is quite likely that a variety of processes manifest themselves on the scalp concurrently with those manifested by P300, although the ardor with which this proposition is embraced varies across laboratories. However, a P300-like component appears in everyone's pantheon of components, and it is to this component that we direct our attention in this precommentary.

3. Note the distinction between the function of the noise itself (it has none) and the function of the process generating the noise as a byproduct. This is an apt analogy to the ERP, as we are not ascribing any functional significance to the potentials we record on the scalp. Rather, we assume that what we record are byproducts of the activation of processes that do have functional significance.

4. For those who are skeptical about analogies to computers, we note that we are using this comparison merely to illustrate the use of different descriptive levels when discussing an information-processing system.

5. The term "oddball" applies to all tasks that satisfy the following conditions: (a) The subject is presented with a series of events, where "event" can be defined in a complex and abstract manner as long as the subject can distinguish one event from another; (b) a classification rule is defined which categorizes each of the events into one of two categories; (c) the subject is assigned a task whose performance depends on applying the categorization rule to the events; (d) events in the two categories are chosen at random, that is, they constitute a Bernoulli sequence. In general, a fifth condition has also been obtained, namely, (e) the probability of one of the categories is substantially lower than that of the other category. It is this focus on the rarity of one class of events that gave the paradigm its label ("oddball"). And, in general, the rarer the event, the larger the P300 it elicits (Duncan-Johnson & Donchin 1977). However, it has been known for some time that rarity is neither necessary nor sufficient to elicit a P300. (See Fabiani et al., 1987, for a review of the paradigms used in P300 experiments.)

6. Donchin et al. (1973) used the following words: "In view of the diversity of the P300 function that our data reveal, it seems that a reasonable approximation is to assume that P300 reflects the activity of a general-purpose processor which is invoked on demand by a host of data processing requirements" (p. 322). This formulation appears to have confused a number of authors who interpreted us as saying that P300 is a generalized processor with no specific function. The intent, however, was quite the opposite. The phrase "general-purpose," for which we used a Floating Point Processor as an example, was meant to imply a device with quite a specific function that could, however, subserve a larger variety of higher-level functions. As noted above, the retina is a device that is specialized for the acquisition and initial processing of information carried by light. Yet it is a quite general device, in the sense that it can be used to look at, look for, or look after whatever it is that the person's task requires at the time.

7. It should be noted, though, that the assumption does gain credence from the convergence of the very large number of studies conducted under its guidance.

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P300 and the validity of psychophysiological descriptions of behavior

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The hypotheses advocated by Verleger and Donchin & Coles (D & C), divergent as they may be in certain respects, have one basic idea in common. It is an assumption about the subjective schema of the experimental situation or "all available data about the environment" (Donchin 1981) stored in the subject's (S's) memory. According to the hypotheses under discussion, crucial moments in the schema state – "context updating" or "context closure" – are manifested in brain electrical activity as the P300 wave. The authors all use this concept to describe internal processes basic to behavior. The main goal of research using event-related potentials (ERPs) is to make inferences about the dynamics of internal processes, hidden from external observation, through characteristics of ERPs. This is why it is so important to analyze the basic assumptions of certain models about the processes underlying behavior and to discuss their possible consequences for psychophysiological research.

The ideas about the structure and dynamics of internal processes discussed in both target articles have been elaborated upon by contemporary cognitive psychologists with the help of concepts taken from one of the most rapidly developing domains of human practice: computer technology. This approach sees a resemblance between the structure and organization of the brain and computer processes (Neisser 1976). The heuristic importance of this approach is beyond doubt, but one point pertinent to this discussion should be stressed here: As applied to real processes underlying behavior, the computer view cannot be considered anything but a metaphor.

The computer view has one of two results: There is either a strict matching of the main constructs of a subjective schema with experimental variables under the investigator's control (as with Verleger in his rigorous adherence to paradigmatic rules in the sense of Kuhn 1970), or these constructs become hardly accessible for measurement and formalization (see the work of Donchin and colleagues cited in the accompanying reference list). In this connection, it is worth recalling that logical difficulties in measuring subjective probabilities were analyzed by von Wright (1962), who pointed out that their values are not measured but are attributed by the experimenter, who assumes the subjective probabilities to be identical with the objective ones related to certain events. The metaphoric nature of the description of the processes underlying behavior raises one more problem: how to correlate the brain processes that manifest themselves in ERPs through measurable characteristics – morphology, latency, polarity, amplitude, and topography – with basic metaphoric constructs that turn out to be difficult either to measure (subjective probability) or to formalize (task relevance).

To solve the problem of the P300, it is very important to develop a valid psychophysiological description of the internal processes underlying behavior. This should, on the one hand, characterize the specific nature of brain processes while, on the other hand, adequately describe the relationships between the organism and the environment. This type of description could serve as a sound ground for the critical assessment of competing hypotheses.

From our viewpoint, the verification of the context updating hypothesis does not require further direct neurophysiological evidence, as Donchin & Coles (D & C) claim (these data are already abundant), but rather an adequate psychophysiological description of internal processes. Lacking this description, the hypothesis, despite its creative potential, may remain only a brillant guess. A possible approach to the construction of this type of psychophysiological description of internal processes has been outlined in the functional system theory (Anokhin 1974;

Shvyrkov 1985). According to this theory, behavior is a specific kind of relationship between an organism and its environment based on the actualization of elements of experience mutually related by the timing of their phylogenetic and ontogenetic development. These elements of subjective experience are functional systems of integral behavioral acts which emerge in relation to the goals of a subject, specific to motor activity and environmental conditions. Consequently, elements of subjective experience fix certain relationships between an organism and its environment.

The actualization of elements of experience can be studied by observing the activity of specialized units (Shvyrkov 1985). Behavioral specialization of units has been confirmed in a number of experiments (e.g., Mountcastle et al. 1975; O'Keefe 1979; Rank 1973). Functional system theory allows us to describe both organism–environment relationships and brain processes in the same terms, consisting of the structure and dynamics of subjective experience. Now, what specific characteristics of the structure and dynamics of experience are manifested by the P300 wave? Recording slow brain potentials in humans and rabbits under similar conditions – performing signal-detection tasks – we tested the structure of experience by recording cortical unit activity in animals, applying the data obtained to interpreting ERPs in humans and animals.

The external observer describes the behavior in this task as a sequence of two behavioral acts maintained by two diverse sets of elements of experience. In the process of implementing an act, elements necessary to achieve the goal are selected; in other words, the set of elements becomes increasingly specified. A negative-going shift accompanies this. The transition from one act to another coincides with the interval during which opponent elements of experience (underlying successive acts) are activated simultaneously. This leads to a decrease in the specificity of the set of elements of experience. This overlapping of sets of elements of experience related to successive acts coincides with the development of a positive potential, identified as P300 (Aleksandrov & Maksimova 1985; 1987).

The data reported formally support the context updating model. A certain "discontinuity" in the behavioral continuum (i.e., a change in the contents of internal processes) is a factor determining the emergence of P300. This analogy suggests that the context closure model is related to the context updating model as a more fragmented description of the process of change because it stresses just one aspect of it – the termination of the preceding state. This suggests an equally valid complementary hypothesis of "context opening." It should be stressed, however, that our data demonstrate that P300 is associated not with the change of the elements' set but with the simultaneous activation of the sets of elements of experience related to the preceding and following behavioral acts.

This leads to the conclusion that solving the P300 problem will require the experimental study of sets of elements of subjective experience and their relations throughout the entire course of the behavior investigated. Elements of experience should be among the main constructs used in the psychophysiological description of the internal processes underlying behavior. The various kinds of ERPs (e.g., VEP, AEP, P300, CNV, movement-related potentials) turn out to be not autonomous electrophysiological phenomena, but fragments of a potential corresponding to the realization of successive behavioral acts and the transition from one act to another (Maksimova & Aleksandrov 1987). The P300 problem accordingly loses much of its uniqueness in the context of research on the experiential structure and dynamics of the ERP method.

We still need methods by which to assess the structure and dynamics of experience from observed behavior. We have analyzed the behavior of two opponents playing a tic-tac-toe variant. To win, one must obtain an uninterrupted line of 5 signs on a board with 15 × 15 squares (Maksimova 1987). Under these conditions, the player's sequence of actions and the available number of alternative moves is not assigned by the experimenter but inferred from the real record of the game and from the quantitative evaluation of the possible consequences of a certain game situation. The player's behavioral act was defined as an interval between two successive moves of the opponent. The description of the behavioral act included numerical evaluations of the game situation after the opponent's move (the initial situation), transformations of the situation by player (the player's action) and the game situation after the opponent's move (i.e., the resultant situation, which reflects the value of the player's move coming closer to winning or losing). Acts with identical numerical indices for the starting situation, the player's action, and the resulting situation are assigned to the same type. For six players, 500 types of behavioral acts have been identified. A players repertoire of acts is considered his subjective experience in tic-tac-toe, the acts being the elements of experience.

An analysis of the probabilities of transitions from an act of one type to acts of different possible types, of the trajectory of the hand moving over the board in choosing the move, and of the temporal characteristics of acts indicates that every act is chosen from the set of simultaneously activated elements of experience, that is, from the set of all acts possible for the player in that position. After the player's move, all the likely acts after the opponent's expected move are simultaneously activated, providing the potential elements for the next act, and so on. The correlation between the dynamics of elements of experience and averaged slow potentials showed that during the selection of the move, the activation of specific elements of experience increases, being accompanied by decreased activation of competing elements. This coincides with the negative ERP shift. When competing elements of experience that have been activated in equal measure grow in number, a positive wave occurs. These preliminary data suggest that there are rigorous quantitative relationships between ERP parameters and the internal processes underlying behavior.

P3: Byproduct of a byproduct

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The ferocity of the exchanges between Verleger and Donchin & Coles (D & C) reveals deficiencies not only in the specific models but also in current P3 research in general. We do not believe that a theory about the meaning of the P3 can be of relevance if it is based purely on the phenomenon itself, especially if it is not discussed in relation to other ERP (event-related potential) components. Such an approach can hardly improve our understanding of early information processing or neocortical functions in general. The "functional significance" (D & C) of P3 or any other ERP component can become clear only if the phenomenon is analyzed (theoretically and empirically) *together* with the electrocortical and cognitive-behavioral processes preceding, accompanying, and following it in a particular experimental situation. Both papers painstakingly avoid even mentioning any of the well-known brain responses other than P3; both papers ignore the fact that we observe P3s embedded in an ongoing stream of parallel and serially organized brain processes and responses.

Before we outline our main arguments against such an isolated focus on P3, a statement about the usefulness of cognitive terminology for ERP research seems to be appropriate. The "cognitive boxes" (presented so nicely by Verleger) yield predictions only if the process symbolized within the box is tied to a measurable behavioral or physiological response. A construct