

Comments on time in action and perception

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Time as a physiological sequence of connected states differs in some respects from the legion of processes in nature that proceed in the temporal dimension. Within the living organism it is intimately joined to the unknown mechanism of memory in both its long- and short-time versions. The beginning and the end of a short-time sequence are held together by short-time memory. A striking example of the role of long-time memory is Wilder Penfield's well-known finding while stimulating the temporal lobe of a patient. She responded by recalling a long lost happening in great detail, as it had developed, in a sequence of perfect temporal precision. The patient re-experiencing the event was at the same time aware of lying on the hospital operating table. This, by the way, elicited Sherrington's comment that it must be nice to hear the preparation speak!

Numerous well-timed sequences are known to physiologists as belonging to the genetic make-up; for instance, reflex deglutition which engages 12 muscles on either side in a well-regulated succession (Doty 1968). Others are acquired, like the majority of programmed motor acts, some of which need a very high degree of accuracy in the timing of the muscles cooperating in a movement. A component of adaptation enters into this process because of the limiting conditions set by the progressive changes of the inertia and momentum of the moving parts with age. Walking and running are examples.

The organizational problems of time and timing in acquired neural sequences are hardly within reach of present-day neurophysiology. Purposive motor acts contain so many elusive components – some of them tied to the operations of will and consciousness – that theorizing in this field is apt to become sheer speculation. It is barely possible to come closer in understanding than to assume with Fuster (1981) that a decisive organizing role is played by the prefrontal cortex and that the cerebellum plays a no less decisive and related role in the coordination of movements.

There is, however, one aspect of time in motor control that may serve to divulge an opening. This is the velocity at which an established motor act is being performed. It is difficult to imagine that the complex integration of velocity would be lacking one or several specific sites in the cortex.

The modern analytical EEG-methods stimulate the hope that one day sites of velocity control may be revealed. Should this come true, basic analytical procedures stand a chance of uncovering some principles of control in the temporal dimension. But on the whole, the organizational world of motor timing brings us so close to the real genius of our brain that understanding it seems a very distant goal if it ever comes within reach. At a moment's notice our will may demand new muscular combinations and the motor 'mariotte' executes the order, perhaps not perfectly at first but, after a while, well enough controlled in speed and precision. Time and timing are at the free disposal of the dictator in the brain.

Visual perception provides some useful approaches to awareness of time as incorporated in the experience of the velocity of a directional movement across the field of vision. Velocity is the inverse value of the time required for the movement of an image over a given retinal distance, say, the span of the field of view. Thus an animal has available an exact measure of time, albeit indexed by velocity, a most vivid impression. Both velocity and distance are, of course, analyzable by present techniques and the relevant literature is already too extensive to be done justice in these brief comments. Let me only remark that there is little use for a perception of abstract time in midair, as long as time is incorporated in a most useful integration serving to detect the velocity and direction of a movement that in many ways engages the animal's interest in survival. Our purposive brain is bent on handling problems of perceived time in ways that make some sense. To take another example, a difference in time (latency) between the arrival of the impulses from the two eyes brought about by a dark glass in front of either eye, produces the Pulfrich Effect: a rotation of the spot of a pendulum swung in the vertical plane in front of the observer.

In acoustics, a difference in time between the arrival of impulses from the two ears causes us to localize the emitting source. Yet that difference, depending on the distance between the ears, makes extraordinary claims on precision. The information in this case arrives from two crossed and two uncrossed paths. From experiments on dichotic listening it is known that complex mechanisms of inhibitory suppression are part of the receiving apparatus.

Since we have no receptive structure for perceiving time as such – the time in midair – psychologists have taken to experimental exercises with a notion of duration and its variable contents (Frankenhaeuser 1959; Ornstein 1969). To

physiologists, time as duration would mean something only in terms of expectation, a sign of which is the "expectancy wave" of an EEG-record, whatever that means. Anyhow, time elapsed does provide a rough measure of the duration required for an expected event to come off. In this sense, it contains a real meaning, in addition to being analyzable from different points of view. Even the Pavlov dogs can be taught to salivate in response to 'time'. The brain, with this response, as always, has created a process corresponding to its needs.

Imagine for a moment that it were possible to assign a 'creative index' to the components traceable in a synthesis or integration; then, surely, time would rank very highly. Acoustics exemplify this statement in so many different ways that they virtually approach the status of a field stimulated by a time receptor! Consider, for instance, the perceived effect of three clicks given in the following three temporal arrangements: . . . / / and . . . /

These induce three characteristic experiences of acoustic timing, clearly differentiated. They occur in speech and song and it would not be difficult to measure the time thresholds for the intervals needed to produce them as separate entities. Perhaps this has been done; I am not familiar with the psychological literature. I have used them here to introduce the world of music, vastly dependent on temporal integrations both in its motor and sensory aspects.

I have said enough, I believe, to illustrate my general view, which is that the brain is employing time as a creative element in motor and sensory processes. There is no specific time receptor but the brain behaves as if it had one. Will, the motor dictator, rules over a perfect timing machine available for actions over a wide range of speed. In vision, time is most obviously integrated in judgments on the velocity of movement of objects within the visual field; in acoustics, the whole world of rhythm and tonality is based on processes of temporal integration.

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