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EVENT-RELATED BRAIN POTENTIALS AS A POINT OF ENTRY INTO THE INTEGRATED ANALYSIS OF THE COGNITIVE AND AFFECTIVE BASES OF PERCEPTUAL AND AESTHETIC EXPERIENCES

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The behaviour of man is caused by a myriad of complex biological, psychological and sociological processes. However, because man is a biological being, it is intuitively obvious that a complete understanding of the nature and causes of behaviour will necessitate that behaviour be studied also from a biological perspective. In the light of this theoretical framework, it is not a surprise that experimental aesthetics has put particular emphasis on the assumption that the origin of aesthetic preferences are biological, and that artistic behaviour serves adaptive functions. In this regard, the most sustained attempt to place art within a biological perspective has come from the work of Berlyne (1971; 1974) which linked aesthetic behaviour to exploration. According to him, artistic activity grows out of some fundamental characteristic of the human nervous system. In particular, he emphasized the psychophysiological concept of "arousal". In other words, he argued that the level of arousal in the nervous system could be increased by external stimulus patterns, including the collative variables of novelty, complexity, surprisingness, and puzzlingliness. However, what should be stressed is that, in Berlyne's (1960) theory, the collative variables are conceptual rather than physical properties of the stimulus. In fact, according to him the psychophysiological response to stimuli is governed by the symbolic value or meaning of the stimulus to the subject. And again, both the physiological and psychological aspects of the orienting response to the stimulus are part of our pursuit for knowledge. This "epistemic" response is governed and evoked purely by an intrinsic cognitive imbalance.
Knowledge, in fact, differs from Stimulus-Response (S-R) habit formation in generating a persistent set of beliefs and expectancies which are not bound by the external environment. In a way, then, it can be said that, on the one hand, Berlyne's thought further bolstered Sokolov's (1963) mediational match-mismatch model which emphasized the role of expectations of biological value in paying attention to a stimulus, and, on the other hand, that it pioneered the modern developments of the psychological theory. Psychology, in fact, has moved on from the idea that we are receivers picking up information from the world "out there" via our senses, to the idea that perception is a constructive and selective process, involving our testing out perceptual hypotheses, which are influenced by prior knowledge, past experience, current tastes and emotional states. Then, the focus has turned to the objective study of sensation, perception, attention, memory, imagination, learning, thinking, and decision making. Again, it has become the current opinion that the investigation of these processes, which is equivalent to the study of human information processing, has deep implications to the comprehension of the mechanisms underlying the knowledge of the world. Such mental processes are clearly of vital importance to any theory of knowledge. Thus we need to know their place in a general theory of knowledge if we want to be able to use this knowledge to a better understanding of the expressive and aesthetic functions of art. The first constraint to which we are faced by in deciding to objectively investigate the way in which the individual derives knowledge, that is, information, from his environment, is the choice
of a reliable method of investigation. It is obvious, in fact, that the method of study is strictly interwoven with psychological theory, since from different questions or conceptions of the topic to be studied derive different experimental methods. Furthermore, from the results obtained by means of a particular method, confirmations or disconfirmations of the importance of asking just those questions are derived. As a natural extension of this way of proceeding, psychological theories are confirmed and developed or rejected. For this reason, the method and the results obtained by means of it cannot be discussed independently of the theory and content of psychology. In this regard, the recent advent of computer techniques have provided neuroscientists with a tool which appears to have high face validity for the study of the workings of the brain actively acquiring knowledge. This methodology, marking the brain's transient responses to particular stimulus patterns, and for this reason being known as Event-related brain potentials or ERPs, allows the systematic investigation of the effects of information on a responsive individual while he or she is engaged in a variety of perceptual and cognitive tasks. The most significant way in which psychological theory and brain research by means of ERPs have met and influenced one another is through the concepts of human information processing which was developed in cognitive psychology. The basic idea of cognitive psychology is that our knowledge of and interaction with the world is accomplished through a variety of transformations associated with information processing. In his classic book, Cognitive Psychology, Neisser (1967) suggested that
"the term 'cognition' refers to all the processes by which the input is transformed, reduced, elaborated, stored, recovered and used."
Then, in the light of the typical "flow chart" model of human information processing, Neisser (1967) distinguishes an initial "preattentive selection" stage of stimulus features, automatically carried out, leaving a sensory or "iconic" memory; an input filtering system which rejects information from unattended sensory channels; a short-term memory of limited capacity; and a last stage of long-term memory fixation or decision-making, where inputs are compared against memory, thus allowing a constructive process of recognition and categorization of specific stimuli. It is at this late level that expectancies and predictions intervene to determine what stimuli are selected and identified. As a reflection of the theory, the bioelectric peaks and throughs sequentially occurring in time as stimulus information progresses through these hypothetical processing stages, and composing, as a whole, the ERP waveforms recorded on the scalp, have been divided into "exogenous" and "endogenous" components (even though an ERP component is not always synonymous with a peak in the waveform), according to their latency of occurrence. Early latency exogenous components are taken as indexes of the automatic, preattentive analysis of the physical properties of the stimulus, whereas evidence has accumulated that the late latency endogenous components are the expression of later cognitive processes invoked by the psychological demands of the situation, rather than evoked by the presentation of stimuli. The results obtained by experimental research have shown that the
distinction of the effects of incoming information on ERP exogenous and endogenous components reveals to be artificial and of short heuristic value. As a consequence, these results have suggested the inadequacy of an orthodox bottom-up or data-driven information processing approach which casts the perceiver into a role of passive recipient of sensory information. A solution of this problem has been attempted not by substituting new terminology, but analysing experimental findings in the light of a more heuristic psychological theory of cognition. In this regard, the incorporation of the Gibsonian (1974) principles of an "ecological approach" to perception into the theoretical conceptualization of "schema", proposed by Neisser (1976) in his theory of "perceptual cycle", has shown to be fit. Neisser, in fact, describes schemata as "cognitive structures that prepare the perceiver to accept certain kinds of information rather than others and thus control the activity of looking" (1976, p. 20); in addition, "the schema accepts information as it becomes available at sensory surfaces and is changed by that information: it directs movements and exploratory activities that make more information available, by which it is further modified" (1976, p. 54). But, more importantly, "The schema assures the continuity of perception over time in two different ways. Because schemata are anticipations, they are the medium by which the past affects the future; information already acquired determines what will be picked up next (This is the underlying mechanism of memory... )" (1976, p. 22). In this theoretical framework, the secular opposition between the "object" and "subject"
of perception of between bottom-up or data-driven and top-down or schema-driven perceptual processing seems to be at last overcome. Looking at the data offered by ERP experimental research, it is becoming increasingly clear that the processes that the endogenous ERP components, mainly the so called positive P300 component, manifest are those very processes inferred by cognitive psychologists in relation to the core concept of schema. As a whole, in fact, these data persuasively suggest that the P300 is the surface bioelectrical manifestation of the process of contextual updating of a control schemata as result of the mismatch of a current stimulus, not with some fixed list of attributes, but rather with the anticipatory schemata, characterized by a hierarchical structure and by prototypes rather than lists of attributes. When such a manifestation of context updating is seen as a reaction of the brain to past events which simultaneously prepares the brain for an optimal processing of future events, as repeatedly demonstrated experimentally, it follows that P300 “behaviour” gives strong support to Neisser’s (1976) theory of knowledge acquisition through anticipatory schemata. In addition, it assures the continuity of the conscious experience deriving from the perceptual cycle. In a way, this can be visually appreciated in Fig. 1. Going further, the evidence that has been accumulated showing that the so called exogenous components are affected by the top-down influence of the schemata on perceptual processing lends some more support to Neisser’s (1976) ecological theory of cognition. It is significant, however, that this evidence suggests also the inadequacy of the
traditional contraposition between the intraperceptual and extraperceptual theories of information processing. Even more significantly, the general theory of knowledge acquisition supported by the ERP research reveals a fair amount of similarity to accounts by Berlyne of aesthetic reactions and knowledge acquisition couched in terms of the arousal or tension consequent upon a conflict between the current stimulus and what is expected, even though it goes forward stressing the prominent part played by schemata. If we continue with the perceptual cycle metaphor, however, a consideration of the above argues insistently for the brain capacity for conceptual processing which provides a complex framework for classifying stimuli. Because, in fact, man has an available conceptual classification system for stimuli and symbols he is able to process information about the environment quite rapidly. The advantage of more efficient processing of information is that the organism can respond more readily and appropriately to the environment. As we noted above, this conceptual classification system in which objects are spatially and temporally represented consists of the schemata. The recent results provided by ERP depth recordings from neurological patients and animals (mainly primates and cats) suggest that a portion of the P300, P3b, arises in or near the hippocampus, a large structure of the brain's limbic system. This provides persuasive evidence for a neuroanatomical physical substrate for the cognitive mapping system, defined by cognitive psychologists schemata or cognitive map. Thus, in the light of the previous and present P300 findings, the hippocampus, that is known
to play a major role in the access to memory by our nervous system, would be at the center of the cognitive mapping classification system with its function of integration of information from all major sensory modalities, and its close relationships with the locomotion system in three-dimensional space and more remote representational symbolic systems, such as language. However, the fact that over the last 20-30 years the hippocampus has been linked to simple classical conditioning and viewed conjointly with the motivational-reward system, makes compatible the above mentioned point of view with the view of the limbic system as a holistic functional unit, in which the hippocampus is seen as the integrative neurophysiological substratum of cognition, emotion and motivation. This allows the recognition that behaviour can be initiated by external stimuli and cognitive processes as well as by the biological deficits that have served as the cornerstone of the drive reduction model. Behaviour, in fact, is purposive and schematic in nature; again, it is continuous and does not disappear with a response to a stimulus and appear anew with a new stimulus. Cognitive psychophysiology thus aims to locate and manipulate the physiological concomitants of specific schematic strategies, and to end with the external events this involves. Then it will require no great temerity to regard these goals of study as intimately related to the study of emotions, motivations, attention and arousal. A number of recent ERP studies support this assertion. Experimental results, in fact, give evidence of the existence of two arousal systems, one related to brain-stem reticular activating system and
the second system identified with limbic structures responsible for modulating behaviour through incentive related stimuli, conceptualized as mutually inhibitory. In essence, in humans a correct response in a stimulus discrimination task (independent of the sensory modality studied) is associated with a strong momentary activation of the neurons of the hippocampus and amygdala and a large P300 component over the cortex, a phenomenon very likely mediated by limbic inhibitory discharge to the brain-stem aspecific arousal system. This is consistent with the results obtained in animals in relation to the so called reward contingent positive variation. This consistency has been used to justify the view that, in man and very likely in phylogenetically higher species, the incentive value is no longer confined to satisfaction of primary drives but also encompasses hedonic gratification from various tasks, such as detecting a specific stimulus pattern, discriminating between different stimuli, or a semantic problem. At this point, the close resemblance between these theoretical developments of cognitive psychophysiology and Berlyne's (1960; 1971) accounts of arousal as the psychobiological bases of appreciation of art and aesthetic material will hardly have escaped anyone. In conclusion, then, it appears that using the ERPs as quantifiable measures of human cognition and emotion we can not only help to test existing theories of human information processing and cognition, but we can also help to build new and more heuristic ones. This review, I hope, has presented a fair amount of support for the claim that the explanatory framework outlined may be used at least as a guide to
predict a perceiver's behaviour for a number of seemingly diverse areas related to perception and aesthetics. That such an enterprise can be accomplished makes such a framework more credible, and may serve as an impetus for the necessary further research.

REFERENCES


Fig. 1. On the left, examples of average ERP waveforms, recorded at the vertex of the head in response to a frequent stimulus (probability = 80%) (dashed line) and a rare stimulus (probability = 20%) (solid line) randomly and sequentially administered, are shown. Subject’s task was to count the rare stimulus; S = stimulus delivery time. Above: the frequent stimulus was a 65 db SPL, 2000 Hz pip tone, whereas the rare stimulus was a 65 db SPL, 1000 Hz pip tone. Below: the same stimuli as above but with reversed probability. As a whole, the data suggest that information processing is mediated by the mismatch of the rare stimulus, independently of the physical nature of the latter, with the individual’s subjective expectancies deriving from a top-down representation (e.g. schemata) of the task condition. On the right, Neisser’s model of schemata, as embedded in the perceptual cycle, is shown. Note the strict relationships between this theoretical model of cognition and brain functioning as shown by ERPs.