UNCONSCIOUS AND CONSCIOUS PROCESSES DURING VISUAL PERCEPTION

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Key words: visual perception, unconscious processes, conscious processes

Abstract. Ongoing unconscious processes may be influenced by related conscious processes without self-awareness. (a) When the conscious semantic interpretation of physically identical shapes changes due to their angular rotation, the sequence of saccadic movements and the localization of eye fixations over the shapes change as well. (b) The amplitude of the P 300 wave of visual evoked potentials is related to the conscious cognitive interpretation of identical stimuli. (c) The instants of figure reversals are influenced by conscious cognitive programs delineated by means of corresponding experimental instructions. It is assumed that unconscious and conscious processes may be considered functional manifestations of the same complex and specific neuronal network at different levels of its hierarchical organization and that mutual interactions between both types of processes do not require the existence of any mediating “interface” system.

The relationship between the human brain and individual consciousness is of basic significance from the point of view of both the neurosciences and philosophy. In principle, two conceptual approaches can be distinguished in this field: Consciousness is considered either in the
sense "outside" or "above" the brain (6, 7, 11, see also 9) or as a specific function of the brain, characterizing a certain level of the hierarchical organization of a complex and specific neuronal network (12, 14, 21, 22, 23). In the former case the existence of a special subsystem (interface) linking conscious and unconscious processes (1) must be hypothesized (Fig. 1). The aim of the present paper is to list experimental evidence in favor of the assumption that conscious and unconscious processes represent different hierarchical levels of the same functional system in which communication from conscious to unconscious processes and vice versa exists, i.e., no special "interface" between them is needed.

(a) The first group of experiments dealt with eye movements recorded by means of a corneal reflectance technique (3) in subjects looking at nonsense polygonal shapes (Fig. 2). These shapes were selected in a way that allowed eventually different semantic interpretations—associations at different angular orientations. The rotation was chosen as a transformation that did not change the physical appearance of the stimulus.

The stability of verbal associations was investigated first (4, 5) at neighbouring angular positions (see horizontal axis in Fig. 2) and was found to depend on angular position. For some angular positions the changes in the interpretation of shapes were more probable than for other ones. The type of this dependence was typical for particular shapes (two are shown in the upper part of Fig. 2).
Fig. 2. Upper part: stability of verbal associations of naming the polygonal shapes shown here at different angular orientations on the horizontal axis (modified according to 4, 5). Lower part: eye fixation points over the same polygons (in one of the subjects) at different angular orientations with the subject's semantic interpretations (modified according to 15).
The shapes were presented at positions where the associations were different. Eye fixation positions were recorded when the subject was inspecting the shapes for successive recognition from a group of similar figures. Finally, the subject was asked to recall the spontaneous associations — semantic interpretations, evoked by the shape during inspection when the association appeared and to complete the shape by salient features in accordance with this association.

Two-dimensional histograms of eye fixations over the shapes (see the lower part of Fig. 2), one-dimensional histograms of the number of fixations over selected features (angles) and sequence of fixed features of the shapes, represented by transition matrices were constructed by means of a computer. It was found that, irrespective of angular rotation, the fixations tended to concentrate mostly around the angles (2). The general finding was that the distribution differed in cases where the semantic interpretation varied and was equal when the interpretation remained the same. A first order Markov dependence between the successively fixed features was found when the shapes had semantic meaning, while without it the sequence of fixed features was random.

From these types of experiments it follows that the location and sequence of eye fixations, i.e., the target point selection by saccadic eye movements which is a fully unconscious process, is controlled by conscious cognitive mechanisms of higher order.

(b) In the second group of experiments the amplitude of the late positive waves (P 300) of visual responses, induced by an identical group of stimuli, was compared under two different cognitive conditions, both of which were of a conscious nature (18–20).

A computer, combined with an electronic programming device, allowed the classification of single evoked potentials into two groups, according to a psychological (conscious) criterion, and to average them separately (Fig. 3). The experiment was a modification of the known "7 ± 2" paradigm; the task of the subject was to determine the number of simultaneously presented (always for 200 ms) white light squares randomly placed on the screen (6–10 items).

After each stimulus the subject told the experimentater what he saw. Thereupon the experimentater sent the single evoked response, waiting in the processor of the computer, into one of the two systems of averaging.

It was found that in the majority of cases a correct recognition of the number of items was combined with a higher amplitude of the late positive (P 300) component of visually evoked responses. Similarly, after the evoked responses were classified according to the subject's certainty or uncertainty during recognition, irrespective of the objective correct-
Fig. 3. Upper part: schematic representation of human visual evoked potential classification into two groups according to a binary (cognitive) criterion permitting separate averaging (and comparison) of potentials evoked by similar stimuli and differing only in the cognitive criterion used. Lower part: averaged evoked potentials recorded during recognition of the number of simultaneously presented items, the criterion of classification being the subject's certainty or uncertainty during the task (modified according to 19).

ness or incorrectness of the statement, the P 300 wave of higher amplitude was usually found in evoked potentials, corresponding to certainty during recognition. Special experiments showed that both factors, correctness / incorrectness and certainty / uncertainty, are interrelated.

These experiments have demonstrated that neuronal processes, underlying the late positive component of visually evoked potentials (which are naturally unconscious), are related to the conscious cognitive factor manipulated in the experiment.

(c) The third group of experiments dealt with subjective figure reversal. The alternation of both cognitive interpretations of the shapes was signalized by the subjects, who were properly instructed psychologically, by slight and automatic hand movements. The resulting “alternating point process” characterized by two possible states with instantaneous transition between them was then analysed by a computer.

The same stimulus shapes could be considered in accordance with the psychological instruction, a geometrical representation of either two- or three-dimensional objects which were reversible in both conditions (Fig. 4).

The shape shown in the upper part could be seen either as a flat figure-background pattern (with a spontaneously alternating horizontal or vertical “spool” interpretation) or as a three-dimensional object alter-
natively concave or convex. The results of statistical analysis proved that the intervals, corresponding to three-dimensional subjective interpretation, were longer as compared to those corresponding to two-dimensional interpretation of the physically identical stimuli. The subjects did not realize this difference (16).

Similarly the shape shown in the lower part of Fig. 4 could be interpreted either as a two-dimensional alternating "propeller", or a version of the three-dimensional Necker cube. Intervals, corresponding to the three-dimensional interpretation (requiring probably more elementary neuronal steps) were again longer as compared with those during the two-dimensional interpretation of equal stimuli, with the subjects being unaware of it (17).

It follows from these experiments that the rate of spontaneous and automatic reversible figure reversals, realized post facto by the subjects, is influenced by the conscious cognitive program introduced into their memory by means of instructions.

It can be concluded on the basis of these three types of experiments that ongoing unconscious processes may change depending on the related conscious processes during visual perception, of which the perceiving subject is usually unaware. It is almost a trivial statement that
Conscious experience is the result of preceding unconscious processes taking place in the sensory systems ("Nihil est in intellectu quod non ante in sensu"). The basic theoretical assumption of the present paper is that unconscious (physiological) and conscious (psychic) processes may be considered functional manifestations of the same complex and specific system of neuronal networks at different levels of their hierarchical organization. Both types of processes may take place within the same system. Their mutual influence and interactions do not require the existence of any mediating “interface” between them (see Fig. 1B). The experimental results of Gershuni (8) and considerations of Pavlov (10) are in accordance with this assumption. The quality of consciousness might appear as a specific attribute of a certain neuronal network of the human brain at a definite level of its intrinsic organization.

As conscious phenomena are attributes of the complex and specific neural matter, they cannot be dissociated from it. No “soul” is outside and without the “body”, no parapsychic phenomena exist; “consciousness” cannot be attributed to organisms not comprising neural matter at the corresponding level of intrinsic organization etc. (13).

REFERENCES


