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Book review

The Brain's Alpha Rhythms and the Mind

John Crosley Shaw. Elsevier Science B.V.
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It is well known that the alpha rhythm is the most common component of the brain's electrical activity, the electroencephalogram (EEG), which can be recorded in a healthy awake adult human. This, it seems, is the only fact about alpha rhythm that we can be sure about. Is alpha activity a single *alpha rhythm* (as is classically described), or are there many oscillations at alpha frequencies in the brain, forcing us to use the more generic term *alpha activities* to encapsulate this wider concept? The precise nature of alpha oscillations is as yet unclear: does alpha rhythm result from intrinsic cellular oscillations or does it emerge due to reverberating circuits which depend on the interaction time constants of two or more cells? What does fast or phasic variability of alpha activity mean? If the periods of alpha synchronization reflect "rest" or an "idling state" of the brain, then why does synchronized alpha activity dominate in the EEG of an awake adult human? From viewpoint of the common sense, it is not economical for an organism to "use" the brain cortex only half (on average) of the total time that a human is awake. We do not yet fully understand the biological, behavioural, physiological and functional significance of alpha rhythm and its responses. Moreover, there are a lot of misconceptions about alpha rhythm in relation to the functions of the brain's hemispheres, and to altered states of consciousness, which need to be corrected and put in perspective.

It is not surprising that starting from the first registrations of EEG there has been considerable interest in the sphere of brain alpha rhythm and in the search for a general theory that can explain what alpha rhythm is and why and how it originates. Over the past century the diversity of results has led to many alternative hypotheses which account for the genesis of alpha oscillations. Besides well-known and generally accepted hypotheses, there are a number of more exotic ones which describe alpha rhythm as an atavistic feature of humans, or which explain the dominating alpha oscillations in terms of evolutionary adjustment of neuronal tissue to oscillations of the earth's atmosphere.

All these suggest the need to develop a general theoretical framework that allows researchers to handle an enormous amount of diverse observations related to alpha phenomena: there have been more than 50.000 research publications on this subject since 1950 and therefore not surprisingly the subject has became "saturated".

Show's recent book "The Brain's Alpha Rhythms and the Mind" collates these numerous and diverse observations into a comprehensive body of knowledge, reviewing the whole field of alpha rhythm from early discoveries to recent research. In addition, Shaw addresses fundamental and methodological scientific problems highlighted in studies of alpha rhythm and explores arguments and strategies different researchers have employed to arrive at their conclusions.

The first chapter provides some historical background to EEG and alpha rhythm and a brief introduction to their characteristics. The following two chapters expand on these initial themes and introduce more modern thinking about alpha activity. These show the fact that alpha rhythm is not a unitary phenomenon, rather it demonstrates considerable variation and changes depending on age, mental state, the cognitive task being performed and from which cerebral area the EEG signal is being recorded. The concept of "attention" and its relationship with alpha rhythm are also introduced. The association between oculomotor activity and alpha reactivity, the review suggests, might indicate that motor activity influences alpha oscillations, as was described for mu rhythm. This relationship is almost certainly a function of "attention".

In the fourth and fifth chapters, Shaw describes the limitations of using an alpha reactivity model which assumes that alpha topography is an indication of functional activity in the cortex. Shaw puts forward a set of valid argument for this view. In summary, it is obvious that if one accepts the classical model that alpha is blocked in those areas of the brain that are involved in the information processing then it will be difficult to find any consistent patterns except for very simple types of mental activity using this model. In the following chapter Shaw reviews some of the more recent studies which relate alpha topography to cortical function. Finally, the chapter also highlight two properties of alpha activity in relation to cognition: the functional heterogeneity of alpha frequency band, and the fact that in some subjects presented with mental tasks, alpha activity is enhanced rather than blocked – the paradoxical response.

The seventh chapter is in our opinion one of the most important. It deals with the structural organization of alpha rhythm and describes some of the methods used to investigate its structural organization, beginning with early macroscopic "global" views to more recent investigations. This chapter might have benefited from references to two other approaches currently used in alpha rhythm studies: firstly, the analysis of self-criticality of alpha oscillations and secondly, the analysis of the temporal structure of alpha activity. The first of these two approaches is based on the fact that the recurrence of similar patterns observed over different time scales reflects a sort of natural integrity, i.e., structures and/or dynamics which become unavoidably correlated over all time-scales. The results of research have indicated that successive oscillations in alpha band are indeed correlated – even over thousands of oscillation cycles. The framework for the second approach is as follows: the rapid transition processes occurring in the amplitude of a continuous alpha activity mark the boundaries between quasi-stationary segments for this activity. It is assumed that each homogenous segment within alpha activity corresponds to a temporary stable microstate in the brain's activity – an operation. The transition from one segment to another could reflect the moment of switching from one neuronal network activity to another. The synchronization of these segments (EEG structural synchrony) between different EEG channels reflects the synchronization of different brain operations and constitutes the 'operational synchrony' phenomenon. As a result of this process, the transient metastable states of alpha activity emerged in the form of so-called operational modules. Using this approach, it has been possible to describe the main temporal characteristics of the segmental structure of alpha activity in adults during resting conditions, cognitive tasks, different type of stimulation and under pharmacological influence, and also in healthy children as well as children with schizotypal disorders. The spatial-temporal relationships between segmental descriptions of alpha activity in different channels were demonstrated. It was shown that the characteristics of alpha segments, as well as the spatial structural synchrony of alpha activity change considerably in accordance with the type of

stimulation, the cognitive task and pharmacological influence. A strong correlation between the dynamic structure of alpha activity and the dynamic structure of the memory task was observed and this is expressed through a gradual increase in the EEG structural synchrony process, together with a growth of cognitive loading. Thus, it is now possible to explore the temporal structure of alpha activity and inter-area functional interactions within the network of cortical areas by examining the topographic sharp transition processes within alpha activity on the scalp surface, millisecond by millisecond.

In the eighth and ninth chapters, Shaw reviews the inter-individual differences and the relationship between alpha rhythm and personality and intelligence. The author provides evidence that the characteristics of classical alpha rhythm are genetically determined, but concludes that in spite of a variety of studies into individual differences, whilst group differences in EEG characteristics were often found, a definitive classification of a single individual on mental characteristics was not achieved. Shaw also discusses thalamic and reticular systems of the brain which are important for understanding mental activity that influence the generation and control of alpha oscillations. The following chapter contains a detail description of the work of Klimesch who points to a strong association between the memory components of cognitive activity and EEG alpha activity. Also, in this chapter Shaw includes some conflicting results.

In chapter eleven, Shaw covers the following very interesting subjects: alpha activity and perceptual gating, the scanning hypothesis, and timing in the brain. The author suggests that alpha activity is involved in some timing processes in the brain but it is difficult to define the relationship between the associated behavioural processes. Moreover, many processes use different timing sources and there are models of perceptual framing that do not rely on a basic time interval. In this chapter Shaw discusses another controversial issue: discreteness–continuality of perception, cognition and brain activity.

Chapter twelve deals with magnetoencephalogram (MEG) studies of alpha activity. Shaw reviews the basic principals of MEG studies and compares EEG and MEG data. In chapter thirteen, which is dedicated to alpha activity in biofeedback, meditation and hypnosis, Shaw raises the issue of pseudoscience and alpha "experience". He has a rather negative view of the use of alpha activity as a tool for the application in biofeedback, and for its relevance to meditation and hypnosis. One exception is the use of the sensorimotor rhythm which does have some positive application though it is not usually classified as an alpha rhythm.

Chapters fourteen and fifteen are dedicated to the work of Mulholland and Petsche respectively. Shaw details Mulholland's alpha feedback paradigm and "behavioural stillness" model, and Petsche's studies of "thinking" and alpha synchronisation. We would add the following comment on the meaning of alpha synchronisation and desynchronisation: The realization of individual brain operation demands the formation of functionally interconnected neurons in a relatively large neuronal assemble. Synchronisation of neurons activity is the main mechanism here. This synchronisation has a rhythmical nature. As a result, the formation of a neuronal assemble is accompanied by a rhythmical increase in the total potential, whereas a disruption of the neuronal assemble is characterized by a decrease in total potential. Thus, the well-known phasic structure of alpha activity (or alterations of synchronisation and desynchronisation periods) mainly reflects the processes of formation and disruption of cortex neuronal assembles respectively. In this framework, periods of alpha synchronization and desynchronisation do not mark episodes of "rest state" and "active work" respectively, but are the signs of two types of cortical processing *equally active* but differing in the way the

neighbouring neurons are used. Chapters sixteen and seventeen give an overview of the many studies and models of the generation of alpha activity, and the modern view on EEG generation. One general conclusion from the work Shaw has reviewed in these chapters is that while a great deal is known about the generation of brain oscillations, the relationship of the scalp-recorded EEG to its sources is complex and it is difficult to draw any conclusions on. It may nevertheless become apparent that the existence of distributed epicentres, or "multiple cortical generators", is a common result from both intracerebral and scalp studies of alpha activity, reviewed in these chapters.

In the eighteen chapter Shaw concentrates on the connection between alpha and intention and consciousness. The author introduces the concept of "intention" and describes an alternative view to the peripheralist (classical) model of brain function which supposes that what we perceive controls behaviour. This alternative view is that what we perceive is controlled by our intentions that in turn control our behaviour, - a centralist model. With the current interest of neuroscientists in consciousness, Shaw also briefly reviews alpha activity in states of reduced consciousness.

The final chapter nineteen is an epilogue in which Shaw provides an overview of the entire book and arrives at the conclusion that "alpha activity can be studied on a range of timescales, from the microstates of Lehmann showing changes in alpha topography measured in intervals of 10-50 ms …, to the "thinking" studies of Petsche showing consistent topographic patterns measured in minutes… Unfortunately, no definitive conclusion about the functional significance of alpha activity can be made."

This book has one particularly important feature: throughout the book the author addresses important issues such as "cognitive stile," "entrainment," "binding" and "alpha coma" as well as providing a clear distinction between pairs of terms often confused, such as "attention – intention," "activity – activation," "cognitive – motor," "action – movement," "reaction time - action time," "monotony – predictability." Two appendixes supplement the book. Appendix 1 reviews EEG technology and related developments in signal analysis in a way that it is easy to understand for readers, who are not the specialists in this field. Appendix 2 provides a historical review of the term "desynchronization".

This book highlights that current knowledge about alpha activity is as yet incomplete and thus will remain a subject of considerable scientific research. This book is an appropriate reference tool, not only for experienced researchers, but also for young neuroscientists and students. It should also help to stimulate the interest of scientists to design new experiments and devise new concepts.

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