pharmaceuticals, the study of the determinants, neural mechanisms and limitations of our conscious world is required.

The present author feels that, given its intrinsic properties, consciousness (which will be used here interchangeably with such terms as awareness, immediate experience and subjective world) must be defined, as Köhler might have stated, "from the inside," despite the difficulties this poses for empirical investigation. Failure to recognize the inherently private quality of consciousness would lead us to ignore subjective experience as a means for both understanding more objectively obtained data and developing new hypotheses. Natsoulas (1978) provides the closest approximation to this definitional approach:

> Consciousness$_4$: Direct Awarness—One exemplifies consciousness$_4$ by being aware of, or by being in a position to be aware of, one's own perception, thought or other occurant mental

episode. It is a matter, however, of being noninferentially aware of them, or of undergoing what we may call "direct awarenesses". (p. 911)

The study of the subjective world places one at the intersection of two great philosophical dilemmas, the mind-brain problem and the conscious-unconscious distinction. The mind-brain problem concerns the relationship between those phenomena we categorize as products or processes of the "mind" (subjective experience), and those we categorize as "brain" (physiology, anatomy, biochemistry and behavior). The conscious-unconscious distinction raises the question of whether we experience all, or even any, of the mental processes resulting in behavior and mentation.

Historically, attempts to resolve the mind-brain problem fall into one of four classic solutions; materialistic monism; idealistic monism; parallelistic dualism; and interactional dualism (Broad, 1925; Russell, 1921; Ryle, 1949). *Materialistic monism* holds that the phenomena of the Mind do not exist or are illusions. Only the external world is real. This is the position most often defended by the ardent behaviorists (e.g., Watson, 1913). *Idealistic monism* holds that only the phenomena of the Mind are real. The external world is illusory. This is the position held by some practitioner's of Zen philosophy (e.g., Suzuki, 1970), but has not been accepted by any major euroamerican scientific school. *Parallelistic dualism* holds that the phenomena of the Mind and the Brain are both real, but they do not causally affect one another. A small group of neuroscientists holds this position today (e.g., Hofer, 1982; Weiner, 1972), and are generally referred to as "epiphenomenalists." Finally, *Interactional dualists* hold that both the phenomena of the Mind and Brain are real and causally affect one another. One prominent neuroscientist currently holds this position (Eccles, 1978, 1980). Most neuroscientists today seem to have decided that the phenomena of both the Mind and Brain are real and the experiential distinction between them is an illusion. The phenomena of the Mind and the Brain are one and the same, but viewed from different perspectives. Thus, the question of mind-brain or brain-mind causality is moot. This position holds that subjective events give at least some insight into brain processes because they *are* brain processes. This position is variously called *Mind-Brain Identity Theory* (Ryle, 1949), *Psychoneural Equivalence* (Uttal, 1978) or *Dual-Aspect Monism* (Russell, 1921).

Having ignored the mind-brain problem for many decades by defining psychology as the science of behavior, behavioral science and neurobiology (Uttal, 1978) have now arrived at a point where mentalistic notions such as "cognition" (Mahoney, 1980; Neisser, 1967) and "emergent principles" (Popper, 1966; Sperry, 1969) are increasingly common and generally accepted as necessary. While occasional voices have been heard arguing for the use of this rich but intrinsically private source of data as complementary to behavioral and neurobiological methods (Eccles, 1980; James 1890; Köhler, 1960; Sperry, 1966), only recently have scholarly and systematic attempts been made to study experience per se. This is due, in part, to the heuristic futility of such efforts when the phenomena under scrutiny are not concomitantly validated by other methods (Boring, 1950). With increasing biological and behavioral sophistication, the time may be ripe for an examination of the phenomena, methods and emerging organizational principles of the study of the subjective world (Davidson and Davidson, 1980; Dixon, 1981; Eccles, 1980; Pope and Singer, 1978; Uttal, 1978). What is intended here is a struggle towards an empirical strategy for understanding this most central fact of human existence. No coherent overarching theory is offered since none seems tenable at the present time. Rather, working assumptions, organizational principles, technologies and relevant phenomena are reviewed to provide a basis for the development of a useful theory of the determinants of our subjective world as it occurs in the natural context of life.

Methodology in Studying Awareness

How does one empirically study the ephemeral flow of one's subjective world? How does one avoid mentalistic tautology? There are those who are satisfied with merely defining experience as such (Perls, 1969; Perls, Hefferline and Goodman, 1951). For these individuals, no appeal to objective phenomena is accepted or assumed to be necessary. Rather, the phenomena are viewed as self-evident. If interobserver agreement does not occur, no effort is expended in clarifying a cause for such confusion. Rather, potentially accurate (although empirically questionable) reasons are given: "You are not me!", "You are resisting!", etc. This is a sterile means of objectifying subjective phenomena. The task requires that we examine why one individual experiences some neurophysiological event under stated conditions and another does not.

As scientists, students of the mind-brain problem must be willing to assume at least the possibility of a causal determinant (or determinants) for every event, subjectively experienced or objectively verifiable (e.g., subject to direct interobserver agreement). Without such an assumption, no empirical search would be worth undertaking. But the conceptual and methodological difficulties of studying subjective experience have generally tended to undermine such determinism and have led to the introduction of either speculative mentalism, if the investigator chose to pursue the larger issues, or reductionistic irrelevance, if in pursuit of scientific rigor. In spite of its essential role in achieving formal, communicable knowledge, science has, until recently, eschewed the study of subjective experience in favor of more "objective" areas of inquiry. Instead of experience, we have studied neurophysiology and behavior. This has been a productive approach. Its yield has been hard and replicable data that can be subjected to the test of interobserver agreement. If scientist A arranges essentially the same circumstances used by scientist B to observe phenomenon X, and succeeds in doing so, replication and interobserver agreement between A and B is achieved (Sheridan, 1971). If not, re-examination and manipulation of circumstances may then yield agreement or expose error in the original observation and interpretation. But how does one go about arranging circumstances so that scientist A can experience what B experienced? How can scientist A know if B's use of a particular verbal label to describe an experience denotes the same subjective event? Scientist A may infer from B's nonverbal behavior (tone of voice, flushed face, nervous mannerisms, etc.) or the label B uses that B is, in fact, experiencing the same subjective event. However, such inferential means of achieving agreement are, rightfully, suspect for all but the most simple environmentally-derived sensory events (Greenspoon, 1955; Rosenthal, 1966; Schachter and Singer, 1962). We must approach the study of subjective experience cautiously, despite its omnipresence and centrality in our day-to-day lives (Argyle, Salter, Nicholson, Williams and Burgess, 1970; Dawes and Kramer, 1966; Ketterer, 1982; Scherer, Koiuvumaki and Rosenthal, 1972; Zajonc, 1980). But we must also recognize that interobserver agreement, as achieved in many (but not all!) other arenas of science, is intrinsically impossible for the study of subjective experience. Only by doing so may we gain some ground on the puzzle of consciousness.

Rigorous psychological science has advanced by adhering to Occam's razor (Sheridan, 1971) when inferring mental phenomena. That is to say, by applying behavioral or biological criteria when assessing the need for invoking new mentalistic constructs, one can reduce the unproductive squabbles that occur with less rigorous efforts (Lieberman, 1979, 1981). If we invoke new mental constructs only when a large group of individuals agree on the occurrence of a subjective event (under stated conditions) or when behavioral or biological phenomena demand an explanation that is outside the realm of such interobserver agreement on mental events, we may avoid arguing over the occurrence or nonoccurrence of highly idiosyncratic experiences (Lieberman, 1979).

Some theorists assert that the initiation and explicit control of complex and coherent behavior should be the basis for inferring consciousness. For example, Griffin (1976) relies exclusively on inference from organism initiated behavior (such as the waggle dance of a particular species of honeybee which directs its companions to a food source) to argue that some form of internal representation must occur. Presumably such an internal representation has a phenomenological concomitant. Since we are necessarily dependent upon inference from even human behavior for proof of another being's experiential world, such an approach is not wholly inappropriate. For those who argue that even human verbal report is insufficient for demonstrating tche occurrence of a subjective world, such reasoning would be unacceptable. No appeal to evidence, short of that which is immediately available to sensory reception by external observers, will satisfy.

We generally rely on inference, from both verbal reports and nonverbal behavior, to ascertain whether another person is experiencing what we experience in a given situation. Thus, the behavior of an organism is always the basis for deciding whether the organism is experiencing a given event. However, behavior alone does not prove the existence of conscious awareness. For example, a spinal cord transected from higher central nervous system processes is capable of behaving (i.e., responding reflexively to a stimulus). Would we assert that this allows us to infer a subjective world? In the absence of verbal abilities, we are forced to rely on inference from nonverbal behavior. For example, few people would argue that an aphasic patient is a nonconscious being.

And yet, one must begin the study of awareness with a respect for individual verbal reports. These reports are phenomena as much in need of examination as other observable behavior, even if not accepted as veridical reflections or descriptions of the experienced world. The fact that verbal report can frequently be inaccurate as a predictor of behavior (Nisbett and Wilson, 1977) has, unfortunately, often been misinterpreted as support for the assertion that verbal report bears little or no relationship to subjective experience. This is an assertion wholely lacking in empirical foundation. Many psychologists have chosen to ignore the verbal report-subjective experience relationship, thus avoiding the mind-brain problem. However, the topic of interest here is the individual's moment-to-moment experienced world. And only via the individual's verbal report or other observable response, and our own immediate experience under the same circumstances, may we ascertain the occurrence or non-occurrence of such phenomena. This does not mean that blind acceptance of the predictive usefulness or accuracy of subjective reports is necessary. However, the assertion that our subjective experience has no correspondence to our verbal descriptions or objective reality is patently absurd (Smith and Miller, 1978; Stevens, 1975; White, 1980), and unlikely to lead to productive investigation of those psychoneural mechanisms that are consciousness. Rather, the more useful working hypothesis might be that accuracy of self-report on subjective experience, as a reflection of experience and predictor of behavior, varies with a number of unspecified parameters. For example, abstractness, distance in time from an experienced event or poor verbal ability might be expected to interfere with accurate reporting. Thus, it is necessary to maintain cognizance of those influences likely to reduce accuracy or complicate interpretation of subjective reports.

Barriers to the Study of Subjective Events

There are a number of phenomena that are likely to interfere with one's ability to obtain a complete and accurate description of an individual's subjective world. First, in studying the naturally occuring flow of subjective experience we are in a quandary similar to that faced by relativity theory in physics. *The observer (whether investigator observing a subject or subject observing him/herself) affects the observed by the act of observing.* When we ask a subject to report on his/her subjective experience, we can no longer be certain that the conscious events are the same as they might be if he/she were not consciously and volitionally attending to and reporting on them. For example, the mere attempt to verbally report the flow of experience reduces the rapidity of shifts in cognitive/attentional foci (Pope, 1978). Further, the physical or mental presence of an observer (self or other) produces a cognitive set resulting in a self-censoring of certain types of subjective experiences or reports (e.g., those socially designated as abnormal or inconsequential). For example, in Milgram's (1975) classic work on obedience to authority, a number of parameters were demonstrated to have a significant impact on subject compliance to the experimenter's requests. Yet, when asked why they complied, subjects framed explanations of their behavior in terms of who was "responsible" for the experiment. None noted the manipulated, and presumably causal, influences. Such post-hoc explanations of one's own behavior are clearly influenced by plausibility and audience (Nisbett and Wilson, 1977). The attentional demands of the task, and the subject's discomfort with his/her complicity in the experiment, appear to have led to a narrowed cognitive focus on a socially acceptable answer (designating personal nonresponsibility) and the confederate's deserving "stupidity."

Secondly, *waiting until an event is over allows memory processes to filter and reconstruct actual experience.* One's conscious memory of immediate experience is always a truncated version of the total subjective field. For example, in normal subjects much information in iconic (visual) or echoic (auditory) sensory registration memory fades so rapidly that focusing attention on one part of the subjective field in order to report on it allows the rest of the field to fade from access for verbal description (Cherry, 1953; Neisser, 1967; Sperling, 1967). Post-hoc recall of material to which attention was not directed is often distorted by, as yet, ill-defined processes (Loftus and Loftus, 1980).

Third, *the richness and detail of one's subjective field is so vast that even the trained analytic introspectionists of the early 1900s reportedly took fifteen minutes to describe a second or two of observation* (Boring, 1950). This vast amount of information is generally in the form of visual or auditory stimulation—those senses with which we monitor our environment. Unless we are prepared ahead of time to encode the subjective field in great detail, most of the information it contains (particularly those parts on which attention is not focused) fades from accessible memory. Whether such contextual material is recorded, but unaccessible, is unknown. For most people, most of the time, it is ecologically unusual (e.g., in illness or during meditation) for attention to be focused on somatic, kinaesthetic, tactile, proprioceptive or olfactory stimulation. Thus, low intensity variation in those sensory processes will tend to go unreported/experienced.

Fourth, one's subjective experience is not a binary phenomenon. Rather, *one's experience of various stimuli in the experienced world seems to fade in intensity* *as the stimuli recede in space and intensity from the point of attentional focus.* This figure/ground characteristic is intrinsic to awareness, as argued by the Gestaltists (Köhler, 1967). But it is important to note that objects of attentional focus ("figure") are generally experienced and remembered in greater detail than those which constitute context ("ground"). This distinction affects recall of at least visual and auditory events (Broadbent, 1958; Cherry, 1953; Sperling, 1967) with figure being recalled better. It is unclear, at this time, whether those events constituting ground are recorded and/or recallable under special conditions (e.g., hypnosis, drug-induced, later spontaneous recall of previously "forgotten" information, etc.).

Fifth, *verbal labels are frequently not accurate for stimuli (e.g., somatic arousal) which have not been subject to constant interpersonal feedback training in the subject's past* (Leff, 1978; Zajonc, 1980). This is particularly true for the somatosensory experiences which constitute emotion (Izard, 1977; Plutchik, 1980). Given the tendency for attention to be externally focused, it is not surprising that verbal labels are most accurate and specific for experiences arising from stimuli outside the body (Plutchik, 1980) and with which the subject has had more, rather than less, experience. This does not mean that labels of somatic events are totally unrelated to objective measures of such stimuli. Indeed, if appropriate conditions are arranged and appropriate measures used, significant relationships between somatic arousal and reported (experienced) arousal are observed (Ehrlichman and Wiener, 1980; Ekblom and Goldberg, 1971; Gutmann, Squires and Pollack, 1981; Heiman, 1977; Ketterer, 1982; Lollgen, Graham and Sjogaard, 1980; Smith, Ketterer and Concannon, 1981; Thayer, 1970; Wincze, Hoon and Hoon, 1977). However, under ecologically normative circumstances, self-report of affective arousal is determined more by the interpersonal contingencies of the immediate environment than by the degree of arousal per se (Gazzaniga and Volpe, 1981; Ketterer, 1982; Ketterer and Smith, 1985; Ketterer et al., 1985; Nisbett and Wilson, 1977; Schachter and Singer, 1962).

Validating Subjective Events

The most fundamental means of scientifically verifying the "reality" of an event is interobserver agreement. If two or more independent observers agree that an event took place, one has the requisite beginnings of scientific inquiry. However, it is common in science to posit the existence of hypothetical events or processes and to test predictions based on one's understanding of these events/processes as a means of validating or disconfirming their existence (Popper, 1966). Thus, interobserver agreement need not be of the subjective experience itself, but may be of the behavioral effects of an hypothesized effect or process. Mental phenomena, by their intrinsic nature, are not subject to direct interobserver validation and must be confirmed in another way. Lieberman (1979) points out that, for introspective data, at least three other means of supporting the validity of subjective events exist. These include: within-subject agreement; cross-subject agreement; and convergent agreement.

The first means is to *test the reliability of reports about a subjective event for a given subject across a number of trials with consistent environmental stimulation (e.g., subliminal tachistoscopic presentation).* Such methods have been used in psychophysics with great success (Stevens, 1975). A subject may be asked to rate the relative brightness of a pair of lights several times in a random series of trials. Agreement across these trials raises confidence in the occurrence and validity of the source of judgment (subjective experience). Failure to achieve such agreement would raise doubts about its predictive usefulness, if not its very occurrence.

Second, *one can ask different subjects to report their experience under a standard stimulus situation when a standard behavioral response is given.* Failure to achieve cross-subject agreement does not, in and of itself, disprove the occurrence of the experience leading to the subjective report. However, it does raise doubts as to its predictive usefulness. This is also a method used by psychophysicists (Stevens, 1975). Verbal abilities enter into consideration here. Our labels for internal phenomena are determined by our past sociocultural experience in labeling (Leff, 1978). The ability to discriminate fine distinctions in internal experience is, almost certainly, a function of interpersonally reinforced experience at internal attentional focusing (Glass, 1977; Holmes, 1974; Ketterer, 1982; Ketterer and Smith, 1985; Leff, 1978; Smith and Miller, 1978; White, 1980).

Third, *we can invest some confidence in a subjective report if it is consistent with other evidence.* Such evidence might consist of nonverbal behavior. When subjective report and nonverbal behavior are congruent, we can have greater assurance of the validity of the report than if they are not. If a child states that he/she was angry at school and the teacher reports that the child threw things about the classroom and yelled abusively, we can trust the child's subjective report. If the teacher's report were the same and the child reported no anger, we would have to question the validity of one or the other.

Another means of studying subjective experience is to study the reports of patients who have incurred damage to identical areas of the central nervous system. *Consistency in self-reports in response to standard stimuli or task demands across a group of homogeneously damaged patients raises one's level of confidence in the validity of the source of such reports.* Lack of consistency, again, would not necessarily indicate a lack of validity. But it would not bolster one's hopes for a strong empirical approach to subjective experience. This method has been most illuminating and scientifically heuristic. The presentation of a unilateral stimulus to callosally-sectioned patients, and their inability to respond appropriately with motor systems controlled by contralateral cortex, may well be responsible for the recent increased interest in consciousness (Sperry, 1964, 1966, 1968, 1969).

A final possible way of achieving a relatively high degree of concurrent confidence while studying subjective experience is, as noted in the introduction to this paper, to *assume "psychoneural equivalence" (Kandel, 1979; Ryle, 1949; Uttal, 1978) as a working thesis and to study the electrochemical concomitants (or correlates) of psychological activity under varying stimulus conditions.* The assumption of identity between some group of brain processes and psychological phenomena does not allow one to escape the problem of mapping one domain (subjective experience) onto the other (neurophysiological processes), particularly when nonmotoric processes are involved. In identifying the relevant paramenters, not only must we demonstrate that the anatomical location is functionally feasible, but that the temporal course of the electrochemical event(s) coincides with that of the subjective event and that the neurophysiological configuration involves input from the indicated sensory channels or central nervous system processes ("memory"). Development of such techniques as evoked potentials (Begleiter, 1979; Otto, 1978), nuclear magnetic resonance blood flow (Singer and Crooks, 1983) and positron emission tomography (Wagner et al., 1983) are increasing our access to the formerly unavailable black box.

It is assumed here that all mental processes, including the subjective experience of awareness, are concomitants of some electrochemical configuration or configurations in the central nervous system. The psychoneural equivalent of one's being aware of only a small part of one's total potential experiential world may be found in the fact that thousands of signals reach the brain each second from every part of the body and yet only a small portion emerges as figure in experience—and thus overtly conscious and verbalizable. At the cellular level, learning to ignore nonattended bodily cues may involve inhibition of the firing of its CNS representation or merely prevention of spread of such activity to other populations of cells. Under ideal conditions, one would hope to find a neural event which occurs if, and only if, a particular subjective experience also occurs. However, one must bear in mind the possibility that a psychoneural event could occur without being experienced. Thus, absolute co-occurrence of the subjective experience and the objective brain event may not reasonably be used as the criterion for psychoneural equivalence. The best that can be said is that a neural event which occurs every time a subjective event occurs (within measurement error) may be its psychoneural equivalent. However, the neural event may also occur at other times without the subjective experience. The techniques that psychophysiologists have developed to study sleep (Arkin, Antrobus and Ellman, 1978), memory (John, 1972; John, Shimokichi and Bartlett, 1969), perception (Erdelyi, 1974; Ritter, 1978; Shevrin and Dickman, 1980; Shevrin and Fritzler, 1968), cognitive processes (Begleiter, 1979; Comper and LaCroix, 1981; Ketterer and Smith, 1977; LaCroix and Comper, 1979; Ritter, 1978; Smith and Ketterer, 1982) and affective arousal (Ketterer, 1982; Ketterer and Smith, 1985; Smith, Ketterer and Concannon, 1981; Stern and Janes, 1973; Zajonc, 1980) are all germane here. Most of these indirect measures of CNS activity are dependent upon a number of complex intermediating biological mechanisms (Greenfield and Sternbach, 1972; Martin and Venables, 1980). These influences make direct inference problematic, but not totally inappropriate. In addition, such measures are typically reflective of large ensembles of CNS cells rather than focally discrete tissue or complex patterns of activity that are widely distributed. While such techniques must be interpreted cautiously, they are not without some use to the study of awareness and subjective experience.

Content of Awareness

In this section, we take up the task of defining the "what" of consciousness. Of what stimuli, bodily or mental processes are we aware? And, by implication, of what nervous system activity are we unaware? Why are only some brain events experienced and not others? Why does most of normal waking consciousness seem to be focused on external events (generally of a visual or auditory nature) or memories/anticipations/fantasies of such events?

The focus or figure of attention may be any type or, more likely, constellation of stimulation, including: visual; auditory; tactile; vestibular; olfactory; proprioceptive; kinaesthetic; somaesthetic; or cognitive. For present purposes, the latter category includes such commonly identified subjective events as "thought," "fantasy," "dreaming," "imagery" and "memory." Cognition is presumably structured by previous informational transformations of sensory data (i.e., prior experience). Ground in the experienced world refers to all concurrent sensory input and cognitive activity that is not experienced directly. Much of ground is accessible to consciousness if attention is focused on it, but there appear to be many psychoneural processes that are not accessible to conscious awareness under any conditions (Erdelyi, 1974; Gazzaniga and Volpe, 1981; Holmes, 1974; Nisbett and Wilson, 1977; Posner, 1982; Puccetti, 1981; Shevrin and Dickman, 1980; Zajonc, 1980). Certainly one does not directly experience such basic cognitive activities as phoneme categorization (Liberman et al., 1967) or suppression of background stimulation. One might also note that, during day-to-day routine, no focal cognizance of the adjustments carried out to control the immense number of somatic processes that regulate vegetative function occurs (e.g., blood pressure; localized blood flow; gastric secretion; opening and closing of the duodenum), despite the fact that conscious content has a powerful relationship to such processes (Ax, 1953; Cannon, 1932; Davison, Robins and Johnson, 1983; Ketterer, 1982; Orton et al., 1983; Schuele, 1983).

Additionally, the temporal limits of the experienced world must be recognized. Whatever one experiences is experienced "now." Even though we perceive events as having varying duration, our immediate subjective world is in the psychological moment. This experience of "now" has generally been studied in the context of theory about perceptual defense—the notion that we choose (nonconsciously) to perceive only those events that are nonthreatening (Erdelyi, 1974). While the defensive functions of perception have proven difficult to demonstrate, the study of its paradigmatic methodology, subliminal perception, has provided us with an approximate lower limit to our ability to perceive the passage of time. Subliminal perception involves the presentation of stimuli for very short intervals. At some lower limit of stimulus duration, subjects uniformly deny experiencing the stimulus at all. This limit appears to be about 10 to 30 milliseconds. However, the subliminal paradigm is an artificial situation where attention is consciously directed to only one very simple stimulus. Estimates of the minimal time necessary to perceive an event rise with more complex information processing situations. Efron (1970a, 1970b) asked subjects to decide on the "simultaneity" of onset (or onset for one and offset for the other) of two stimuli and found that 120–240 milliseconds was the approximate duration in which simultaneity was reported. This estimate agrees with data derived from evoked potential studies of perceptual processing (Renault et al., 1982). Thus, our best estimate of the "immediate experienced moment" in more natural circumstances is 100–250 milliseconds.

External Sensation as Primary Cognition

The most striking aspect of our attention to the external world is its ever-changing nature. If we "attend to our attention," we find that it is constantly changing focus from one figure/ground constellation to another. However, most changes in the environment appear to occur *prior* to our attending to them. That is, we do not consciously choose to attend to environmental changes in stimulation. The shifting of attention toward a loud noise allows us to gain more information about its source that may be adaptively useful. But the detection of such a stimulus in an otherwise steady-state background environment generally appears to occur *prior* to volitionally directed attention (Broadbent and Gregory, 1964; Deutsch and Deutsch, 1963; Moray, 1959; Treisman, 1960). This is the process Pavlov (1927) referred to as the "orienting response" (OR). Information triggering an OR is apparently processed preattentively.

What function then does the constant shifting of attention serve in the absence of a stimulus eliciting an OR? Perhaps a suggestion lies in the phenomenon experienced when one does not allow attention to shift or when one reduces all external stimulation to a steady-state minimum (Lilly, 1972; Schuman, 1980). When such limits are placed on external stimulation, we lose the subjective experience of the stimulus. Eventually, the brain appears to manufacture (or perhaps attend to already active but normally unattended?) hallucinatory experiences of a dreamlike nature (Lilly, 1972). For reasons that are unclear, such experiences are frequently accompanied by powerful affective arousal. In light of this observation, we can infer that normal waking consciousness may require relatively constant external stimulation to exert preemptive control over weaker internal mental processes that are often emotionally arousing.

Cognitive Processes

What used to be called "thought" or "secondary process" (Freud, 1920) mental activity is here called cognition. Cognition is a mentalistic construct with ill-defined boundaries. For present purposes, cognition is defined as the transduction, transformation, storage or use of environmentally-derived, information-carrying energy patterns by the central nervous system. Such psychoneural activity may or may not be subjectively experienced by the organism. Clearly there are mental processes, distinct from affect, that can be grouped under cognition—discrimination, memory, language, reasoning, abstraction, etc. Yet most mental phenomena sit on the border between affect and cognition. Attitudes, for example, are cognitions (ideas, assumptions) in response to which a particular person displays affective arousal of relatively strong intensity. The assertion "Handguns should be banned" is an idea about which one can feel neutral, positive or negative. If one feels neutral, the idea is largely cognitive. If one feels positive or negative, the mental event ceases to be wholly cognitive in nature and starts to become affective (Izard, 1977; Lazarus, 1984; Plutchik, 1980; Zajonc, 1984). There is probably no such thing as a purely cognitive or purely affective mental event. More likely, all mental activity has at least some cognitive and some affective processing. The question of the relative independence of affect and cognition will only be answered definitively when we have achieved a more comprehensive body of knowledge about psychoneural relationships (Lazarus, 1984; Zajonc, 1980, 1984). It may aid comprehension if we begin this section with the assumption, as noted by Plutchik (1980), that cognition is presumed to have evolved to predict future events and thus foster adaptive behavior.

Memory. There is a tendency to conceptualize memory as a unitary, sequential information-processing phenomenon. But used in its broadest sense, the term memory encompasses at least two distinct sets of processes. For present purposes, we must distinguish between "conscious" (or "declarative") and "automatistic" (or "procedural") memory (Fox, 1983; Herbert, 1983). Conscious memory occurs when a person experiences him/herself volitionally or spontaneously recalling some piece of information. This is memory as the layperson uses the term. Like most mental processes, we are aware of memory when it is not working smoothly, as in the tip-of-the-tongue phenomenon. Automatistic memory is the storage and use of information without the concomitant experience of "recalling." When one enters an unfamiliar building and yet manages to negotiate hallways and doors efficiently and smoothly, one is calling on previously stored information about what to expect and how to use such structures. Yet no conscious recalling of past experience with doors and hallways is necessary for that information to be used. One uses the recorded information without the conscious experience of doing so. Both forms of memory occur for all sensory information. But visual and auditory images seem to be the primary constituents of conscious memory.

Conscious memory is generally conceptualized as a sequential set of temporally-overlapping storage processes. These are frequently referred to as: "iconic/echoic" or "sensory registration," "immediate" or "short-term" and "remote" or "long-term" stores. The first of these, as conventionally conceived, has largely been abandoned as a significant phenomenon for storage and use of information (Haber, 1983). But the sequential nature of memory "consolidation" is still widely held.

The topic of conscious memory would not be complete without consideration of the historical topic of repression (Freud, 1920). Repression is classically defined as the automatic, nonvolitional and unconscious exclusion from conscious awareness of an event, memory, impulse or other occurent mental episode because of its capacity to cause "psychic pain" (negative affect). Holmes (1974) challenged the theory of repression by reviewing the lack of experimental evidence and empirical support for four corollaries derived from the theory. These four corollaries are:

(1) ...repression is a loss (of awareness) which is specifically designed to selectively eliminate from consciousness those memories or related associations which cause the individual "pain."
(2) ...repression is not under conscious control.
(3) ...material which is repressed is not lost but rather stored in the unconscious.
(4) Repression...involves the assignment of material to the unconscious after the material has been consciously recognized by the individual. (pp. 632–633)

Holmes and his colleagues induced "ego threat" (i.e., psychic pain) by providing subjects with negative feedback following a Rorschach test (e.g., "indicates homosexuality"), and then testing the subject's memory for events during Rorschach administration, as well as memory for a separate experiment that immediately followed the Rorschach feedback (e.g., a paired learning task in another room). The effects of ego-enhancing feedback (e.g., "indicates brilliance") and cognitive interference (reading nonsense words) following Rorschach feedback, as well as pre-Rorschach instructions designed to induce a volitional set to remember, were also studied in one or more of a series of experiments. In direct contradiction to corollaries 1, 2 and 4 above, data has been garnered which demonstrates that:

(1) Ego-threat is nonselective (i.e., it affects all information, however innocuous, being currently processed) in its effects on recall rather than specific to the "painful" stimulus (Flavell, 1955; Holmes, 1972; Holmes and Schallow, 1969).

Cognitive interference (i.e., a stimulus assumed not to cause psychic pain) produces a memory decrement of the same magnitude and type as ego threat (Holmes and Schallow, 1969).

Ego enhancing stimuli (i.e., a stimulus also assumed not to cause psychic pain) produce a memory decrement of the same magnitude and type as ego threat (Holmes, 1972).

Threatening words are as easy to recall, once learned, as nonthreatening words (Truax, 1957). Thus, the memory decrement is probably not a recall problem but a storage problem.

(2) Introduction of a set to learn material dissipates the effects of threat induced repression (Aborn, 1953). Thus, conscious and volitional cognitive processes can affect repression.

(4) Subjects selectively attend to (i.e., ruminate about) rather than avoid, threatening tasks (D'Zurilla, 1965). Thus, subjects are obsessionally aware of the pain-evoking stimulus rather than unaware of it.

Holmes summarizes by asserting that a phenomenon which appears strikingly similar to those events used as exemplars of repression has indeed been observed to exist in the laboratory. But careful empirical scrutiny of this phenomenon has consistently revealed that it is more accurately conceptualized as a selective attentional, rather than a repressed memory, mechanism. Affective arousal (i.e., ego threat) during stimulus exposure and/or attempted recall, appears to "scramble" those cognitive processes responsible for volitional recall.

The meaning of a stimulus (i.e., its adaptive significance?) also seems to determine whether or not attention is paid to it at the time of exposure and thus whether or not the stimulus will be volitionally recallable. Such attentional focusing is a primary determinant of availability for volitional and conscious recall.

> Consider the typical case of repression in which the client cannot remember elements of his experience which the therapist deems important. The difference between what the client does remember and what the therapist thinks the client should remember may be due to differences in the client's and therapist's focusing of attention and sets rather than to repression by the client. That is, independent of any defense, the client may not have focused attention on the elements of experience considered important by the therapist, a focusing which would influence the level of learning and subsequent recall. Analogously, when after driving across a bridge the commuter does not remember the same things as the structural engineer, can it be said that the commuter is repressing? The fact that later the repressed material is subject to recall is probably not due to the "return of the repressed" but rather to the client's change in (attentional) orientation during the course of therapy. (Holmes, 1974, p. 650)

Automatistic memory occurs without the experience of the returning of a stored event to awareness. When we enter a room and see a chair we have never seen before, we rarely experience any information processing or feature detection/pattern matching concerning its labeling or use. This high-speed, automatistic use of stored information in the CNS (i.e., "memory") is accomplished without consciousness. Freud (see Dixon, 1981) might have referred to this as preconscious activity, accessible to consciousness but not currently experienced. To what extent does such nonexperienced information processing affect our behavior and conscious mental activity?

The accuracy of automatistic memory is so great that we rarely notice it until disruption makes its former presence apparent, as in senile cognitive losses. Patients with diffuse cortical dysfunction will display lapses in the effect contextual information has on their volitional behavior and mentation (e.g., performance of social behaviors inappropriate to the social context such as talking loudly at a movie). The accuracy of conscious memory appears to be less than that of automatistic memory. This is particularly true of situations where initial stimulus exposure or attempted recall occured during emotional arousal (Holmes, 1974).

Fantasy. A good deal of one's day is taken up with internal imaginings of events. Reliving old events, such as interpersonal confrontations in which one comes up with clever repartee that failed to appear during the real event, or anticipating a forthcoming meeting of great significance, are experiences familiar to everyone. Such daydreams cannot completely be explained as stored information (memory) because they frequently contain novel configurations of events, persons or environments. Rather, they represent the use of our considerable cognitive complexity to learn more from previous events, to cope with our own affective response to previous events and to foster improved performance in future ones. Such mental episodes are generally visual and auditory in nature. Tactile, kinaesthetic, somaesthetic, olfactory and gustatory images are rarely present in consciousness. This mental activity appears to serve many purposes including: learning new responses from past failures (Spielberger and DeNike, 1966); allowing temporary emotional release (Perls, 1969); permitting smoother performance of an anticipated action (Gallwey, 1974); and permitting rehearsal of a memory for long-term storage (Horton and Turnage, 1976; Sperling, 1967).

Thought. Cognition is sometimes referred to as being *abstract or stimulus-independent*. That is, a symbol or image with no intrinsic meaning is capable of substituting for events, objects or categories of events or objects, which do have such meaning. Human activity is thus freed from dependency on the immediate physical presence, or a representation of that presence, of a stimulus in order to be able to cognitively plan manipulation of it. Such activities are often, although not always (Boring, 1950), experienced as visual images of the symbol or the stimulus object itself.

Another feature of experienced cognitive processing is *categorization*. We rarely experience this process unless an ambiguous stimulus is presented to us. For example, individuals we generally meet are automatistically and nonconsciously grouped as male or female, black or white, etc. Only when the cues we use for such categorization (e.g., hairstyle and length, coarseness of skin, size, body build, voice, etc.) are mixed, or fall in the middle of a distinguishing continuum, do we become aware of the process. For example, when long hair became fashionable on young men in the 1960s, it was common to hear people talk about their uncertainties or misclassifications as to sex when initially perceiving some men.

Sequencing is another feature of cognition we rarely experience per se. But most people, upon reflection, will say they experience their thoughts as following a direction—general to specific or vice versa, temporally sequential in terms of planned/remembered/fantasized events, etc.

Most experienced cognition consists of a *shuffling of attentional focus between external events and related thoughts.* The greater the variety and change of external stimulation, the less internal cognitive activity is experienced, presumably because of increased dedication of psychoneural circuitry to the processing of external information (Wickens et al., 1983). But more ecologically common is some intermediate level of stimulation. At these intermediate levels of external stimulation, attentional focus can to some extent be controlled volitionally. Such control is disrupted by emotionally significant stimulation occuring outside the figure of attention. The CNS constantly monitors ground/contextual stimulation for such significant events and disrupts attentional focus for reorienting.

Volition, Self-Control and Explanatory Cognition. Nisbett and Wilson (1977) point out that cognition constructed to explain one's own behavior is often inaccurate (see also Gazzangia and Volpe below). Apparently, behaviorally causal networks in the CNS are often either not experienced consciously or are not reported. For example:

> In the experiment by Nisbett and Schachter, subjects were requested to take a series of electric shocks of steadily increasing intensity. Prior to exposure to the shock, some of the subjects were given a placebo pill which, they were told, would produce heart palpitations, breathing irregularities, hand tremor, and butterflies in the stomach. These are the physical symptoms most often reported by subjects as accompanying the experience of electric shock. It was anticipated that when subjects with these instructions were exposed to the shock, they would attribute their arousal symptoms to the pill, and would therefore be willing to tolerate more shock than subjects who could only attribute these aversive symptoms to the shock. And, in fact, the pill attribution subjects took four times as much amperage as shock attribution subjects.
>
> Following his participation in the experiment, each subject in the pill attribution group was interviewed following a Spielberger-type graded debriefing procedure. (a) Question: "I noticed you took more shock than average. Why do you suppose you did?" Typical answer: "Gee, I don't really know... Well, I used to build radios and stuff when I was 13 or 14, and maybe I got used to electric shock." (b) Question: "While you were taking the shock, did you think about the pill at all?" Typical answer: "No, I was too worried about the shock." (c) Question: "Did it occur to you at all that the pill was causing some physical effects?" Typical answer: "No, like I said, I was too busy worrying about the shock." In all, only 3 of 12 subjects reported having made the postulated attribution of arousal to the pill. (d) Finally, the experimenter described the hypothesis of the study in detail, including the postulated process of attribution of symptoms to the pill. He concluded by asking the subject if he might have had any thoughts like those described. Subjects typically said that the hypothesis was very interesting and that many people probably would go through the process that the experimenter described, but so far as they could tell, they themselves had not. (Nisbett and Wilson, 1977, p. 236)

Social psychological research has demonstrated innumerable examples of the same phenomenon in other contexts. The failure of subjects to recognize the role of setting on compliance to authority (Milgram, 1974), the availability of others when deciding whether or not to help someone (Latane and Darley, 1970; Latane and Rodin, 1969) and the nonverbal behavior of others in controlling one's own body placement (Siegman and Feldstein, 1978) are all examples of causal events that subjects typically deny as having had any influence over their behavior. However, Nisbett and Wilson have been taken to task by White (1980) and Smith and Miller (1978) for their absolute denial of awareness of determining influences. Criticisms of their reasoning include failure to consider the implied context of debriefing questions, differential attentional focus at the time of stimulus exposure or behavior occurrence, failure to query phenomenal experience in vivo rather than post-hoc and failure to arrange control situations which would optimize, rather than minimize, the probability of awareness.

Nisbett and Wilson's work does raise the question of the importance of contextual (i.e., ground) information on determining behavior and conscious experience. Those stimuli impinging on the sensorium to which attention is not paid are not ignored or unregistered by the nervous system. Rather they appear to be processed in a phylogenetically primitive cognitional manner. We know the CNS uses this information because personally relevant stimuli embedded in ground are detected differentially at the same levels of intensity as stimuli not compelling such attentional reorientation (Moray, 1959). Polanyi (1958) refers to such background (or contextual) information usage as "tacit knowledge." It appears to form a major determinant of our behavior and experience despite our nonawareness. Such knowledge is sometimes, and may always be, overlearned stimulation or behavior that was initially consciously processed. Several recent pieces of work with unusual human CNS preparations are instructive.

Weiskrantz (1980; Weiskrantz, Warrington, Sanders and Marshall, 1974) has demonstrated that individuals who experience blindness by virtue of cortical damage to the occipital region are able to "guess," at better than chance levels, the location of visual stimuli. While it is known that other visual processing tracts exist than those which are received occipitally, it has always been assumed that conscious experience of a stimulus was a necessary prerequisite for volitional task behavior. Clearly, these alternate nonexperienced tracts may contribute to such behavior even though the individual is not aware of the accuracy of his or her performance. Some such subjects claim to have a feeling or hunch about their responses but most insist they are merely guessing. This is partially consistent with Weiner's (1972; Hofer, 1982) suggestion that the psychoneural circuits resulting in behavior are causally distinct from those resulting in experience. However, clearly Weiskrantz' patients did use this collateral information to achieve their better-than-random performance (Torjussen and Magnussen, 1983; Weiskrantz, 1983; Zihl, 1983).

Gazzaniga (Gazzaniga and Volpe, 1981), using split-brain patients, has demonstrated the automatistic (and generally incorrect) nature of self-explanatory cognition for psychoneural processing that does not have access to linguistic regions of the brain. By showing different pictorial stimuli to each visual hemifield and then offering eight choices of matched stimuli, Gazzaniga is frequently able to elicit two motoric responses—one from each hand. The right hand responds with the correct match for the left hemisphere pictorial stimulus and the left hand with the match for the right hemisphere. However, when asked to justify the choices, patients do not report the stimulus presented to the right hemisphere but instead confabulate a rationale based on the left hemisphere stimulus. For example, when presented with a right hemifield/left hemisphere stimulus of a chicken and a left hemifield/right hemisphere stimulus of a snow storm, subjects will justify their correct responses of a chicken claw and a snow shovel by saying the chicken claw goes with the chicken and one needs a shovel to clean out the chicken shed. No mention is made of the snow storm stimulus and the motoric response generated by that stimulus is automatically incorporated into a seductively cogent explanation based on the known stimulus. Gazzaniga points out that such procedures generally agitate the patient (presumably because of the conflict between different brain systems in acceptable explanations) until he/she is reminded of his/her unique neurological status and the testing method. However, such explanations were rapidly forgotten with the next presentation and the patient would automatistically resume providing confabulated explanations for his/her right hemisphere behavior.

Much of experimental psychology provides further evidence for nonconscious processing affecting overt behavior without the subject's cognizance. Nonverbal (Siegman and Feldstein, 1978) and environmental (Ittleson et al., 1974; Milgram, 1974) influences are particularly likely to go unrecognized by the subject because they are processed as context/ground. Given the limitations of our conscious attentional processes, it appears that many (if not most) psychoneural influences on behavior are not experienced consciously. The over-riding need to generate acceptable explanations of one's own behavior may be a consequence of humankind's dependence on social relationships for survival. For example, it is possible to differentially reinforce behavior in a person without his/her cognizance and increase or decrease its frequency (Dawson, 1973; Furedy, 1973; Greenspoon, 1955). Such effects are ground/contextual and thus not experienced.

Internal Sensation as Primary Affect

Bodily sensation, excepting in illness (Pennebaker, 1982) or some mental disorders like depression (Cassem, 1978), appears to be largely automatistically processed. During day-to-day routine, we rarely attend to bodily sensation. For example, adjustments in interpersonal distance during conversation are carried out with no conscious attention to their determinants or the actual behavior itself (Dittman, 1978). During such events, our attention is focused on the person we are interacting with. And yet, the minor discomfort of too much or too little interpersonal distance, usually without our experiencing it, is capable of leading to whole body movements such as shifting positions in a chair. Indeed, attention ("self consciousness") in such situations often disrupts the motoric smoothness of such nonverbal behavior. This is most evident in sports where behavior must be maximally efficient (Gallwey, 1974). In addition, we appear not to be wired to experience most bodily sensations as discretely as, say, visual sensation. Many bodily processes we are incapable of experiencing at all. Try as we may, we are generally unable to experience our stomach or alveoli. What vague sensations we have of them appear to arise from their effect on other organs (e.g., pressure on the intestinal cavity or expansion of the chest). With the aid of biofeedback, we can gain some control over such processes but even then our experience of them remains a vague, poorly articulated sensation which may arise from other structures.

Affective Processes

There are probably only six to ten primary (i.e., genetically prewired) affective states, each having evolved over the course of human descent for a generic type of interaction with the environment (Plutchik, 1980). People are able to reliably distinguish this number of affective states (Ekman, Levenson and Friesen, 1983; Plutchik, 1980) and similarity ratings clustered according to factor analysis support similar groupings. The hundreds of other emotions, moods and feelings we have names for are probably variants in intensity (e.g., feeling irritated may be low intensity anger) or mixtures of the primary affective states (e.g., mirth may be a mixture of surprise and joy).

Affective arousal seems to compel action. Mandler (in Miller, 1983, p. 146) describes the responses of spinal cord patients whose central nervous system has been severed from new sensory information. Such patients generally report diminished intensity of emotional arousal compared with their premorbid state. The loss can even be scaled according to the level of spinal cord trauma. The anatomically higher the injury, the greater the loss of feeling. Animals experimentally sympathectomized have great difficulty learning new tasks, but remember tasks learned prior to surgery as well as nonsympathectomized animals. While they can function fairly well with their stored memories, new learning is difficult or impossible.

Social maturation consists, in part, in learning not to respond (i.e., to inhibit response) to the first, probably genetically determined, impulse attendent to affective arousal. Under interpersonal contingencies children learn not to hit when angry, not to cry when hurt, not to run when afraid, etc. A large part of this learning is nonmotoric (cognitive), although motoric processes may be involved in the initial learning process.

Those circuits in the CNS whose temporal patterns *are* emotion are phylogenetically older than the ones to which we attribute higher cognition (Gould, 1980; Jaynes, 1976; MacLean, 1954; Papez, 1937). Affect is primarily experienced and described as bodily sensation (an "empty" heart, the "pain" of loneliness, the "tension" of anger). The present author holds that those phenomena classified as affective (moods, feelings, emotions and some aspects of attitudes, desires, wishes, impulses, etc.) are either the direct result of bodily sensation or of nonvolitional and automatistic memory of bodily sensation. Indeed, apart from the behavior it compels and cognition it shapes (Izard, 1977; Papez, 1937; Plutchik, 1980; MacLean, 1954), the somatosensory experience of emotion *is* the experience of emotion. This experiential fact was the foundation of the James-Lange theory of emotion (James, 1890) which held that the somatic arousal attendent to emotion is the emotion. Critics charge that the James-Lange theory cannot be wholly accurate because (1) the subjective experience of emotion, at least in adult humans, often precedes attendent somatic arousal and (2) somatic arousal is supposed to be indiscriminable across affective states. Both of these criticisms are suspect.

The exemplar critique of the James-Lange theory is offered by Schachter and Singer (1962) who injected subjects with epinephrine or saline, gave them an alternative explanation of the consequent somatic arousal ("side effects") or not, and then presented them with either a euphoric or anger-provoking social situation. Epinephrine subjects receiving no explanation experienced what they perceived as genuine and situationally appropriate emotion. Those receiving the alternative explanation experienced "cold" ("as if") emotion. These results have been interpreted as indicating that emotion is nothing more than a cognitive labeling process based on external (nonsomatic) information and nonspecific arousal. Such an interpretation is biologically and psychologically naive (Reisenzein, 1983). Not only have the results gone unreplicated (Marshall and Zimbardo, 1979; Maslach, 1979), but conceptual flaws are rapidly becoming apparent.

First of all, the amount of epinephrine used (10 ml) was small. Epinephrine disappears rapidly from the bloodstream and is presumed to be utilized almost immediately (Liddle, 1981). It is more than likely that the injected epinephrine was metabolized before subjects were even exposed to the social stimulus. Placebo-epinephrine effects may not have been due to cognitive labeling but to an induced predisposition to arousal. Secondly, no attempt was made to measure actual physiological arousal of the different groups. It was assumed that physiological arousal was the same across the groups because they all received the same amount of epinephrine. Even if a gross measure of arousal had been taken and found to be the same across groups, relatively small variations in some somatic locale might be the source of self estimates of arousal. It seems more than likely that the brain monitors more physiological parameters and with more precision than any experimenter to date. Third, the authors assumed that the social stimulus had no additional effect on physiological arousal except via labeling, an unlikely assumption (see Hofer, 1982; Pennebaker, 1981; Weiner, 1972; Zajonc, 1980). And finally, the data are reported in a nomothetic format. It is not clear what proportion of the subjects within each cell actually followed the group pattern.

On the basis of Schachter and Singer's work, the two major criticisms of the James-Lange theory were accepted as valid. This occurred despite the fact that the authors offered no direct demonstration that reliable, significant differentiation in physiological arousal patterns fails to occur across emotional states. Indeed, the more refined our techniques become, the more evidence we find of reliable differences across emotional states (Ax, 1953; Ekman, Levenson and Friesen, 1983; Pennebaker, 1982; Steptoe, 1981) although there may be some interindividual variation in such patterns (Pennebaker, 1982).

The second criticism of the James-Lange theory—that physiological arousal is too slow to explain phenomenological arousal—also is on dubious ground. It seems more likely that, in the mature human, subjective affective arousal is to some extent a learned phenomenon. Automatistic memory, a ubiquitous psychoneural process, and/or genetic programming can be invoked to explain the instantaneousness of experienced emotion in the adult human. Casual observation of infants suggests that the onset of their affective states are as gradual as somatic arousal. As the human grows, he/she probably learns (automatistically) to anticipate the sensory experience that accompanies presentation of appropriate emotional stimuli.

Affect and Cognition

How do people control affective arousal (both somatic and phenomenological)? Aside from avoiding or seeking situations which arouse emotions, *people use deliberate cognitive strategies to modulate affect.* Tucker (Shearer and Tucker, 1981; Tucker and Newman, 1981) asked subjects to enhance or reduce affective arousal and found that subjects did so via "analytic/verbal" strategies (e.g., counting, thinking rationally) while enhancement was accomplished via "global/imaginal" cognition (e.g., imagining one's self as part of the scene, enhancing sensory aspects of the scene). Attending to affect generally facilitates reduction in intensity but people rarely recognize this process as efficacious (Johnson, 1973; Leventhal et al., 1979).

Emotion affects the content of memory recall. Depressed individuals are more likely to recall negative events and to recast events in a negative explanatory manner than nondepressed individuals (Clark and Teasdale, 1982). Thus, current affect affects the content—and currently available cognitive structure—for understanding previous events. If John's (1972) model of memory is correct (see below), then affect may be a powerful determinant of the psychoneural state that represents the "statistical, configurational" engram posited to be memory. Recent findings of diffusely represented neuroendocrine nonsynaptic release of putative intercellular transmitters (Dismukes, 1979; Roberts and Bush, 1981) may be consistent with this notion.

Aside from compelling adaptive response (no simple matter in a complex social creature like homo erectus where a given behavior rarely results in a single contingency), *affective arousal appears to disrupt cognitive activity.* For example, anxiety disrupts verbal/intellectual cognition (Shearer and Tucker, 1981; Tucker et al., 1978). And affective arousal, at the time of initial processing of a stimulus, appears to disrupt memory storage in a manner that makes it inaccessible to later volitional, non-cued recall (Holmes, 1974). Positive and negative affect have the same effect and there is evidence that the memory is, in fact, stored even though not accessible. This attentional-disruption process and consequent memory loss may be what Freud observed in those patients he conceptualized as repressing (Holmes, 1974).

Zajonc (1980) has argued that *it is possible to form an affective response to a stimulus prior to being able to cognitively label or identify it.* Zajonc points out, for example, that masked word stimuli presented tachistoscopically are more accurately judged as semantically similiar than visually similiar or physically present. Thus, "meaning" evaluation (the equivalent of "significance" or affect) is the first, and most basic, of evaluations performed by the nervous system. It is difficult to conceive how an accurate judgement regarding semantic similiarity could be made without some form of prior categorization, a process conventionally conceived of as cognitive. But such a result is intriguing since it carries implications for the fate of our affective responses to nonexperienced (i.e., contextual or ground) stimuli and their influence on subsequent behavior and experience. Dixon (1981) suggests that such information processing, occurring as it does outside of figure (as in subliminal stimulation), is distinct in many ways from that which occurs with conscious awareness. Such processing appears to be based on affectively significant visual and auditory associations rather than verbal associations (Branca, 1957; Razran, 1939; Reiss, 1946; Worthington, 1961).

Since somatosensory stimulation is available as an attentional focus at any time, *there is probably no state of mind that is nonaffective.* The distinction between experiencing no emotion and any particular emotion is probably due to attentional factors and the signal/noise ratio. When attention is rigidly directed elsewhere (than towards somatic sensation) and/or somatic arousal is low, no emotional state is identifiable. When attention is somatically focused and/or somatic arousal is high, emotion is experienced strongly. Thus, the experience of emotion appears to be a threshold phenomenon with the threshold varying according to a relatively stable attentional predisposition or "cognitive style" (Shapiro, 1965) and the total amount of sensory stimulation being concurrently processed. Transient fluctuations in immediate focus of attention, transient fluctuations in arousal and the occurrence/nonoccurrence of other distracting psychoneural stimuli determine whether or not a given affective state will be experienced and how intensely it will be experienced (Ketterer, 1982; Ketterer et al., 1985; Ketterer and Smith, 1985). People vary greatly in the accuracy with which they report sensory data. And those who are labeled anxious or emotionally labile may be overly sensitive to transient, low intensity fluctuations in somatic states (Schandry, 1981).

Determinants of Entry to Awareness

Neurological Fiat

One of the most obvious, and yet least discussed, of the determinants of immediate experience is the structure of the CNS. *Our nervous system evolved to cope with certain types of environmental events and not others.* Thus, some bodily structures have no sensory receptors and can provide no experience. The paradox of the brain itself being insensate when cut is the best example. But some bodily structures do have efferent systems feeding back to the CNS and yet are not experienced. For example, we are unaware of the behavior of our duodenum. Under ecologically unusual circumstances (i.e., biofeedback), we can exert some control over its activity. Yet even while controlling the activity of the duodenum, we have little or no experience of its movements. Certainly nothing comparable to our experience of our arm or leg movements occurs. Another example of CNS structural limitations to consciousness is provided by the fact that stimuli of a very short duration either are not very common in our "average expectable environment" (Hartmann, 1958) or are unimportant to survival. Thus, visual events occurring below a certain level of physical energy per unit time are not experienced. It reportedly requires only one photon, the minimal energy package of light, to cause a retinal cone receptor to fire under optimal (dark adapted) conditions (Cornsweet, 1970). However, not until we reach much larger amounts of stimulus energy per unit time is there evidence that the CNS is recording and using information. And even larger amounts of stimulus energy per unit time are required for subjective events to occur.

The phenomenon of subliminal stimulation and its consequent effect on evoked potentials and overt behavior illustrates that stimulus energies below those necessary for subjective experience to occur can still have detectable behavioral and experiential CNS effects (Dixon, 1981). Such artificial conditions are largely irrelevant to information processing during routine day-to-day events (Haber, 1983). None-the-less, the subliminal perception paradigm provides a relatively well controlled means for studying the fate of nonexperienced input to the CNS. Dixon (1981) makes a strong case for the likelihood that such nonexperienced input is processed in a nonverbal manner. Rather than having its effects determined on the basis of semantically-structured algorithms/schemas/associations, such input appears to be processed via nonverbal (i.e., on the basis of visual or auditory associations) structures (Fiss, 1966; Hilgard, 1962;

Pine, 1964). For example, Shevrin and Fritzler (1968) presented subjects with a rebus (a word picture consisting of two visual stimuli whose combined names would suggest a third stimulus, such as a pen and a knee) at subliminal (10 ms) or supraliminal (70 ms) duration, and scored verbal associations as (a) uncombined visual stimulus associates (such as "ink" and "leg"), (b) clang associations (such as "pennant" or "any") or (c) rebus associates (such as "coin" or "Lincoln"). Results indicated significantly more rebus associates to the subliminal stimulus. Thus, nonexperienced processing appears to result in non-normative cognitive processing. If this is true for more ecologically common contextual information processing, it may support the hypothesized special relationship between language and conscious experience, or at least the ability to remember and report on conscious experience (Gazzaniga and Volpe, 1981; Jaynes, 1976; Sperry, 1968).

Attention

While attention has been a traditional topic of interest for psychologists (James, 1980; Köhler, 1967), it has only achieved respectability in behavioral circles by virtue of empirical demonstrations of its effects. For example, Sperling (1967) flashed three × three arrays of letters to subjects, followed by a tone indicating which row the subject was to report verbally. By attending to the appropriate set of letters in the icon and accurately reporting only that set (regardless of which set the tone indicated), the subjects demonstrated that nonattended (ground) stimulation decayed from available mental experience. Thus, the effect of loss (for purposes of verbal reporting anyway) due to nonattention was demonstrated. E. Colin Cherry (1953) has demonstrated the same process for auditory stimuli.

Perhaps the most notable characteristic of awareness is that it is always "of something." One is rarely without any object, or figure, of awareness which, in turn, is always embedded in a context or ground. The learning of awareness without a focal object is asserted to be a skill requiring years of practice (Suzuki, 1970). We are so predisposed to have an object of awareness that the idea of awareness without such a focus is inconceivable for most people. The neurophysiological concomitant of *the figure/ground distinction* may be reflected in evoked potentials. For example, evoked potentials (EPs) elicited by "primary" (volitionally attended) stimuli are larger than those elicited by nonattended stimuli in a reciprocal manner (Wickens et. al, 1983). Thus, nonattended stimuli apparently arrive at cortical levels even though they are contextually processed.

When our awareness is of a given object, we are said to be "attending to" it. While this phrase carries the connotation of orienting our body and external sensory receptors in a manner that maximizes proximal stimulus strength, we are also said to be attending when we think a problem through, remember a sequence of events or divert our attention to a conversation occurring across the room while appearing to continue to attend to something else. Clearly, the commonality here is that consciousness is of some subset of active CNS events, whether internally or externally generated. The realm of potential objects of attention is very large. But only some subgroup constitutes the object of attention at any one point in time. The CNS clearly monitors some, and perhaps all, of these nonattended stimuli despite our noncognizance of such monitoring (Broadbent and Gregory, 1964; Deutsch and Deutsch, 1963; Moray, 1959; Treisman, 1960). Some examples may be ideas that "pop into one's head" (as in the "eureka" experience) or unwilled and sudden changes in unattended stimulation (a loud noise or pinprick) that refocuses one's awareness on a new object.

Attention to a figure is a necessary prerequisite for conscious, volitional (i.e., "willed") memory of that figure as noted by Holmes above. It is interesting to note that the attentional bias hypothesized by Holmes is not itself volitional but rather an overlearned, automatic, habitual means of scrutinizing the world. We attend to, and thus later recall, those things which we have learned are useful, important and rewarding in some way. Such choices cease to be conscious and volitional in familiar situations.

Overlearning and Automatization

The capacity of the nervous system to store and use information to cope with new (but *not* novel) tasks is truly remarkable. This process occurs as a result of repeated coping with similar task demands. When first taking up tennis, one's bodily movements are usually volitional, cumbersome, ineffective and reactive. With sufficient practice they became automatic, smooth, efficient and anticipatory. At the zenith of the sport are players who report being "in the zone" when they are functioning most effectively and without the experience of effort or self-consciousness. This process of *gradual loss of cognizance with overlearning is characteristic of virtually all complex cognitive (e.g., reading) and behavioral skills* (Furst, 1971; Liberman, 1983; Shiffrin and Schneider, 1977).

> Any reader who has mastered typing, driving a car, or playing a musical instrument can verify these arguments in an informal way. While the skill is being learned, one must consciously control every activity involved, rendering the task difficult and tiring but also making it possible to report on what is being done and why. As skill develops, the fluency of the action increases and conscious control lessens. A point is reached when a typist, for example, asked where a given key is on the keyboard, is unable to answer verbally; the knowledge is said to be "in the fingers." The routinized and overlearned nature of such skills seems to eliminate the necessity of their being consciously controlled at every stage and thus prevents accurate self-reports. (Smith and Miller, 1978, p. 361)

As noted above, our verbal explanations of our own behavior are rarely accurate (Gazzaniga and Volpe, 1981; Nisbett and Wilson, 1977), in part because of these overlearned cognitive, attentional processes and the inherent limitations of conscious content (Miller, 1956). The immediate social/interpersonal anticipated contingencies operative on our verbal self-explanations only occasionally reward accuracy (Milgram, 1974).

Neurophysiology of Awareness

The central mystery of the mind-brain problem for the modern behavioral or brain scientist, is the "where" of consciousness. More specifically, what neurophysiological constellations of electrochemical activity constitute a given subjective event? Some investigators (the epiphenomenolists) seek to deny this question (Hofer, 1982; Kandel, 1979; Kornhuber, 1978; Weiner, 1972) and some (the interactive dualists) invoke metaphysical processes in attempting explication of the mind-brain problem (Eccles, 1978; Popper and Eccles, 1977). But the majority seem to have shifted to one of a group of positions that assume consciousness is a concomitant of a given brain process or set of brain processes. Variously called dual-aspect monism (Russell, 1921), mind-brain identity (Ryle, 1949) or psychoneural equivalence (Uttal, 1978), this position is reductionistic, materialistic, mechanistic and emergent. That is to say, a material cause (substrate? equivalent? concomitant?) of consciousness is posited as a necessary prerequisite for its existence, but consciousness stands as an emergent product of higher-order structural organization of neurophysiological processes that would not have been predicted given an otherwise complete description of the functioning of brain cells and subsystems.

Given the fundamental epistemological distinction between our knowledge of the nervous system and our subjective experience, it behooves us to ask how we can localize the ghost in the machine. More succinctly, what neurophysiological processes are the material equivalent of (or substrate for) a given conscious experience? The answer to this question will necessarily involve not only the location (anatomy) but the particular temporally patterned, electrochemical activities that give rise to a particular conscious experience.

In order to be able to safely infer equivalence between a neurophysiological event and a psychological process, Uttal (1978) notes the need to: (1) demonstrate equivalence of duration and timing; (2) avoid the error of analogy, as is often made between the habituation of a behavior and the habituation of a neuron; (3) establish the validity of the CNS system theorized about as appropriate to the psychological event; (4) avoid assuming the inherent validity of a mathematical model simply because it provides the best available fit to the data; (5) avoid covarying more than one controlling stimulus dimension; and, (6) demonstrate not only a probabilistic relationship but necessity and sufficiency.

Since it is likely that a given mental event may occur without the concomitant subjective experience (Dixon, 1981; Freud, 1920; Holmes, 1974; Neisser, 1967, 1976; Nisbett and Wilson, 1977), we cannot require an absolute one-to-one correspondence of the neurophysiological and subjective events. However, the neurophysiological event must be present if the subjective event occurs. In addition, since redundancy appears to be common in central nervous system processing, we must recognize that close scrutiny of a subjective event may be necessary when studying brain damaged individuals. A given environmental event is represented centrally as a configuration of widely separated sensory and memory channels (Goldman-Rakic and Schwartz, 1982; Ojemann, 1983; Szentagothai, 1972). If, say, the ascending auditory channels are damaged we ought to predict subjective experiential (when the patient is cognizant of an experiential loss) or subjectively-based performance (when the patient is not cognizant of any such loss) deficits.

Certainly we must acknowledge the essential role of the ascending reticular activating system (ARAS) for the existence of consciousness to occur (Moruzzi and McGoun, 1949). However, it is unlikely that ARAS arousal alone, in the absence of concomitant cortical activity can explain consciousness (French and McGoun, 1952.)

The representation of memories in the CNS remains one of the most puzzling aspects of brain function. Lashley's engram (Lashley, 1950) appears to be an overdetermined parallel representation in a temporally dynamic, statistically configured ensemble of cortical column firings (Goldman-Rakic and Schwartz, 1982; Szentagothai, 1972). John describes his understanding of memory as statistical and configurational in nature (John, 1972; Thatcher and John, 1977).

> The critical event in learning is envisaged as the establishment of representational systems of large numbers of neurons in different parts of the brain, whose activity has been effected in a coordinated way by the spatiotemporal characteristics of the stimuli present during a learning experience. The coherent pattern of discharge of neurons in these regions spreads to numerous other regions of the brain. Sustained transactions of activity between participating cells permit rapid interaction among all regions effected by the incoming sequence of stimuli as well as the subsequent spread. This initiates a common mode of activity, a temporal pattern which is coherent across those various regions and specific for that stimulus complex. As this common mode of activity is sustained, certain changes are presumed to take place in the participating neuronal populations, which are thereby established as a representational system. . . .
>
> This theory is statistical, in that the informational significance of an event is represented by the average behavior of a responsive neural ensemble rather than by the exclusive behavior of any specifiable neuron in that ensemble. . . . The theory is configurational in that new responses are based upon the establishment of ensemble activity, rather than upon the elaboration of new pathways or connections. (John, 1972, p. 851)

What John has done is to repeatedly present stimuli, with and without conditioning responses, to cats while recording brain activity. Averaged evoked potentials to learned stimuli yield an idiosyncratic but nonetheless characteristic waveform. When the cat incorrectly generalizes to another stimulus and yields the learned response to the first stimulus, the initial waveform is recorded (John, 1972).

In support of this model, John (1972) also points out that: (1) ablation has failed to locate the site of any memory. Although ablation has produced apparent memory deficits, these are always attributable to generalized damage to such psychoneural processes as motivation, attention or response set; (2) memory deficits following ablation are not evident when the ablation takes place in small sequential steps rather than all at once. This would seem to indicate that no particular site is a necessary prerequisite for functional memory; (3) the firing of individual neurons, while probabilistically responsive to a given stimulus, has never been shown to change in a highly consistent and predictable manner; (4) the firing pattern of a single neuron cannot communicate enough information to account for the complex abilities of humans and animals; (5) many cells in many parts of the brain (18–92% depending on type of stimulus and region of brain) respond to a variety of senses; and (6) learning even a simple conditioning task produces a change in cell behavior in many parts of the brain.

The use of this relatively new tool, the averaged evoked potential, has not yet been fully exploited in examining the conscious-nonconscious distinction in memory. While it is difficult to temporally localize the onset of a memory triggered nonconsciously (nonvolitionally), the use of this technique to study conscious memory seems promising. Most such research to date has been limited to the use of subliminal stimuli to elicit nonconscious brain events (Dixon, 1981; Shevrin, Smith and Fritzler, 1969, 1970, 1971).

Localizing Consciousness: Psychoneural Equivalence

It is a paradox of our sensory apparati that we do not experience perceptual events as being located where the necessary and sufficient neurophysiological event apparently occurs—in the CNS. Rather we experience such events "out there", either at the peripheral receptor (in the case of tactile stimulation) or in the external environment (in the case of auditory or visual localization). Perhaps the most dramatic example of this is the phantom limb phenomenon (Ewalt, Randall and Morris, 1947). But more subtle phenomena also occur.

Damage to peripheral nervous structures does not keep experiential phenomena from occurring if appropriate CNS stimulation occurs (Ojemann, 1983; Penfield and Rasmussen, 1950). While sensory experience appears to be focally organized in cerebral cortex (Lezak, 1976; Walsh, 1978), more complex subjective experiences appear to be redundantly represented in multiple cortical locations by patterned activity of columnar nodules (Goldman-Rakic and Schwartz, 1982; Hubel and Wiesel, 1965; Szentagothai, 1972). However, the loss of visual, tactile and auditory sensation by predictable cortical damage strongly supports the cerebral cortex as the seat (location? equivalent?) of consciousness.

Awareness: The Visual System as Exemplar

Perhaps the most interesting aspect of what is lost with primary sensory cortical damage is raised by several examples of visual phenomena. While it used to be thought that binocular visual fixation was near perfect, recent work by Steinman (Kowler and Steinman, 1980; Steinman, 1974; Steinman et al., 1973) indicates that there is considerable inaccuracy in fixation, particularly following a saccade. Yet this inaccuracy does not result in experienced visual blurring or crossed images. There is a limit to this tolerance of input. When one crosses one's eyes for example, one experiences two semi-superimposed visual images. This relative independence of conscious experience from minor inaccuracies in sensory input probably extends to other sensory systems. It suggests that our internal experience is, as argued by Neisser (1967, 1976), a construction by the nervous system rather than a passive one-to-one representation of sensory inflow. If our sensory experience of external events were a one-to-one representation of proximal stimulation, we would expect reports of discrete central losses to be easily reportable. However, this appears not to be the case. Homonymous hemianopsia occurs in individuals with lesions of, or tumors pressing on, the right or left optic tract behind the chiasma (in which case there is a splitting of the macula) or of the primary parietal visual receptive areas (in which case the macula is spared). Such conditions result in functional blindness for the opposite half of the visual field. However, the patient is typically unaware of the visual field defect, except by inference, and puzzled by his/her inability to perform such tasks as ambulation without bumping into objects that fall into that part of the visual field that is missing (Patten, 1978). It is remarkable that such a gross sensory loss often goes unreported and, apparently, unexperienced as such by the patient as a blind spot. This is presumably due to "filling in" by central processes. If central representation is a function of cerebral cortex, we may infer that these processes remain intact in such ascending visual tract lesions.

Another intriguing finding in regard to visual experience is the observation that a stimulus in one part of the visual field of a person with mild parietal damage can disappear with contralateral stimulation (Lezak, 1976; Patten, 1978; Walsh, 1978). Such contralateral stimulation occurs in that part of the subjective field referred to as ground, as does the disappearing object. Presumably the processing demands of the new stimulus require dedication of neurophysiological activity that was previously in use for the initial object. This flexibility of use, for production of a subjective experience, is impressive. Within the span of a fraction of a second, new functions appear to be assigned to previously dedicated hardware.

Awareness as an Ecologically Valid Phenomenon

While observations of the functioning of a given subsystem (such as vision) are intriguing, the examples mentioned above are a far cry from a complete exemplar for modeling consciousness as it is experienced during day-to-day routine. A closer approximation to the complexity of ecologically common consciousness is provided by studies of cortical function.

Perhaps the most heuristic work has been done by Sperry and his students (Sperry, 1964, 1966, 1968, 1969) in the 1950s and 1960s. At that time, treatment of intractable epilepsy with commissural sectioning was becoming common (Krynauw, 1950). Despite the centrality of this surgically induced lesion, no clinically significant behavioral deficits were being detected. A student of Sperry's, Ronald Myers, began a series of studies with cats that led to the conclusion that commissurally-sectioned animals trained to respond to unilateral stimulation were unable to transfer learning when tested with contralateral stimulation (Myers, 1955; Myers and Sperry, 1958; Myers, Sperry and Miner, 1955). For all intents and purposes, the cats appeared to be unconscious of the learning that had taken place. Sperry (1964, 1966, 1968, 1969) sought out patients who had undergone such surgery and replicated the finding in humans. For example, Geschwind describes a patient who, when asked to salute with the left hand, will first salute with the right. If he is prevented from doing so, he is unable to comply with the request (Geschwind in Miller, 1983, p. 131).

The example provided by Geschwind illustrates another feature of the split-brain patient. Clearly the right hemisphere understood the context, if not the specific content, of the message from Geschwind. That is, the right hemisphere must have known it was to do something or it would not have copied the left hemisphere generated gesture. What is remarkable is that, even immediately following surgery, such patients exhibit relatively little conflict while carrying out bilaterally coordinated activities. Thus, if the left hemisphere learned to communicate nonverbally with the right, it appears to have done so prior to surgery, when the commissure was still intact.

Since the typically nonverbal right hemisphere is silent on the subject, great rancor has ensued about its conscious status in both the disconnected and normal states. It is unclear what criteria one would use to ascertain the existence of consciousness in a nonverbal organism. In the case of comatose humans, the resumption of coherent activity is accepted even if the patient remains aphasic. In the patient maintaining some residual right hemisphere linguistic skills, LeDoux, Wilson and Gazzaniga (1977) and Sperry, Zaidel and Zaidel (1979) argue that certain abstract mental properties (such as sense of self, feelings, interpersonal and activity preferences, sense of the future and aspirations and goals) are present in the disconnected right hemisphere and are evidence of consciousness.

Others have argued that, in the absence of linguistic skills, consciousness is not possible (Eccles, 1980; Popper and Eccles, 1977; Serafetinides, Hoare and Driver, (1965). However, what are we to make of the conscious status of preverbal children or animals (Griffin, 1976). Surely we would not assert that they are not sentient beings? While there may be qualitative differences in their experiential world relative to our own (Harosi and Hashimoto, 1983), we should bear in mind that such differences may be no greater than those imposed by culture (Deikman, 1971; Lee, 1950). Thus, the precluding of conscious status for brain subsystems would appear to be premature.

If consciousness is the psychoneural equivalent of redundant activity in the cerebral cortex, what happens to individuals suffering diffuse cortical loss as a result of multi-infarct or Alzheimer's dementia? We generally think of such people as conscious. Certainly such individuals show a reduced responsiveness to stimulation, sometimes as a result of attenuated peripheral sensory system functioning but more often due to a loss of central redundancy of information processing. Such patients are often dependent on overlearned environments and routines to function normally (Mace and Rabins, 1981), presumably because such familiarity lessens the need for novelty-induced, nonredundant, nonautomatistic (Hartmann, 1958; Ketterer, 1982; Smith and Miller, 1978) information processing. Removal from a familiar environment or an increase in environmental demands are often the eliciting events that lead to a first diagnosis of these disorders (Mace and Rabins, 1981). It seems likely that the capacity of these patients' cerebral cortices to handle new task demands in an efficient manner is reduced. One wonders, is consciousness also "reduced?"

The Functions of Awareness

> *Sperry:* Suppose you could work out the brain mechanisms involved in the perception of red in great detail, and then suppose you could show that if you change those mechanisms a little bit in particular features, you'll get green, or with another change, you'll get a sense of taste. When you reach that point, I would think you would be in a position to assert that you understand these mental processes.
>
> *Globus:* Granting you a "utopian neuropsychology," would you then say that your data supports epiphenomenalism, interactionism, double-aspect theory? A demonstration of a correlation between phenomenal experience and neural events is not the problem. The problem is how we might go from that empirically supported correlation to a theory which will account for it. (from Globus, Maxwell and Savodnik, 1976, p. 327)

Why do humans experience any of their mental activity at all? The principles of physics, chemistry and neurobiology do not, to date, indicate any need for conscious mental experience. It is at least theoretically conceivable that humankind could have evolved without conscious awareness. Consciousness is sometimes referred to as an emergent property (Popper, 1966), one which is not predictable from the properties of its constituent parts (e.g., the components of the nervous system). However, emergent properties are generally functionally explicable in terms of a broader framework than that applied to their constituent parts. Little effort has been expended in trying to examine the features of normal waking consciousness and what they might portend for its functional purpose. Such an examination may provide clues to a presumed evolutionary need for the development of consciousness.

While we may identify components of conscious experience which appear to serve various functions, we should keep in mind that all such components displayed by the human nervous system probably evolved to serve adaptation and survival (Gould, 1980; Jaynes, 1976; Plutchik, 1980). The present author feels that four functions may have necessitated the evolutionary development of conscious awareness. The divisions between these functions—neuropsychologically, temporally and functionally—are murky and academic rather than clearcut and real. Nonetheless, they may serve to begin the examination of the functional purpose of consciousness. All four of these functions subserve adaptation.

Perhaps the most obvious feature of conscious awareness is *its sensitivity to salient change in the external environment.* For example, P300 waves in evoked potentials are associated with stimuli which reach consciousness (Begleiter, 1979). This function presupposes that the adaptive purpose of consciousness is the representation of meaningful stimuli (those conveying information allowing prediction of significant events). Presumably such meaningfulness serves adaptation to the environment in some way. But the adaptiveness can be obscure to the casual observer.

The capacity to rapidly detect and automatistically (without the experience of "volition") focus attention on a stimulus which has changed in intensity, location or quality is of obvious survival value (Broadbent and Gregory, 1964; Deutsch and Deutsch, 1963; Moray, 1959; Treisman, 1960). Sabre-toothed tigers and New York cabbies have never, fortunately, learned to stop roaring before pouncing on unsuspecting homo sapiens. The detection of violations of an internal steady-state model of the background environment (novelty) and the genetically-programmed orienting response (Pavlov, 1927), are certainly well studied phenomena. It is important, however, to emphasize the capacity of the central nervous system to constantly redefine the internal steady-state model of the background environment. As one leaves a quiet building and enters a noisy street, one automatically ignores sounds and sights that would have compelled attention only seconds before. These changes in environmental expectations of background stimulation are accomplished automatically and without the experience of volitionally shifting sets. There is, however, usually an experience associated with rapid and large shifts in background stimulation. Entering a noisy and crowded street after being in a quiet building is often arousing. The reverse journey often is said to relax one.

Attentional focus allows one to narrow one's awareness to a restricted part of the potential subjective field. This restriction requires the concurrent inhibition of all other stimuli (internal or external) competing for attention. To some extent the orientation of stimulus receptors (ears, eyes) allows such restriction, but this narrowing is complemented by internal central nervous system properties that produce the experience of figure and ground.

Perhaps more interesting is the fact, noted above, that attentional focus is overwhelmingly directed to those sensory processes used to detect external environmental change—vision and audition—or cognitive processes anticipating or analyzing environmental (often interpersonal) events. When these sources of ongoing stimulation are curtailed, as in sensory deprivation experiments, one's awareness of otherwise ignored (ground) sensory input and cognition (fantasies) often increases dramatically (Lilly, 1972). Interesting in this context is the observation that the nervous system needs a constant change of figure in order to function. When one focuses attention strictly on one stimulus, it begins to disappear into a ganzfeld (Schuman, 1980). Thus consciousness of external stimulation depends to some extent on a relatively constant change in the focus of attention.

Further, what happens to stimuli which are not the focus of attention? It appears that such stimuli influence behavior, and possibly cognition, to a larger degree than generally appreciated (Nisbett and Wilson, 1977; Siegman and Feldstein, 1978; Wachtel, 1977; White, 1980) despite our difficulties with intuitively recognizing and articulating their role. The effect of external stimulation on dream content (Arkin, Antrobus and Ellman, 1978; Freud, 1899), the ability to drive a car while so lost in thought as to be unable to recall the trip (Smith and Miller, 1978) and the effect of physical interpersonal proximity on body movement during conversation (Dittman, 1978), are all examples of the fact that the brain processes and responds to concurrent stimulation which is outside figure in the experienced world. Such processing, and response thereto, appears to take place automatistically and nonconsciously (Hartmann, 1958) and thus is qualitatively different from that which compels attentional focus. Those external stimuli, and resulting behaviors/cognitions, which require conscious processing tend to be novel and/or rapidly changing (Shiffrin and Schneider, 1977).

Another possible reason for the existence of conscious awareness is that *consciousness may be necessary for some types of learning and memory.* It appears that classical Pavlovian (Begleiter, Gross, Porjesz and Kissin, 1969; Insko and Oakes, 1966; Wieland, Stein and Hamilton, 1963) and operant (Greenspoon, 1955; Ritter, 1979; Shevrin and Fritzler, 1968) learning are possible, indeed even ubiquitous, without conscious mediation. Those stimuli which are consciously experienced and recognized as learned (i.e., carry meaning or behaviorally contingent adaptive value) are generally salient (culturally identified as germane or physically obvious) and communicated with others (Nisbett and Wilson, 1977; Pribram, 1980). Consciously experienced events may allow behavioral anticipation/preparation for future events. Such a mental process would have obvious survival value. The ability to predict contingencies and then shape one's behavior so as to maximize attainment of goals or avoid dangerous circumstances would be a great improvement over needing to wait until such events do occur in order to respond to them.

It appears that conscious experience at the time of initial exposure to a stimulus allows for later conscious recall (Sperling, 1967). Both immediate experience and later conscious recall are necessary for communication of the experience and what was learned about it. Gazzaniga (Gazzaniga and Volpe, 1981) points out that patients undergoing lateralized sodium amytal inactivation of the left hemisphere deny, a few minutes later, experiencing a stimulus which was presented to, and responded to by, the right hemisphere/left hand. This can be interpreted as indicating that conscious experience of a stimulus (probably as "figure") may be a necessary prerequisite of conscious volitional recall of the event. Such recall would, in turn, be a prerequisite of interpersonal verbal reporting. For a species intransigently dependent on group cooperation for survival, the need for a large and complex body of useful information to communicate is obvious. If consciousness is a prerequisite of complex communication with other members of one's species and such communication fosters survival and procreation, the distal purpose of consciousness is adaptation and survival. The proximal purpose is communication to others.

Additionally, if there is a nonrandom relationship between nervous system information processing and experience as Weiner (1972) points out, the ability to represent to one's self another person's experience would allow "empathic" understanding of another's experiential state. Such an ability would also foster group cohesion and survival.

The final possible function of conscious awareness is *its necessity for formal cognitive problem-solving.* That is to say, some forms of cognition appear to occur only in conscious experience. These are usually abstract, symbolic and logical/analytical in nature and appear to serve interpersonal communication, prediction or problem solving (Plutchik, 1980). For example, it is difficult to conceive that geometric proofs may be solved without some conscious processing of the problem. Such a purpose for the existence of consciousness would imply that consciousness is a necessary part of a causal chain or network resulting in certain complex types of final behavior.

Some have argued that consciousness might be parallel to, and thus noncausal for, the determinants of behavior. Weiner (1972; Hofner, 1982) has promulgated just such a view of brain processes and consciousness, referred to as the "transduction of experience." Conscious content might bear some relationship to the brain processes producing behavior but such coincidental relationships are viewed as occurring over separate brain paths that are simultaneously activated by the same stimulus gestalts. Different parts of a particular stimulus gestalt would hypothetically give rise, independently, to the behavior and the conscious experience. What is missing from Weiner's notion is the purpose of consciousness per se. Why would the brain develop a somatically or behaviorally noncausal system for the sole purpose of producing consciousness? And why, as Ritter (1979) notes, would consciousness have such systematic relationships to behaviors or environments:

> If conscious experience of taste bore no causal relationship to eating behavior, then there should be no relationship between the taste of food and its nutritious and harmful effects. Indeed, there should be no significant difference between the number of nutritious foods we eat which are delicious and which are repulsive, assuming that adaptation to the eating of appropriate nutritious foods occurred independently of the conscious experience of taste. (p. 206)

Psychology and Consciousness

Psychology has been biology-phobic for too long. Psychology is an emergent subfield of biology just as biology is an emergent subfield of chemistry. While a defensive posture may have been an historical and intellectual necessity during our early development, the result has been an inability of the field to tackle, without behavioristic flinching, the mind-brain problem in its most significant form. A combination of rigorous behavioral and neurophysiological methodologies now hold the promise of elucidating this historical puzzle: what brain processes produce (or "give rise to," or "are the equivalent of") consciousness. The author believes that the primary barrier to embarking on such experimental forays is a residual fear among the majority of his fellow psychologists that a complete knowledge of the biology of psychobehavioral phenomena will make our field obsolete. This is highly unlikely. Chemistry has not, and will not, replace biology. Likewise, biology will never replace psychology. We would be well advised to enhance our field by mining our phenomena with the techniques biology has made available. Most neuroscientists recognize the limitations of biology as explicar of psychobehavioral processes.

> In the case of the brain, the biological disciplines have made and will continue to make remarkable progress toward understanding its structure, its metabolism, its functional interrelationships, and the mechanisms which underlie behavior, and they have solved or will solve those mental disorders which are primarily the result of disturbances there. But in the area of information, content, and experience, stored as it is in the complex interrelationships of 13 billion neurons, biology is extremely pretentious if it thinks that it can unravel them by means of its tools. There will, no doubt, someday be a biochemistry or a biophysics of memory—but not of memories.
>
> . . . [W]e do not always get closer to the truth as we slice and homogenize and isolate—that which we gain in precision and in the rigorous control of variables we sometimes lose in relevance to normal function, and, in the case of certain diseases or problems, the fundamental process may often be lost in the cutting. (Kety, 1960, pp. 1867–1868)

Until such time as psychology welcomes the phenomena of awareness as a legitimate object of study, and integrates the use of controlled stimulation, well-defined behavioral (including verbal) responses and central nervous system technology in the pursuit of understanding such objects, we will fail to address the most important of our tasks as scholars and scientists. The black box, conceptualized as the human nervous system, is increasingly available to empirical scrutiny. Surely it is time to admit openly that we are seeking empirical means of studying the subjective world. Having learned well the dangers of speculative mentalism, it may now be possible to forge ahead with the search for means of avoiding them while still achieving the fundamental goal—an accurate and predictively powerful understanding of the world as we experience it.

References

Aborn, M. (1953). The influence of experimentally induced failure on the retention of material acquired through set and incidental learning. *Journal of Experimental Psychology, 45*, 225–231.

Argyle, M., Salter, V., Nicholson, H., Williams, M. and Burgess, P. (1970). The communication of inferior and superior attitudes by verbal and non-verbal signals. *British Journal of Social and Clinical Psychology, 9*, 222–231.

Arkin, A.M., Antrobus, J.S. and Ellman, S.J. (1978). *The mind in sleep: psychology and psychophysiology.* Hillsdale: Lawrence Erlbaum Associates.

Ax, A. (1953). The physiological differentiation between fear and anger in humans. *Psychosomatic Medicine*, 15, 433–444.

Begleiter, H. (Ed.) (1979). *Evoked brain potentials and behavior.* New York: Plenum Publishing Company.

Begleiter, H., Gross, M.M., Porjesz, B. and Kissin, B. (1969). The effects of awareness on cortical evoked potentials to conditioned affective stimuli. *Psychophysiology, 5*(5), 517–529.

Boring, E.G. (1950). *A history of experimental psychology.* Englewood Cliffs: Prentice-Hall.

Branca, A.A. (1957). Semantic generalization at the level of the conditioning experiment. *American Journal of Psychology, 70*, 541–549.

Broad, C.D. (1925). *The mind and its place in nature.* London: Routledge and Kegan-Paul.

Broadbent, D. (1958). *Perception and communication.* Oxford: Pergamon Press.

Broadbent, D.E. and Gregory, M. (1964). Stimulus set and response set: the alternation of attention. *Quarterly Journal of Experimental Psychology, 16*, 309–312.

Cannon, W.B. (1932). *The wisdom of the body.* New York: W.W. Norton.

Cassem, N.H. (1978). Depression. In T.P. Hackett and N.H. Cassem (Eds.), *Massachusetts general hospital handbook of general hospital psychiatry* (pp. 209–225). Saint Louis: C.V. Mosby.

Cherry, E.C. (1953). Some experiments on the recognition of speech with one and with two ears. *Journal of the Acoustical Society of America, 25*, 975–979.

Clark, D.M. and Teasdale, J.D. (1982). Diurnal variation in clinical depression and accessibility of memories of positive and negative experiences. *Journal of Abnormal Psychology, 91*(2), 87–95.

Comper, P. and LaCroix, J.M. (1981). Further evidence of lateralization in the electrodermal system as a function of relative hemisphere activation. *Psychophysiology, 18*(2), 149.

Cornsweet, T.M. (1970). *Visual perception.* New York: Academic Press.

Davidson, J.M. and Davidson, R.J. (Eds.), (1980). *The psychobiology of consciousness.* New York: Plenum Press.

Davison, G.C., Robins, C. and Johnson, M.K. (1983). Articulated thoughts during simulated situations: a paradigm for studying cognition in emotion and behavior. *Cognitive Therapy and Research, 7*(1), 17–40.

Dawes, R.M. and Kramer, E. (1966). A proximity analysis of vocally expressed emotion. *Perceptual and Motor Skills, 22*, 571–574.

Dawson, M.E. (1973). Can classical conditioning occur without contingency learning? A review and evaluation of the evidence. *Psychophysiology, 10*(1), 82–86.

Deikman, A.J. (1971). Bimodal consciousness. *Archives of General Psychiatry, 25*, 481–489.

Deutsch, J.A. and Deutsch, D. (1963). Attention: some theoretical considerations. *Psychological Review, 70*, 80–90.

Dismukes, R.K. (1979). New concepts of molecular communication among neurons. *The Behavioral and Brain Sciences. 2*, 409–448.
Dittman, A.T. (1978). The role of body movement in communication. In A.W. Siegman and S. Feldstein (Eds.), *Nonverbal behavior and communication* (pp. 69–96). Hillsdale: Lawrence Erlbaum Associates.
Dixon, N. (1981). *Preconscious processing*. New York: John Wiley and Sons.
D'Zurilla, T. (1965). Recall efficiency and mediating cognitive events in "experimental repression." *Journal of Personality and Social Psychology, 3*, 253–256.
Eccles, J.C. (1978). A critical appraisal of brain-mind theories. In P.A. Buser and A. Rougeul-Buser (Eds.), *Cerebral correlates of conscious experience*. Amsterdam: North Holland.
Eccles, J.C. (1980). *The human psyche.* Heidelberg: Springer-Verlag.
Efron, R. (1970a). The relationship between the duration of a stimulus and duration of a perception. *Neuropsychologia, 8*, 37–55.
Efron, R. (1970b). The minimum duration of a perception. *Neuropsychologia, 8*, 57–63.
Ehrlichman, H. and Wiener, M.S. (1980). EEG asymmetry during covert mental activity. *Psychophysiology, 17*(3), 228–236.
Ekblom, B. and Goldberg, A.N. (1971). The influence of physical training and other factors on the subjective rating of perceived exertion. *Acta Physiologica Scandinavica*, 83, 399.
Ekman, P., Levenson, R.W. and Friesen, W.V. (1983). Autonomic nervous system activity distinguishes among emotions. *Science, 221*, 1208–1210.
Epstein, R., Lanza, R.P. and Skinner, B.F. (1981). "Self-awareness" in the pigeon. *Science, 212*(4495), 695–696.
Erdelyi, M.H. (1974). A new look at the new look: perceptual defense and vigilance. *Psychological Review, 81*(1), 1–25.
Ewalt, J.R., Randall, G.L. and Morris, H. (1947). The phantom limb. *Psychosomatic Medicine*, 9, 118–130.
Fiss, H. (1966). The effects of experimentally induced changes in alertness on response to subliminal stimulation. *Journal of Personality, 34*, 577–595.
Flavell, J. (1955). Repression and the "return of the repressed." *Journal of Consulting Psychology, 19*, 441–443.
Fox, J.L. (1983). Memories are made of this. *Science, 222*, 1318.
French, J.D. and Magoun, H.W. (1952). Effect of chronic lesions in central cephalic brain stem of monkeys. *Archives of Neurology and Psychiatry, 68*, 591–604.
Freud, S. (1899). *The interpretation of dreams.* New York: Avon Books.
Freud, S. (1920). *Introductory lectures on psychoanalysis.* New York: W.W. Norton and Co.
Furedy, J.J. (1973). Some limits on the cognitive control of autonomic behavior. *Psychophysiology, 10*(1), 108–111.
Furst, C.J. (1971). Automatizing of visual perception. *Perception and Psychophysics, 10*(2), 65–70.
Gallwey, W.T. (1974). *The inner game of tennis.* New York: Random House.
Gazzaniga, M.S. and Volpe, B.T. (1981). Split-brain studies: Implications for psychiatry. In S. Arieti and H.K.H. Brody (Eds.), *American handbook of psychiatry* (Volume 7, pp. 25–45). New York: Basic Books.
Glass, D.C. (1977). *Behavior patterns, stress and coronary disease.* New York: Lawrence Erlbaum Associates.
Globus, G.C., Maxwell, G. and Savodnik, I. (Eds.). (1976). *Consciousness and the brain.* New York: Plenum Press.
Goldman-Rakic, P.S. and Schwartz, M.L. (1982). Interdigitation of contralateral and ipsilateral columnar projections to frontal association cortex in primates. *Science, 216*, 755–757.
Gould, S.J. (1980). *The panda's thumb.* New York: W.W. Norton.
Greenfield, N.S. and Sternbach, R.A. (Eds.). (1972). *Handbook of psychophysiology.* New York: Holt, Rinehart and Winston.
Greenspoon, J. (1955). The reinforcing effect of two spoken sounds on the frequency of two responses. *American Journal of Psychology, 68*, 409–416.
Griffin, D.R. (1976). *The question of animal awareness.* Los Altos: William Kaufman, Incorporated.
Gutmann, M.C., Squires, R.W. and Pollack, M.L. (1981). Perceived exertion-heart rate relationship during exercise testing and training in cardiac patients. *Journal of Cardiac Rehabilitation, 1*, 52.

Haber, R.N. (1983). The impending demise of the icon: a critique of the concept of iconic storage in visual information processing. *The Behavioral and Brain Sciences*, *6*(1), 1–54.
Harosi, F.I. and Hashimoto, Y. (1983). Ultraviolet visual pigment in a vertebrate: A tetrachromatic cone system in the dace. *Science*, *222*, 1021–1023.
Hartmann, H. (1958). *Ego psychology and the problem of adaptation*. New York: International Universities Press.
Heiman, J.R. (1977). A psychophysiological exploration of sexual arousal patterns in females and males. *Psychophysiology*, *14*(3), 266–272.
Herbert, W. (1983). Remembrance of things partly. *Science News*, *124*, 378–371.
Hilgard, E.R. (1962). Impulsive versus realistic thinking: An examination of the distinction between primary and secondary processes in thought. *Psychological Bulletin*, 59(6), 477–488.
Hofer, M.A. (1982). Some thoughts on "the transduction of experience" from a developmental perspective. *Psychosomatic Medicine*, *44*(1), 19–28.
Holmes, D.S. (1972). Repression on interference: a further investigation. *Journal of Personality and Social Psychology*, *22*, 163–170.
Holmes, D.S. (1974). Investigations of repression: differential recall of material experimentally or naturally associated with ego threat. *Psychological Bulletin*, *81*(10), 632–653.
Holmes, D.S. and Schallow, J.R. (1969). Reduced recall after ego threat: repression or response competition? *Journal of Personality and Social Psychology*, *13*, 145–152.
Horton, D.L. and Turnage, T.W. (1976). *Human learning*. Englewood Cliffs: Prentice-Hall, Incorporated
Hubel, D.H. and Wiesel, T.N. (1965). Receptive fields and functional architecture in two nonstriate visual areas (18 and 19) of the cat. *Journal of Neurophysiology*, *28*, 229–289.
Insko, C.A. and Oakes, W.F. (1966). Awareness and "conditioning" of attitudes. *Journal of Personality and Social Psychology*, *4*(5), 487–496.
Ittelson, W.H., Proshansky, H.M., Rivlan, L.G. and Winkel, G.H. (1974). *An introduction to environmental psychology*. New York: Holt, Rinehart and Winston, Incorporated.
Izard, C.E. (1977). *Human emotions*. New York: Plenum Press.
James, W. (1890). *The principles of psychology*. New York: Dover Publications.
Jaynes, J. (1976). *The origin of consciousness in the breakdown of the bicameral mind*. Boston: Houghton-Mifflin.
John, E.R. (1972). Switchboard versus statistical theories of learning and memory. *Science*, *177*, 850–864. (Copyright 1972 by the AAAS.)
John, E.R., Shimokichi, M. and Bartlett, F. (1969). Neural readout from memory during generalization. *Science*, *164*, 1519–1521.
Johnson, J. (1973). Effects of accurate expectations about sensations on sensory and distress components of pain. *Journal of Personality and Social Psychology*, *27*, 261–275.
Kandel, E.R. (1979). Psychotherapy and the single synapse. *New England Journal of Medicine*, 1028–1037.
Ketterer, M.W. (1982). Lateralized representation of affect, affect cognizance and the coronary-prone personality. *Biological Psychology*, *15*, 171–189.
Ketterer, M.W. and Smith, B.D. (1977). Bilateral electrodermal activity, lateralized cerebral processing and sex. *Psychophysiology*, *14*(6), 513–516.
Ketterer, M.W. and Smith, B.D. (1985). Affect cognizance and the type A behavior pattern: labeling, cognitive effort or phenomenological loss? *International Journal of Psychiatry in Medicine*, *15*(3), 225–241.
Ketterer, M.W., Stoever, W.W., Pickering, E.R. and Carney, M.P. (1985). The type A behavior pattern: A review for the primary care physician. *Journal of the American Osteopathic Association*, *85*(10), 649–656.
Kety, S.S. (1960). A biologist examines the mind and behavior. *Science*, *132*(3443), 1861–1870. (Copyright 1960 by the AAAS.)
Köhler, W. (1925). *The mentality of apes*. New York: Harcourt Brace.
Köhler, W. (1960). The mind-body problem. In S. Hook (Ed.), *Dimensions of mind* (pp. 3–23). New York: New York University.
Köhler, W. (1967). Gestalt psychology. *Psychologische Forschung*, *31*, 18–30.
Kornhuber, H.H. (1978). A reconsideration of the brain-mind problem. In P.A. Buser and A. Rougeul-Buser (Eds.), *Cerebral correlates of conscious experience*. Amsterdam: North Holland.

Kowler, R. and Steinman, R.M. (1980). Small saccades serve no useful purpose: Reply to a letter by R.W. Ditchburn. *Vision Research, 20*(3), 273–276.
Krynauw, R.A. (1950). Infantile hemiplegia treated by removing one cerebral hemisphere. *Journal of Neurology, Neurosurgery and Psychiatry, 13,* 243–267.
Kuhn, T.S. (1962). *The structure of scientific revolutions.* Chicago: University of Chicago Press.
LaCroix, J.M. and Comper, P. (1979). Lateralization in the electrodermal system as a function of cognitive/hemispheric manipulations. *Psychophysiology, 16*(2), 116–129.
Lashley, K.S. (1950). In search of the engram. *Symposium of the Society of Experimental Biology, 4,* 454–482.
Latane, B. and Darley, J. (1970). *The unresponsive bystander: why doesn't he help?* New York: Appleton-Century-Crofts.
Latane, B. and Rodin, J. (1969). A lady in distress: Inhibiting effects of friends and strangers on bystander intervention. *Journal of Experimental Social Psychology, 5,* 189–202.
Lazarus, R.S. (1984). On the primacy of cognition? *American Psychologist, 39*(2), 124–129.
LeDoux, J.E., Wilson, D.H. and Gazzaniga, M.S. (1977). A divided mind: Observations on the conscious properties of the separated hemispheres. *Annals of Neurology, 2*(5), 417–421.
Lee, D. (1950). Codifications of reality: lineal and nonlineal. *Psychosomatic Medicine, 12*(2), 89–97.
Leff, J.P. (1978). Psychiatrist's versus patient's concepts of unpleasant emotions. *British Journal of Psychiatry, 133,* 306–313.
Leventhal, H., Brown, D., Schacham, S. and Enquist, G. (1979). Effect of prepatory information about sensations, threat of pain and attention on cold pressor distress. *Journal of Personality and Social Psychology, 37,* 668–714.
Lezak, M.D. (1976). *Neuropsychological assessment.* New York: Oxford University Press.
Liberman, A.M. (1983). What a perception-production link does for language. *The Behavioral and Brain Sciences,* 6(2), 216.
Liberman, A.M., Cooper, F.S., Shankweiler, D. and Studdert-Kennedy, M. (1967). Perception of the speech code. *Psychological Review, 74,* 431–461.
Lieberman, D.A. (1979). Behaviorism and the mind: A (limited) call for a return to introspectionism. *American Psychologist, 34*(4), 319–333.
Lieberman, D.A. (1981). On (very) stubborn refusals to return to introspectionism: A reply to Rachlin. *American Psychologist, 36*(5), 523–524.
Liddle, G.W. (1981). The adrenals. In R.H. Williams (Ed.), *Textbook of endocrinology* (pp. 249–292). Philadelphia: W.B. Saunders Company.
Lilly, J.C. (1972). *The center of the cyclone.* New York: Bantom Books.
Lollgren, H., Graham, T. and Sjogaard, G. (1980). Muscle metabolites, force and perceived bicycling at varying pedal rates. *Medical Sciences and Sports, 12,* 345.
Mace, N.L. and Rabins, P.V. (1981). *The 36-hour day.* Baltimore: Johns Hopkins University Press.
MacLean, P.D. (1954). The limbic system and its hippocampal formation: Studies in animals and their possible application to man. *Journal of Neurosurgery, 11,* 29–44.
Mahoney, M.J. (1976). *Scientist as subject: the psychological imperative.* Cambridge: Ballinger Publishing Company.
Mahoney, M.J. (Ed.) (1980). *Psychotherapy process: current issues and future directions.* New York: Plenum Press.
Marshall, G.D. and Zimbardo, P.G. (1979). Affective consequences of inadequately explained physiological arousal. *Journal of Personality and Social Psychology, 37*(6), 970–988.
Martin, I. and Venables, P.H. (Eds.). (1980). *Techniques in psychophysiology.* New York: John Wiley and Sons.
Maslach, C. (1979). Negative emotional biasing of unexplained arousal. *Journal of Personality and Social Psychology, 37*(6), 953–969.
Milgram, S. (1974). *Obedience to authority.* New York: Harper and Row.
Miller, J. (1983). *States of mind.* New York: Plenum Books.
Moray, N. (1959). Attention in dichotic listening: Affective cues and the influence of instructions. *Quarterly Journal of Experimental Psychology, 11,* 56–60.
Moruzzi, G. and McGoun, H.W. (1949). Brainstem reticular formation and activation of the EEG. *Electroencephalography and Clinical Neurophysiology, 1,* 455.
Myers, R.E. (1955). *Journal of Comparative and Physiological Psychology, 79,* 358.
Myers, R.E. and Sperry, R.W. (1958). *Archives of Neurology and Psychiatry, 80,* 298.

Myers, R.E., Sperry, R.W. and Miner, N. (1955). *Journal of Comparative and Physiological Psychology, 48*, 50.
Natsoulas, T. (1978). Consciousness. *American Psychologist, 33*(10), 906–914.
Neisser, U. (1967). *Cognitive psychology.* Englewood Cliffs: Prentice-Hall.
Neisser, U. (1976). *Cognition and reality.* San Francisco: W.H. Freeman and Company.
Nisbett, R.E. and Wilson, T.D. (1977). Telling more than we can know: Verbal reports on mental processes. *Psychological Review, 84*(5), 231–259.
Ojemann, G.A. (1983). Brain organization for language from the perspective of electrical stimulation mapping. *The Behavioral and Brain Sciences, 6*, 189–230.
Orton, I.K., Beiman, I., LaPointe, K. and Lankford, A. (1983). Induced states of anxiety and depression: Effects on self-reported affect and tonic psychophysiological response. *Cognitive Therapy and Research, 7*(3), 233–244.
Otto, D.A. (Ed.), (1978). *Multidisciplinary perspectives in event-related brain potential research.* Washington: Environmental Protection Agency.
Papez, J.W. (1937). A proposed mechanism of emotion. *Archives of Neurology and Psychiatry, 38*, 725–743.
Patten, J. (1978). *Neurological differential diagnosis.* New York: Springer-Verlag.
Pavlov, I.P. (1927). *Conditioned reflexes.* New York: Dover Publications, Incorporated.
Penfield, W. and Rasmussen, T. (1950). *The cerebral cortex in man.* New York: MacMillan.
Pennebaker, J.W. (1982). *The psychology of physical symptoms.* New York: Springer-Verlag.
Perls, F.S. (1969). *Gestalt therapy verbatim.* New York: Bantom Books.
Perls, F.S., Hefferline, R.F. and Goodman, P. (1951). *Gestalt therapy.* New York: Dell Publishing Company, Incorporated..
Pine, F. (1964). The bearing of psychoanalytic theory on selected issues in research on marginal stimuli. *Journal of Nervous and Mental Disease, 138*, 205–222.
Plutchik, R. (1980). A general psychoevolutionary theory of emotion. In R. Plutchik and H. Kellerman (Eds.), *Emotion: theory, research and experience, volume 1* (pp. 3–34). New York: Academic Press.
Polanyi, M. (1958). *Personal knowledge.* Chicago: University of Chicago Press.
Pope, K.S. (1978). The flow of consciousness. In K.S. Pope and J.L. Singer (Eds.), *The stream of consciousness: scientific investigations into the flow of human experience* (pp. 1–9). New York: Plenum Press.
Pope, K.S. and Singer, J.L. (1978). Regulation of the stream of consciousness: Toward a theory of ongoing thought. In G.E. Schwartz and D. Shapiro (Eds.), *Consciousness and self-regulation, volume 2* (pp. 101–138). New York: Plenum Press.
Popper, K. (1966). Philosophy of science: A personal report. In C.A. Mace (Ed.), *British philosophy in mid-century: A Cambridge symposium, second edition.* London: G. Allen.
Popper, K.R. and Eccles, J.C. (1977). *The self and its brain.* Heidelberg: Springer-Verlag.
Posner, M.I. (1982). Cumulative development of attentional theory. *American Psychologist, 37*(2), 168–179.
Pribram, K. (1980). The biology of emotions and other feelings. In R. Plutchik and H. Kellerman (Eds.), *Emotion: theory, research and experience, volume 1* (pp. 245–270). New York: Academic Press.
Pribram, K.H. and Gill, M.M. (1976). *Freud's "project" re-assessed.* New York: Basic Books.
Puccetti, R. (1981). The case for mental duality: Evidence from split-brain data and other considerations. *The Behavioral and Brain Sciences, 4*, 93–123.
Rachlin, H.A. (1980). A (stubborn) refusal to return to introspectionism. *American Psychologist, 35*, 473–482.
Razran, G.H.S. (1939). Semantic, syntactic and phonetographic generalization of verbal conditioning. *Psychological Bulletin, 36*, 578.
Reiss, B.F. (1946). Genetic changes in semantic conditioning. *Journal of Experimental Psychology, 36*, 143–152.
Reisenzein, R. (1983). The Schachter theory of emotion: Two decades later. *Psychological Bulletin, 94*(2), 239–264.
Renault, B., Ragot, R., LeSevre, N. and Remond, A. (1982). Onset and offset of brain events as indices of mental chronometry. *Science, 215*, 1413–1415.

Ritter, W. (1978). The place of consciousness in brain research. In D.A. Otto (Ed.), *Multidisciplinary perspectives in event-related brain potential research* (pp. 642–645). Washington: Environmental Protection Agency.
Ritter, W. (1979). Cognition and the brain. In. H. Begleiter (Ed.), *Evoked brain potentials and behavior* (pp. 197–228). New York: Plenum Press.
Roberts, A. and Bush, B.M.H. (Eds.), (1981). *Neurones without impulses.* Cambridge: University of Cambridge Press.
Robinson, D.N. (1976). What sort of persons are hemispheres? Another look at the "split brain" man. *British Journal for the Philosophy of Science, 27,* 73–78.
Rosenthal, R. (1966). *Experimenter effects in behavioral research.* New York: Appleton.
Russell, B. (1921). *The analysis of mind.* London: Allen and Unwin.
Ryle, G. (1949). *The concept of mind.* New York: Barnes and Noble.
Schachter, S. and Singer, J.E. (1962). Cognitive, social and physiological determinants of emotional states. *Psychological Review,* 69, 379–399.
Schandry, R. (1981). Heart beat perception and emotional experience. *Psychophysiology, 18*(4), 483–488.
Scherer, K.R., Koivumaki, J. and Rosenthal, R. (1972). Minimal cues in the vocal communication of affect: Judging emotions from content-masked speech. *Journal of Psycholinguisitc Research, 1,* 269–285.
Schneider, W. and Shiffrin, R.M. (1977). Controlled and autonomic human information processing: I. Detection, search and attention. *Psychological Review, 84*(1), 1–66.
Schuele, J.G. (1983). Autonomic response to self-critical thought. *Cognitive Therapy and Research,* 7(2), 189–194.
Schuman, M. (1980). The psychophysiological model of meditation and altered states of consciousness: A critical review. In J.M. Davidson and R.J. Davidson (Eds.), *The psychobiology of consciousness* (pp. 333–378). New York: Plenum Press.
Serafetinides, E.A., Hoare, R.D. and Driver, M.V. (1965). Intracarotid sodium amylobarbitone and cerebral dominance for speech and consciousness. *Brain, 88,* 107–130.
Shapiro, D. (1965). *Neurotic styles.* New York: Basic Books.
Shearer, S.L. and Tucker, D.M. (1981). Differential cognitive contributions of the cerebral hemispheres in the modulation of emotional arousal. *Cognitive Therapy and Research,* 5(1), 85–93.
Sheridan, C.L. (1971). *Fundamentals of experimental psychology.* New York: Holt, Rinehart and Winston, Incorporated.
Shevrin, H. and Dickman, S. (1980). The psychological unconscious: A necessary assumption for all psychological theory? *American Psychologist, 35*(5), 421–434.
Shevrin, H. and Fritzler, D.E. (1968). Visual evoked response correlates of unconscious mental processes. *Science, 161,* 295–298.
Shevrin, H., Smith, W.H. and Fritzler, D.E. (1969). Repressiveness as a factor in the subliminal activation of brain and verbal responses. *Journal of Nervous and Mental Disease, 149*(3), 261–269.
Shevrin, H., Smith, W.H. and Fritzler, D.E. (1970). Subliminally stimulated brain and verbal responses of twins differing in repressiveness. *Journal of Abnormal Psychology, 76*(1), 39–46.
Shevrin, H., Smith, W.H. and Fritzler, D.E. (1971). Average evoked response and verbal correlates of unconscious mental processes. *Psychophysiology,* 8(2), 149–162.
Shiffrin, R.M. and Schneider, W. (1977). Controlled and autonomic human information processing: II. Perceptual learning, autonomic attending and a general theory. *Psychological Review, 84*(2), 127–190.
Siegman, A.W. and Feldstein, S. (Eds.). (1978). *Nonverbal behavior and communication.* New York: Lawrence Erlbaum Associaties, Incoporated.
Singer, J.R. and Crooks, L.E. (1983). Nuclear magnetic resonance blood flow measurements in the human brain. *Science, 221,* 654–656.
Skinner, B.F. (1974). *About behaviorism.* New York: Random House.
Smith, B.D. and Ketterer, M.W. (1982). Lateralized cortical/cognitive processing and bilateral electrodermal activity: Effects of sensory mode and sex. *Biological Psychology, 15,* 191–201.
Smith, B.D., Ketterer, M.W. and Concannon, M. (1981). Bilateral electrodermal activity as a function of hemisphere-specific stimulation, hand preference, sex and familial handedness. *Biological Psychology, 12,* 1–11.

Smith, E.R. and Miller, F.D. (1978). Limits on perception of cognitive processes: A reply to Nisbett and Wilson. *Psychological Review, 84*(4), 355–362.
Sperling, G. (1967). Successive approximations to a model for short-term memory. *Acta Psychologia, 27,* 285–292.
Sperry, R.W. (1964). The great cerebral commissure. *Scientific American, 210*(1), 42–52.
Sperry, R.W. (1966). Brain bisection and mechanisms of consciousness. In J.C. Eccles (Ed.), *Brain and conscious experience* (pp. 298–313). New York: Springer-Verlag.
Sperry, R.W. (1968). Hemisphere deconnection and unity in conscious awareness. *American Psychologist, 23,* 723–733.
Sperry, R.W. (1969). A modified concept of consciousness. *Psychological Review, 76*(6), 532–536.
Sperry, R.W., Zaidel, E. and Zaidel, D. (1979). Self recognition and social awareness in the deconnected minor hemisphere. *Neuropsychologia, 17,* 153–166.
Spielberger, C.D. and DeNike, L.D. (1966). Descriptive behaviorism versus cognitive theory in verbal operant conditioning. *Psychological Review, 73*(4), 306–326.
Steinman, R.M. (1974). *Role of eye movements in maintaining a phenomenally clear and stable world.* Paper presented at the Specialists' Meeting on Eye Movements and Psychological Processes, Princeton, New Jersey.
Steinman, R.M., Haddad, G.M., Skavenski, A.A. and Wyman, D. (1973). Miniature eye movements. *Science, 181,* 810–819.
Steptoe, A. (1981). *Psychological factors in cardiovascular disorders.* New York: Academic Press.
Stern, J.A. and Janes, C.L. (1973). Personality and psychopathology. In W.F. Prokasy and D.C. Raskin (Eds.), *Electrodermal activity in psychological research* (pp. 284–346). New York: Academic Press.
Stevens, S.S. (1975). *Psychophysics.* New York: John Wiley and Sons.
Stockard, J.J., Stockard, J.E. and Sharbrough, F.W. (1977). *Mayo Clinic Proceedings, 52,* 761–769.
Suzuki, S. (1970). *Zen mind, beginner's mind.* New York: Weatherhill.
Szentagothai, J. (1972). The basic neuronal circuit of the neocortex. In H. Petsche and M.A. Brazier (Eds.), *Synchronization of EEG activity in epilepsies.* New York: Springer-Verlag.
Thatcher, R.W. and John, E.R. (1977). *Functional neuroscience: Volume 1. Foundations of cognitive processes.* New York: Lawrence Erlbaum Associates, Incorporated.
Thayer, R.E. (1970). Activation states as assessed by verbal report and four psychophysiological variables. *Psychophysiology, 7*(1), 86–94.
Torjussen, T. and Magnussen, S. (1983). Blindsight: Not all unexpected findings are experimental artifacts. *The Behavioral and Brain Sciences,* 3, 462.
Treisman, A.M. (1960). Contextual cues in selective listening. *Quarterly Journal of Experimental Psychology, 12,* 242–248.
Truax, C.B. (1957). The repression response to implied failure as a function of the hysteria-psychasthenia index. *Journal of Abnormal and Social Psychology, 55,* 188–193.
Tucker, D.M., Antes, J.R., Stenslie, C.E. and Barnhardt, T.M. (1978). Anxiety and lateral cerebral function. *Journal of Abnormal Psychology, 87*(3), 380–383.
Tucker, D.M. and Newman, J.P. (1981). Verbal versus imaginal cognitive strategies in the inhibition of emotional arousal. *Cognitive Therapy and Research, 5*(2), 197–202.
Uttal, W.R. (1978). *The psychobiology of mind.* Hillsdale: Lawrence Erlbaum Associates, Incorporated.
Wachtel, P.L. (1977). *Psychoanalysis and behavior therapy: toward an integration.* New York: Basic Books.
Wagner, H.N., Burns, D., Dannals, R.F., Wong, D.F., Langstrom, B., Duelfer, T., Frost, J.J., Ravert, H.T., Links, J.M., Rosenbloom, S.B., Lukas, S.E., Kramer, A.V. and Kuhar, M.J. (1983). Imaging dopamine receptors in the human brain by positron tomography. *Science, 221,* 1264–1266.
Walsh, K.W. (1978). *Neuropsychology: a clinical approach.* New York: Churchill Livingstone.
Watson, J.B. (1913). Psychology as the behaviorist views it. *Psychological Review,* 20, 158–177.
Weiner, H. (1972). Some comments on the transduction of experience by the brain. *Psychosomatic Medicine, 34*(4), 355–380.
Weiskrantz, L. (1980). Varieties of residual experience. *Quarterly Journal of Experimental Psychology, 32,* 365–386.
Weiskrantz, L. (1983). Evidence and scotomata. *The Behavioral and Brain Sciences,* 3, 464–465.

Weiskrantz, L., Warrington, E.K., Sanders, M.D. and Marshall, J. (1974). Visual capacity in the hemianopic field following a restricted occipital ablation. *Brain*, 97(4), 709–728.
White, P. (1980). Limitations on verbal reports of internal events: A refutation of Nisbett and Wilson, and Bem. *Psychological Review*, 87(1), 105–112.
Wickens, L., Kramer, A., Vanasse, L. and Donchin, E. (1983). Performance of concurrent tasks: A psychophysiological analysis of the reciprocity of information-processing resources. *Science*, *221*, 1080–1082.
Wieland, W.F., Stein, M. and Hamilton, C.L. (1963). Intensity of the unconditional stimulus as a factor in conditioning out of awareness. *Psychosomatic Medicine*, 25(2), 124–132.
Wincze, J.P., Hoon, P. and Hoon, E.F. (1977). Sexual arousal in women: A comparison of cognitive and physiological responses by continuous measurement. *Archives of Sexual Behavior*, 6(2), 121–133.
Worthington, A.G. (1961). Semantic generalization and the mechanism of subception. *Australian Journal of Psychology*, *13*, 206–214.
Zajonc, R.B. (1980). Feeling and thinking: Preferences need no inferences. *American Psychologist*, 35(2), 151–175.
Zajonc, R.B. (1984). On the primacy of affect. *American Psychologist*, 39(2), 117–123.
Zihl, J. (1983). "Blindsight": Turning a blind eye? *The Behavioral and Brain Sciences*, *3*, 468–469.