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"A Biologist Looks at Psycho-Acoustics". I. A. Tumarkin.

The physicist represents par excellence the stimulus response school. He lives in a world of dead meter measurements. In studying a complex system he aims to hold all parameters stationary except the one in which he is immediately interested. His aim is primarily to obtain a measurable output from a measured input. The biologist belongs to the Gestalt school. The subject of his research is nothing less than the whole animal in relation to its total environment. The concepts of function, of purpose, and indeed life itself, so meaningless to the physicist, constitute the essential framework in which all the activities of the biologist take place. Inevitably, starting from such divergent viewpoints, exponents of the two disciplines find increasing difficulty in communicating with each other. The following examples will be discussed in order to illustrate the disastrous results of this breakdown in communication.

1) The function of the intra-tympanic muscles. Ever since Luscher showed that the stapedius contracts in response to loud noise, an enormous amount of energy has been expended in studying this phenomenon. To the biologist most, if not all of this work is meaningless, inso far as noise levels far in excess of the normal dynamic range have been used. Such work can throw no light on the real function of these muscles. Evidence will be adduced that they perform in conditions of near silence. In other words the stapedius reflex is no more indicative of that muscle's function than the knee jerk is evidence of the function of the quadriceps.

2) Similarly most of the investigations of the labyrinthine function utilize stimuli far beyond the normal range. The much publicised differential equations ostensibly defining the performance of the semi-circular canal in terms of mass, elasticity and friction, ignore the fact that it is a living system. Not surprisingly they throw no light whatsoever on the normal function of the labyrinth.

3) In the realm of psycho acoustics most of the effort that has been expended in validating the so called psychometric functions of sensation has been wasted. To the biologist the idea that sensations as bizarre as the taste of an electric shock should be measurable in the same sense as the physicists meter measurements is utterly foreign. Such a property of the conscious mind, if it existed, must have evolved within the last few thousand years or less since the ability to manipulate numbers is

one of the most recent achievements of homo sapiens. No known biological evolutionary force could have given rise to such functions since they serve no biologically useful purpose. This argument would, of course, carry no weight if experiment revealed plausible evidence of measurability. Such evidence, however, is not forthcoming even in the most thoroughly explored sensation of all, viz: loudness. For example investigations at Salford reveal individual exponents of the loudness function varying from .07 down to .013. Figures as divergent as this cannot be reconciled with the official sone-decibel scale which, if it means anything, implies that loudness is a 'function' of intensity in the accepted sense of mathematical physics with an exponent of .03. Attempts have unfortunately been made to bolster the measurability of loudness by appeal to physiological evidence. Zwicker's suggestion that units of loudness correspond to 1.3 mm on the basilar membrane is biologically meaningless. So to is the suggestion that the slope of the sone function reflects the slope of the encephalogram (Keidal and Spreng).

It is noteworthy that the sone has proved completely useless so far as concerns the assessment of noise levels in industry and elsewhere as witness the substitution of a multitude of alternatives such as the Noy, the perceived noise level, subjective intrusiveness and so on. Nevertheless it would be wrong to deduce that all the work that has been carried out on loudness and a host of other sensations has been completely wasted. It is, after all, a matter of some psychological interest that many (but not all) people are able to give fairly consistent numbers to loudness ratios. It has been suggested that inter individual differences may possibly reflect differences in psychological type. Zwislocki has asserted that most people when asked to state a 'moderate number' chose something between 1 and 10. If the exponent of the sone scale was in some way an index of personality it is at least possible that a similar estimate might be obtained with less trouble by simply asking the subject to mention a moderate number.

Above all, however, it is important that biologists should not attach undue importance to these capricious and enigmatic figures. The belief that sensations are mathematically related to one or more physical dimensions of the stimulus is unfortunately widespread in the domain of clinical medicine. Consequently efforts are constantly being made to utilise such hypothetical subjective scales in the assessment of function and in the differential diagnosis of disease. Inevitably these efforts have failed and should be discouraged. Unfortunately psycho physicists still do not take this point of view. The quest for yet more 'dimensions' in the auditory sensation has led to the remarkable claim that volume and density can be so recognised and evaluated with the inevitable claim that experimental evidence confirms the equation.

Volume X Density = Loudness. Perhaps even more remarkable is the suggestion that the 'slight' variations in the loudness function may ultimately throw 'further' light on the workings of the central nervous system in the same way as perturbation in the Uranus lead to the discovery of the planet Neptune. It is time, therefore, to assert emphatically that to date no light whatsoever has been thrown on the nature of the sensory process by any of this work.

4) d'. The success of modern mathematical theories in dealing with the communication of information against a background

of noise has encouraged psycho-physicists to apply similar methods to the performance of the ear, more especially to the establishment of the normal threshold. Unfortunately no note whatsoever has been taken of the known biological characteristics of the living system. For example no attempt has ever been made to enquire from the biologist whether biological 'noise' can be validly treated as band limited Gaussian. Evidence will be offered that it is not. The underlying assumptions of the two interval forced choice method will be criticised, and it will be argued that the methods of signal detection theory, far from improving precision actually impair it simply because the listener is placed in an utterly unnatural situation.

In conclusion it will be suggested that in view of the manifest limitations of the strictly physical approach consideration should be given to the possibility of utilising methods based on the biologists gestalt approach. An account will be given of some work being currently planned along those lines.