

# On the Time of Peripheral Sensations and Voluntary Motor Actions

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## ABSTRACT

Libet's notions of backwards referral for peripheral sensations and unconscious cerebral initiative accompanying voluntary motor action are explored. It is proposed that the unexpected discrepancy between the time at which a peripheral sensation is experienced and the time at which cerebral neuronal adequacy underlying the sensation is attained is due to fundamentally different forms of temporality which are applicable to experiential and neurophysiological reference frames. A similar proposal is made for the unexpected discrepancy in the time of a neurophysiological readiness potential accompanying a voluntary motor action and the time of onset of the intention accompanying the action. Correspondences between experiential and neurophysiological levels of peripheral sensations and voluntary motor actions indicated by Libet's empirical evidence are shown to be adaptive if an individual's experience is important in his interaction with the environment.

## Text

Libet<sup>1</sup> has presented empirical evidence supporting the thesis that the onset of a neurophysiological readiness potential associated with some voluntary motor action precedes that action by about 550 ms. He also presented evidence that the onset of the conscious awareness of the intention associated with a voluntary motor action precedes that action by about 200 ms. On the basis of this evidence, Libet reasoned that the approximately 350 ms difference between the time of onset of the readiness potential and the time of onset of the conscious intention indicates the existence of unconscious intention concerning this voluntary action. Essentially, Libet challenged, "How else can the readiness potential associated with a voluntary motor action be explained?"

In discussing the results of his research as they bear on the question of whether there is unconscious motivation, Libet did not explore fully the implications of other research results obtained by him and his colleagues which bear directly on this question.<sup>2,3</sup>

A consideration of Libet's results concerning peripheral sensation and voluntary motor action indicates that the experiential and neurophysiological

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components of a peripheral sensation or voluntary motor action constitute different reference frames with distinct temporal structures.

### BACKWARDS REFERRAL AND TEMPORALITY

In their research on peripheral sensations, Libet and his colleagues proposed that a subject's experience of some peripheral sensation appears to be referred backwards in time approximately to the instant of stimulation, even though the neuronal processes associated with the sensation require some finite period of time before they attain cerebral "neuronal adequacy". Cerebral neuronal adequacy appears to refer to a stage in the neuronal processing associated with some sensation at which: (1) the experienced sensation is no longer affected by additional sources of neuronal impulses, and (2) the neuronal processes associated with the sensation support the conscious awareness of this sensation. In support of this phenomenon, Libet noted empirical evidence indicating that the experience of a peripheral (skin) sensation may be influenced for a duration of up to 500 to 600 ms following the initial physical stimulation giving rise to this sensation by experimentally induced cerebral stimulation applied to somatosensory cortex, postcentral gyrus. In addition, about 500 ms of direct cortical stimulation of somatosensory cortex, postcentral gyrus is required for an experienced sensation.

Libet also found that when cortical stimulation to postcentral gyrus was introduced prior to the peripheral (skin) stimulation, subjects reported that the experience associated with the peripheral stimulation preceded that experience associated with the cortical stimulation. Libet reasoned that the experience associated with the peripheral stimulation appeared to be referred backwards in time. Using other empirical evidence concerning the physiology of somatosensory sensations and empirical results concerning experimentally induced stimulation of medial lemniscus, Libet reasoned that subjective awareness of the peripheral sensation appeared to occur approximately at the time of onset of the physical stimulus associated with the sensation.

Libet maintained that a "primary evoked potential" serves as a timing mark for the backwards referral. This primary evoked potential in primary sensory cortex occurs within 10-25 ms (*i.e.* very quickly) after a sensory stimulus. Slower potentials related to the sensation follow. These slower potentials are more widely distributed in the cortex and more concerned with the cognitive aspects of the sensation.

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Concerning medial lemniscus, it was found that direct stimulation of medial lemniscus elicits the same primary evoked potential found when eliciting a peripheral sensation. If this primary evoked potential is the timing mark for the occurrence of the peripheral sensation, it is reasonable to expect that this potential should also act as the timing mark for the experience elicited by medial lemniscus stimulation. Unlike the peripheral sensation, though, medial lemniscus requires durations of stimulation similar in length to those required by the cortical stimulus (*i.e.* in the neighbourhood of 500 ms) in order for the experience of a sensation to occur. Given these circumstances, Libet and his colleagues expected that if stimulation were provided for a peripheral sensation and for medial lemniscus at the same time, subjects would report that the sensations were experienced at the same time. This is what the results bore out.

Perhaps the most intriguing aspect of these striking research results and conclusions is that the times at which the experienced peripheral sensations tested by Libet and his colleagues occur appear to be distinct from the temporality underlying the neurophysiology related to the achievement of neuronal adequacy. If, as Libet suggested, a sensation is experienced approximately at the instant at which some peripheral stimulus is administered to an individual, and empirical evidence indicates that some finite period of time is required from the onset of the physical stimulation to the development of neuronal adequacy associated with the sensation, it is plausible that the time of onset of the experienced sensation is not part of the same temporality governing the associated neuronal processes.

In discussing the nature of backwards referral, Libet noted (p. 241):

It is important to realize that these subjective referrals and corrections are apparently taking place at the level of the *mental* "sphere"; they are not apparent, as such, in the activities at neural levels.

### EXPERIENTIAL AND NEUROPHYSIOLOGICAL FRAMES OF REFERENCE

Though concerned with physical phenomena, near the beginning of his original paper on the special theory of relativity, Einstein made the following comments (pp. 38-39):<sup>4</sup>

If we wish to describe the *motion* of a material point, we give the values of its co-ordinates as functions of the time. Now we must bear carefully in mind that a mathematical description of

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this kind has no physical meaning unless we are quite clear as to what we understand by "time". We have to take into account that all our judgments in which time plays a part are always judgments of *simultaneous* events.

After describing the limitations of an essentially psychological basis for judging simultaneous events, Einstein proceeded to define simultaneity for distant physical events in an inertial frame of reference (*i.e.* a spatial coordinate system, attached to some physical body, in which Newton's law of inertia holds). There is nothing more central for the determination of the temporal ordering of physical events in an inertial frame of reference than the delineation of simultaneous events. For example, on the basis of his definition of simultaneity for distant physical events in an inertial reference frame, Einstein presented his remarkable argument that simultaneity is relative for inertial frames of reference in uniform, translational (*i.e.* rectilinear and non-rotary) motion relative to one another.

In the case at hand, Libet was not concerned with the physical expressions of some phenomenon as concerns their temporal designations in inertial frames of reference in uniform, translational motion relative to one another. Instead, he was concerned with the temporal relation between a phenomenon's experienced and neurophysiological forms. Nonetheless, Einstein's concern about being clear on what is meant by the time of physical events is of direct relevance in considering Libet's experimental results. In particular, the delineation of simultaneous occurrences may be of significant aid in understanding the temporal basis of occurrences studied by Libet. With regard to Libet's results, simultaneity appears to be different for the onset of the physical stimulation and the experience of the sensation associated with a peripheral sensation on the one hand, and the onset of the physical stimulation and the resulting neuronal processes on the other. Whereas the onset of peripheral physical stimulation and achievement of neuronal adequacy are not simultaneous occurrences, the onset of the physical stimulation and the experienced sensation associated with the achievement of neuronal adequacy are corresponding, and essentially simultaneous, occurrences.

If absolute time underlaid both experiential and neuronal processes associated with a peripheral sensation, one would expect that the times of onset of the experience of the sensation and the achievement of the associated cerebral neuronal adequacy to be the same. It appears that they are not, and thus

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absolute time appears an inadequate temporal basis for describing the experiential and neuronal processes associated with a peripheral sensation.<sup>5</sup>

### FORWARD REFERRAL AND UNCONSCIOUS CEREBRAL INITIATIVE

Libet found in his research on voluntary motor action (specifically, flexing the wrist or fingers of the right hand) that an approximately 350 ms difference existed between the time of onset of the readiness potential associated with the action and the time of onset of the conscious intention associated with this action. He concluded that the resulting approximately 200 ms difference between onset of the conscious intention and the associated motor action indicates a type of control function for the conscious intention as regards the actual occurrence of the motor action.

As noted, it is possible that the time at which a sensation is experienced is part of a different temporality than that underlying the neural physiology related to neuronal adequacy. If this is the case, then it is reasonable to expect that the temporality underlying the experience of the intention to act which is associated with a voluntary motor action might be different than the temporality underlying the physiology concerned with the readiness potential. Specifically, perhaps there is a forward referral of the subject's experience of the intention to act relative to onset of the readiness potential.

Just as backwards referral might serve an adaptive purpose by allowing the time of experience of a peripheral sensation to correspond to the onset of the physical stimulation associated with this sensation, so forward referral might be adaptive. Forward referral would allow for the time of experience of the intention to act which is associated with a voluntary motor action to correspond to the onset of this action, keeping subjective experience and processes of the physical world in sync.

In the case of forward referral, occurrences which one would ordinarily consider simultaneous in an absolute temporal structure (*i.e.* the onset of neural activity associated with a voluntary motor action and the onset of the conscious intention to act) are not. Thus, the temporality underlying the neurophysiological processes associated with the voluntary motor action may be different than the temporality which correctly describes the experience of the intention to act.

Libet<sup>1</sup> reported data that the experience of the onset of a voluntary motor action may occur slightly before the onset of the electromyogram at the

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appropriate muscle used to determine the onset of the action. This discrepancy may be up to 100 ms.<sup>6</sup> This discrepancy, even if 100 ms, though, does not alter the general temporal ordering supported by data regarding onset of the readiness potential, onset of experienced intention, and onset of the voluntary motor action itself. Moreover, Libet noted that the temporal discrepancy may be due to the experienced intention being related to the final motor cortical output for the action as opposed to the onset of the electromyogram at the muscle involved. The temporal discrepancy would then just be a delay due to the neurophysiological processes involved in the production of a voluntary motor action and not be a significant discrepancy between the time of onset of the experience of a voluntary motor action and the time of onset of the associated electromyogram.

### THE ADAPTIVE ROLE OF BACKWARDS AND FORWARD REFERRAL

Mention has been made that backwards and forward referral may be adaptive. The adaptive nature of these phenomena, though, depends in large part on the importance of experience in the individual's interaction with the environment. To show how backwards and forward referral can be adaptive, consider the possibility that absolute temporality does exist. Then, a peripheral sensation would actually be experienced when cerebral neuronal adequacy is achieved approximately 500 ms after the peripheral stimulus. Similarly, the conscious intention to engage in a voluntary motor act would occur with the onset of the readiness potential some 550 ms before the beginning of the motor act. There would be essentially two levels of functioning, the actual one tied to the neurophysiology and the illusory one tied to the individual's experience. The individual would be experiencing a peripheral sensation well after the peripheral stimulus and would be experiencing the intention associated with the voluntary motor action well before the action occurred. (It is to be noted that Libet carefully distinguished between intention to act and deliberation over whether to act.) This state of affairs will suffice in this scenario if experience is considered relatively unimportant in the actual functioning of the individual in the environment.

But if an individual's experience is a key component of his interaction with the environment, then the close correspondence of the experiential and neurophysiological levels associated with peripheral sensation and voluntary motor action is critical. As noted, distinct temporal forms, indicated by

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backwards and forward referral, keep experiential and neurophysiological levels in sync.

Further, the increased elegance in these distinct temporal forms eliminates the need for distinguishing the illusory from the actual. Each level is significant in its own right. Thus Libet's data supporting backwards and forward referral not only indicate that absolute temporality does not underlie the experiential and neurophysiological levels of peripheral sensation and voluntary motor action. They indeed point to distinct temporal forms for these levels which are adaptive, but only if experience is important in its own right and is not something superfluous to an essential understanding of the functioning of the individual in the environment.

### CONCLUSION

Close attention to the implications of Libet's research data does not necessarily indicate the existence of unconscious cerebral initiative or an unreal subjective experience of backwards referral. Rather, these data may point toward an alteration of the nature of time when time is used to describe experiential as opposed to neurophysiological concomitants of some peripheral sensation or voluntary motor action. It has been proposed that the correct conceptualisation of Libet's empirical results on peripheral sensation and voluntary motor action is in terms of frames of reference, one neurophysiological and one experiential, in which occurrences considered within a particular frame are described by a temporality which is not identical to that found for the other frame. The adaptive significance of backwards and forward referral, based on the importance of experience for an individual's interaction with the environment, supports the notion of distinct temporal frames of reference for peripheral sensation and voluntary motor action.

### REFERENCES

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