Psychophysiology: A Scientific Discipline or a Literary Genre?

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Keywords: Psychophysiology, conditioning, psychological functions, representations, computer model, description, explanation, metaphor.

The psychophysiologist today puts forward, often too readily, traditional psychological functions or more sophisticated hypothetical constructs to explain observed physiological responses and behaviour patterns. Thus, he will quite easily impute the subject's behaviour to the internal representations of the environment, neatly arranged under attention, intention, motivation, emotion or even volition. Likewise, he will not hesitate to compare the central nervous system's organization and functioning to those of a computer.

Such discourse may appeal initially, for it clearly and evocatively establishes the central 'agents' and their nerve 'reflections' as being responsible for behaviours. When brought into contact with reality, however, we believe it fails to convince.

The psychophysiologist observes and describes behavioural and physiological responses which he builds up

Operant conditioning techniques are commonly used in psychophysiology to produce previously defined behavioural responses in the organism under examination; while the responses are being built up or, more frequently, after they have been established, the experimenter may, for instance, observe the simultaneous occurrence of the imposed behaviour and the activity of dozens of isolated neurons in the cortical, subcortical or spinal zones he is exploring.

This will, without doubt, give rise to the observation that under the effects of stimuli whether appetitive or aversive, the subject's progressively shaped responses are selectively delivered as certain environmental stimuli are presented. This will rarely lead him to acknowledge with Schlag (1980) that 'it is reasonable to assume that transformations within the nervous system, detectable in unit studies, accompany the imposed changes of behaviour'. Even if, Fuster's findings (1981, 1984) seem at times close to this assertion, Watanabe (1986a, 1986b) studying, like him, prefrontal neuronal reactivity during a task involving delayed-response, does not seem to agree.

Fuster (1981) wrote: 'the cues for delayed responses failed to elicit delay activation in prefrontal unit of untrained animals. In trained animals, units exhibiting delay activation in ordinary trials failed to do so in dry runs when the cue was deleted but other stimuli normally preceding it were preserved'; and added: 'all the observations indicate that elevated discharge during the delay is largely determined by the relation of contingency between temporally separate events. This relation is established by learning'. Three years later, Fuster (1984) stated yet again: 'such discharge is in part a phenomenon of the cross-temporal dependency — established by learning — between two events' and he also found a link between the pattern of the prefrontal neuronal discharge during the delay and the length of the latter.

Watanabe (1986a, 1986b) recorded the activity of isolated neurons in the prefrontal cortex of three monkeys which met the
'delayed conditional Go/No-go discrimination' criterion after 6 to 9 months and approximately 1000 reinforced trials per day. Like Fuster (1984), he noted (Watanabe, 1986a) differential change in the activity of certain prefrontal cells contingent upon the colour or pattern of the discriminative stimulus delivered to the animal. He also described (Watanabe, 1986b) neurons where alterations in activity occurred only when the response emitted after the imperative stimulus consisted in withholding a pressing response (No-go response). In short, Watanabe observed synchronization between prefrontal neuronal activity and either the properties of the stimuli distributed during the task or the types of conditioned responses. However, despite the length of the reinforcing procedure set for the monkeys, he did not emphasize the determining role played by 'learning' on neuronal discharge modulation.

The psychophysiologist explains the behavioural and physiological responses he has built up

The discrepancy is only superficial for, in line with a majority of psychophysiologists, both writers come to see the conditioning procedure as a means whereby mental entities emerge, are sealed in the organism and are then 'reflected' by observed behavioural and biological facts. In other words, all these researchers believe that the procedure has but an indirect effect on the responses of the organism and its afferent organs whereas the inferred entities explain them directly.

Thus, Poranen and Hyvärinen (1982) called their study 'effects of attention on multi-unit responses to vibration in somatosensory regions of monkey's brain' and observed that 'attention towards a sensory stimulus (on the other hand) is reflected in the activity of the motor cortex...'; Even Paillard (1985) for whom programming process specified the muscles involved in the motor sequence ('address encoding'), the order in which they come into play ('temporal encoding') and their intensity of force ('frequency encoding') also firmly adopted the legendary 'theory of reflection'. Did he not make it clear that 'the activities of the neurons in the premotor and motor regions (do in fact) reflect the requirements' of this tripartite encoding? In spite of his statements quoted above, Fuster concluded at the end of the paragraph on 'unit activity' (Fuster, 1981, p. 1164) with 'a good case can be made on the basis of unit data for involvement of prefrontal neurons in sensorial attention, short-term memory and motor set'. Finally, Watanabe (1986b) summing up, declared for instance, that 'certain No-go units are considered to be involved in the performance of the No-go response...' and then went on to say: 'although it is possible that some may be related to the implicit time estimation process or to expectancy for the IS (imperative stimulus) presentation which should not be pressed'.

When we have added that the internal map, enabling the animal in an experimental device to attain the reinforcing agent, soon without error, is said to develop in the frontal areas and that the comparator governing performance improvement in the subject is, it is claimed, built up in a preolivar structure, then it would appear that one rarely studies the psychophysiological being today without the aid of notions which recall 19th Century psychology, without the help of the internal copies of the realities that 'lie at the heart of the mechanism of mind' (Mountcastle, 1986) or without the support of entities drawn from computer science.

Scientific concepts and explanatory metaphors

However, on examination, these constructs are found to share several features which make them more at home in the world of mythological beings than in the ranks of scientific concepts. But first, experimental evidence is called for. Now, Fuster did not link sensory attention (visual, in this case) with any variables other than those he could relate to motor preparation or short-term memory; Watanabe did not mark the difference, through experimentation, between the implicit time process and expectancy. Likewise, the material conditions on which temporal encoding depends have been neither objectively recorded nor distinguished from those required for frequency or address encoding.

These different entities have no biological
backing, or, what amounts to the same thing, are present on a multilocular basis. Where does one physically locate those acquired programs which Brooks (1983) said ‘assembled in the brain’... ‘assist’ the subject in his movements? Could the ‘need for biological backing for computer models’, a topical issue in 1983 (Beaubaton, 1983), be side-stepped today? Where is the substrate of visual attention? Is it in the prefrontal cortex (Fuster, 1981) or in the posterior parietal cortex (Bushnell, Goldberg, and Robinson, 1981)? What part of the brain is involved in the motor set? Could it be the prefrontal cortex again (Fuster, 1981) or maybe the cerebellum (Beaubaton, Trouche, and Amato, 1980)? And could one include here the basal ganglia and a few thalamic nuclei (Neafsey, Hull, and Buchwald, 1978)?

The scientific precariousness of ‘the mental objects’ is also due to the researcher’s obvious difficulty in attributing them to certain animals. It is customary for the human subject to be endowed with an image of a goal, with volition and other central routines. The same is true of the monkey. The cat and even the rat do not always escape this treatment either. Yet, as far as we know, the trout’s representative expectancy is seldom called on to explain its movements. But, when some reserve for Homo sapiens alone what others confer on rodents filling their laboratories, it is quite reasonable to expect a clear answer to the following question: where on the animal scale does the break occur between organisms with central determinants of behaviour and those acting and reacting without their intervention?

Finally, the extension of these concepts no longer seems adequate for the techniques of approach to behaviour and physiological response recording. In other words, the psychophysiologist has at his disposal today the means of making observations so precise that they run counter to the couple of inaccurate concepts organizing them.

Besides being open to the criticism just expressed, the actual notion or representation has one particular shortcoming as Kugler, Kelso, and Turvey (1980) pointed out clearly: ‘representation implies a user — an agent with goals, interests and comprehension — an animal-analogue — very much like the entity — an animal — that we are attempting to explain through the mechanism of representation. The infinite regress so enjoined undercuts the possibility of a successful psychology or physiology’.

To sum up, the metaphor can, on occasion, prove useful, when with ‘as if’, it makes a remark clearer and more easily understood. However, we believe it contributes to restricting the scope of scientific thinking when, in the form of an entity, it becomes the prime mover of observed phenomena. This step is all too easily taken, especially when the metaphor is mechanistic. Maxwell, in his time, has declared ‘when any phenomenon may be described as an example of a general principle applicable to other phenomena, then this phenomenon is said to be explained’. He ‘immediately added’ ‘on the other hand, when a complete physical phenomenon may be described as a modification in the configuration and movement of a material system, then the explanation of this phenomenon is considered complete. We cannot conceive of any subsequent explanation being necessary desirable or possible’ (Quoted by Meyerson, 1951, pp. 97–98).

Questioning metaphoric approach

Could it be that the explanatory metaphor no longer meets general scientific approval? In this respect, Beaubaton’s progression between 1983 and 1987 seems to us of some significance. In 1983 he noted that ‘no evidence’ (can be) ‘found for the existence of isomorphism between the computer and the nervous system’ but then went on to examine one by one the experimental arguments justifying the ‘possibility’ or even the ‘necessity’ of the existence of motor programs. With Pailhous, four years later (Beaubaton and Pailhous, 1987) he acknowledged ‘a number of concepts commonly used in the literature on motor control need to be revised or at least qualified’; the authors also noted ‘the pitfalls of continuing to borrow from technical terminology and computer science’ and pointed out, almost reluctantly that ‘the use of metaphors was originally intended to produce a more universal language but has actually led to much confusion and disagreement’. From our point of view it is also
noteworthy that their assertions appeared in a
text in which the cognitive conception of the
control of motor functions held by Zanone and
Hauert (1987) was criticized and in which they
concluded by attributing to the notions the two
psychologists used (such as for example,
‘anticipation’, ‘decision-making’) the shortcomings (they (Beaubaton and Pailhous) found in
the metaphoric language as a whole.

Was Jasper (1982) in favor of abandoning
mental entities when, reassessing his lifetime of
research, he declared: ‘In general, it now seems
in retrospect that it is not possible to study
separately the processes of arousal and attention, habituation, the establishment of a condi­
tioned response and the mechanisms for the
execution of the motor response itself indepen­
dent of conditioning ’; and admitted ‘we naively supposed that we would be able to
differentiate habituation from conditioning as
such’? Finally and paradoxically, could the
possibilities of the ‘neural computer’ as pre­
sented by Fort and Gerschenfeld (1988) take
over from the agents with which psychophy­
siological discourse abounds? Or, must we
have recourse to that machine’s intention and
conscience to explain that these ‘formal central
neurons’ manage already ‘without a program in
the usual sense of the word’ but ‘by modifying
their connections, to correctly associate the
configurations (from +1 to −1) imposed on the
neuronal input’?

What future for psychophysiology?

Clearly, psychophysiology is Janus-faced. On
the one hand, it is founded on realities to which
the experimenter has direct access (the organ­
ism’s physiological and behavioural responses)
and its discourse is an exact description of the
relations between these phenomena and the
variables the researcher himself manipulates.
On the other hand, it turns aside from experi­
mental contingencies and its explana­
tions for biological and behavioural facts
abound with entities equalled in flavor only by
their modernity.

So, a ‘universal language’ or the ‘scientific
mind’? The ‘alchemy of the word’ or the
‘experimental method’? What is the future of
psychophysiology?

References

motricité. Rôle des ganglions de la base du cervelet dans
la programmation et l’exécution du mouvement. Thèse
de Doctorat es Sciences. Université d’Aix-Marseille II.

Beaubaton, D. & Pailhous, Φ. (1987) Is the motor
programm in the body or in the mind? A cruel dilemma! Cahuiers de Psychologie Cognitive, 7, 130–134.

and pallidal control of a goal-directed movement in
monkeys. In: G.E. Stelmach, & J. Requin (Eds.)
Tutorials in Motor Behavior. North-Holland Publishing
Company, pp. 315–327.

Bushnell, M.C., Goldberg, M.E., & Robinson, D. L.
(1981) Behavioral enhancement of visual responses in
monkey cerebral cortex: I. Modulation in posterior
parietal cortex related to selective visual attention.
Journal of Neurophysiology, 46, 755–772.

Brooks, V.B. (1983) Motor control. How posture and
movements are governed. Journal of American Physical
Therapy Assn, 63, 664–673.

ordinateur neuronal, la machine de Boltzmann. La
Recherche, 19, 532–535.

Fuster, J.M. (1984) Behavioral electrophysiology of

unit activity during conditioning in the monkey.
Advances in Behavioral Biology, 26, 319–331.

the concept of coordinative structures as dissipative
structures: I. Theoretical lines of convergence. In: G.E.
Stelmach, & J. Requin (Eds.) Tutorials in Motor
3–47.


Mountcastle, V.B. (1986) The neural mechanisms of
cognitive functions can now be studied directly. Trends
in Neurosciences, 9, 505–508.

Preparation for movement in cat. II. Unit activity in the
basal ganglia and thalamus. Electroencephalography and
Clinical Neurophysiology, 44, 714–723.

Paillard, J. (1985) Les niveaux sensori-moteur et cognitif
du contrôle de l’action. In: M. Laurent et P. Therme
(Eds.) Recherches en A. P. S.l. Marseille, Publication du
Centre de Recherche de l’UEREPS, pp. 147–163.

on multiunit responses to vibration in the somatosensory
regions of the monkey’s brain. Electroencephalography
and Clinical Neurophysiology, 53, 525–537.

Schlag, J. (1980) Are parietal saccade neurons sensory or
motor? Is the question worth asking? The Behavioral
and Brain Sciences, 3, 485–534.

Watanabe, M. (1986a) Prefrontal unit activity during
