



Review article

A brief historical perspective on the advent of brain oscillations in the biological and psychological disciplines

Sirel Karakaş^{a,*}, Robert J. Barry^b^a Dogus University, Department of Psychology, 34722 Kadıköy, İstanbul, Turkey^b School of Psychology, University of Wollongong, Wollongong 2522, Australia

ARTICLE INFO

Article history:

Received 26 September 2016

Received in revised form 9 December 2016

Accepted 9 December 2016

Available online 12 December 2016

Keywords:

Oscillatory dynamics

Principles of oscillatory dynamics

Delta

Theta

Alpha

Beta

Gamma

Spatiotemporal integration

Coherence

Biomarker

ABSTRACT

We aim to review the historical evolution that has led to the study of the brain (body)-mind relationship based on brain oscillations, to outline and illustrate the principles of neuro-oscillatory dynamics using research findings. The paper addresses the relevant developments in behavioral sciences after Wundt established the science of psychology, and developments in the neurosciences after alpha and gamma oscillations were discovered by Berger and Adrian, respectively. Basic neuroscientific studies have led to a number of principles: (1) spontaneous EEG is composed of a set of oscillatory components, (2) the brain responds with oscillatory activity, (3) poststimulus oscillatory activity is a function of prestimulus activity, (4) the brain response results from a superposition of oscillatory components, (5) there are multiplicities with regard to oscillations and functions, and (6) oscillations are spatially integrated. Findings of clinical studies suggest that oscillatory responses can serve as biomarkers for neuropsychiatric disorders. However, the field of psychology is still making limited use of neuro-oscillatory dynamics for a bio-behavioral understanding of cognitive-affective processes.

© 2016 Elsevier Ltd. All rights reserved.

Contents

1. Introduction	336
1.1. Early developments in psychology	336
1.2. An essential step toward oscillatory dynamics: Berger and Adler	336
1.3. The emergence of a new paradigm in the brain sciences	337
2. Explanations provided by the oscillatory dynamics: principles and theories	338
2.1. Principle 1. Spontaneous EEG is composed of a set of oscillatory components	338
2.2. Principle 2. The brain responds with oscillatory activity	338
2.3. Principle 3. Poststimulus oscillatory activity is a function of the prestimulus amplitude and phase angle at the point of stimulation	339
2.4. Principle 4. The temporally occurring brain response is a consequence of the superposition of different oscillatory components	339
2.5. Principle 5. There are multiplicities with regard to oscillations and functions	340
2.5.1. Principle 5a. Each oscillation has multiple functions	340
2.5.2. Principle 5b. Each cognitive function is represented by multiple oscillations	342
2.6. Principle 6. Oscillations are spatially integrated	342
3. Current status and prospects	342
3.1. Neuro-oscillatory dynamics in neuropsychiatric disorders	342
3.2. Neuro-oscillatory dynamics in the psychological sciences	343
4. Limitations	344
References	344

* Correspondence to: Tepe Prime/Neurometrika Medical Technologies, LLC, Mustafa Kemal Mah., Dumlupınar Bulv., No 266, C-90, 06800 Çankaya, Ankara, Turkey.
E-mail addresses: skarakas@dogus.edu.tr, sirel.karakas@gmail.com (S. Karakaş), rbarry@uow.edu.au (R.J. Barry).

1. Introduction

The present paper provides a brief and selective perspective on the historical evolution that has led to the study of the brain (body)-mind relationship based on brain oscillations. The paper is an overview of the current principles of oscillatory dynamics. As such, it illustrates these principles using research findings, demonstrates the applicability of the principles to neuropsychiatric disorders, and discusses the attitude of academic psychologists to the brain-mind relationship and the study of the relationship via brain oscillations. Being a journal article, this paper accounts for only the most significant events and scientists in the three centuries over which the evolution towards the oscillatory perspective occurred. However, we point to review articles for the reader who is interested in further information on the subject matter.

The history of oscillatory brain dynamics may be traced back to two historical events, the first of which is prescientific, and the other scientific but precognitive. Mesmer is the key personage for the prescientific event: Any discussion on brain electricity should acknowledge the work of Mesmer (Pearson, 1790), as he was the first person to discuss what he called “animal magnetism”. Although ridiculed and even discredited in his time, this approach ingeniously underlined the fact that living creatures have an electric field by which they can influence others. In his classic work, Zweig (1932) describes Mesmer as one of the three “mental healers” (the other two were Freud and Eddy) who emphasized the relationship between the body and the mental-emotional life in health and in illness. The second, scientific but precognitive, event was the discovery of the motor strip by Fritsch and Hitzig. Until the late part of the 19th century, dogma had dictated that the brain is inexcitable. Fritsch and Hitzig (1870) abolished this dogma and demonstrated that brain tissue is responsive to electrical stimulation.

1.1. Early developments in psychology

At nearly the same time as the advent of brain electricity as a mechanism of brain function, Wundt was emancipating psychology, the discipline that studied the “mind” component of the brain-mind dichotomy, from philosophy. Wundt founded the new science in 1879, the year he established an experimental psychology laboratory in Leipzig. The founder christened the new science as “physiological psychology”, suggesting that this new science would study not only the mind but also deal with physiology (Wundt, 1874). However, Wundt was using the term “physiology” to refer not to the body/brain correlate of the mind but to the methodology, namely experimental, that psychology would be using (Boring, 1950).

This founding was followed by the classical schools of psychology, the critical aspects of which are summarized in Table 1 (for a review, see Schultz, 2000). The founder of the earliest school, structuralism, was again Wundt. For this school, psychology should analyze consciousness of normal humans into its constituent elements, to discover how these elements are mentally connected, and to determine the laws of their connections. This statement includes two very critical issues. Firstly, Wundt was not referring to the organismic correlates of mental functioning when he was using the term “physiology”. Secondly, in the term “mental connections”, we are confronted with the psychological forerunner of the much later concept of “cognits” by Fuster (1995; for a review, see Karakaş & Başar, 2006a,b) and the concept of “connectivity” (Başar et al., 2014, 2015; Başar and Düzgün, 2015; Başar et al., 2015; Engell and McCarthy, 2010; Martini et al., 2012; Özerdem et al., 2011; Rubinov and Sporns, 2010).

Structuralism sought to answer the “what?” of consciousness and thus sought to discover the contents of the mind. The second school of psychology, functionalism, sought to answer the “why”

or “how” of the mind. Under the influence of functionalism, which was founded in 1896, psychologists began studying the mental activity of organisms (humans and infra-human species) in their struggle to adapt to environmental challenges. W. James, who was considered to be the founder of the functionalist school, published his groundbreaking book, *Principles of Psychology*, in 1890 (James, 1890). In his book, the *stream of consciousness* and *attention*, among other subjects, were ingeniously discussed and laid out nearly as we know them today. Another stage of psychology was marked by the Gestalt school. Wertheimer founded the school in 1913. Inspired by Heider (1977), the slogan of this school was formulated as “The whole is other than the sum of its parts.” (cited in Dewey, 2007, p. 383; Koffka, 1935). The Gestalt school was basically a reaction to the atomistic, analytic, and static approach of structuralism. The Gestalt approach assumed that the mind generates whole forms and global figures, and that human experience is an organized whole (for a treatise on the schools, see Boring, 1950; Schultz, 2000). This statement is the psychological forerunner of the current theoretical concept of the whole brain work (for a review, see Karakaş and Başar, 2006b) and the empirical data on the intricate selective connectivity pattern that support it (for a review, see Başar et al., 2015).

Each classical school of psychology thus emphasized a different concept, but none of them was related to the body/brain component of the mind, or to the relationship between the two components. It was Hebb (1949) who theoretically explained the holistic functioning of the mind on the basis of electrical processes of the brain. His concept of reverberating networks (or the Hebbian networks) is the theoretical ancestor of the brain oscillations, and of the empirical concept of connectivity. In modern times, the connectivity patterns are illustrated in the CLAIR Atlas (Başar and Düzgün, 2015) as coherence functions between the oscillatory components of selected brain areas.

According to the foregoing developments, when brain electricity was only a possibility, scientific psychology had already been founded as an “experimental psychology”, and between 1879 and 1930, it had passed through an era involving several schools of psychology. Throughout these schools, the importance of the structure (structuralism), function (functionalism), and holistic processing in the mind (Gestalt) was emphasized. Behaviorism then arrived, and the study of the mind was discontinued. Under the insistence of the behavioristic school to use only the observables (namely, the stimulus and response), the field turned into a stimulus-response psychology. Everything in between – collectively speaking, “the mind” – was deemed insignificant for understanding behavior. Thus, although it was originally founded as a physiological psychology, psychological thought vacillated between behavior on the one hand and the constructs of consciousness and mind/cognition on the other. With the “radical” behavioristic school, psychology lost even this longstanding construct, the mind. Only with the cognitive revolution, around the 1950s, could cognition and mind find their way back into the realm of psychology once again.

In those days of turmoil, the physiology of the body (specifically the brain) was ignored by the psychologists; accordingly, the important developments in the brain’s electrophysiology were not taken into consideration. Admittedly, this obliviousness was not only on the part of the psychologists. Neuroscientists did not consider the developments in psychology, either. As a result, the findings and hypothetical formulations that the experimentally oriented psychologists provided were not taken advantage of.

1.2. An essential step toward oscillatory dynamics: Berger and Adler

As psychology was coming to the end of the schools era, biological sciences were on the pathway to the discovery of the electrical

Download English Version:

<https://daneshyari.com/en/article/5043516>

Download Persian Version:

<https://daneshyari.com/article/5043516>

[Daneshyari.com](https://daneshyari.com)