CHRISTFRIED JAKOB ON THE CEREBRAL CORTEX: NEUROBIOLOGICAL, NEUROPHILOSOPHICAL AND NEUROEDUCATIONAL CONCEPTS

A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Educational and Social Policy by

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ABSTRACT

The present dissertation examines the culmination of Christfried's Jakob neurobiological, neurophilosophical and neuroeducational ideas from 1890 to 1949. His work numbers 30 books and 200 articles on developmental, evolutionary, anatomical and pathological issues in neurobiology and it further includes pioneering contributions in modern scientific fields such as educational neuroscience and neurophilosophy. We have divided Jakob's work into three periods. During the 'early' period (1890–1912), Jakob mostly carried out anatomical work. In his 'middle period' (1913–1935), he elaborated psychobiological ideas. In the 'late' period (1936–1949), he came up with synthetic neurobiological and neurophilosophical theories. His works were written in German and Spanish and a couple of papers in French. Thus, they had scarce diffusion in the English literature. Given that Jakob's works still provide meaningful clues on the riddle of the human brain, an objective of this study was to render his legacy accessible by a wider audience. Accordingly, an aim of my dissertation consisted in crediting Jakob for the formulation of original ideas in evolutionary, behavioral, cognitive, affective and educational neuroscience as well as in neurophilosophy. In a broad framework, I retraced the evolution of Jakob's avant garde thought and bridged his still timely works with the modern literature.

ΠΕΡΙΛΗΨΗ

Η παρούσα διδακτορική διατριβή πραγματεύεται τη συνεισφορά του Christfried Jakob (1866–1956) στις νευροεπιστήμες, δίνοντας ιδιαίτερη έμφαση στις νευροβιολογικές, τις νευροφιλοσοφικές και τις νευροεκπαιδευτικές του ιδέες. Ο σκοπός της διατριβής συνίσταται στην ανάσυρση και ανάδειξη του πρωτότυπου έργου του Jakob διαμέσου της συστηματικής μελέτης των έργων που δημοσίευσε από το 1890 ως το 1949. Η εξέλιξη της σκέψης του Jakob εξετάζεται μέσα στο ιστορικό πλαίσιο και κάτω από το πρίσμα της προόδου που συντελέστηκε στις νευροεπιστήμες τα τελευταία χρόνια. Γίνονται παραλληλισμοί των ιδεών του Jakob και άλλων μεγάλων διανοητών από το χώρο της Φιλοσοφίας (π.χ. Kant), της Βιολογίας (π.χ. Bernard), της Ψυχολογίας (π.χ. Gibson, James, Piaget) και των Νευροεπιστημών (π.χ. Damasio, Fuster, Maturana, Varela).

Ο Jakob γεννήθηκε, μεγάλωσε και σπούδασε στη Γερμανία ωστόσο πέρασε το μεγαλύτερο μέρος της ζωής του στην Αργεντινή. Πρωτοπήγε στο Μπουένος Άιρες το 1899 για να οργανώσει τη λειτουργία του Νευροβιολογικού Εργαστηρίου του Πανεπιστημιακού Νοσοκομείου της Λα Πλάτα. Δίδαξε στη Σχολή Φιλοσοφίας και Γραμμάτων του Πανεπιστημίου του Μπουένος Άιρες και στη Σχολή Ανθρωπιστικών και Εκπαιδευτικών Επιστημών του Πανεπιστημίου της Λα Πλάτα καθώς επίσης και στην Ιατρική Σχολή του ίδιου Πανεπιστημίου. Παράλληλα, διηύθυνε το Νευροπαθολογικό Ινστιτούτο του Ψυχιατρικού Νοσοκομείου Θηλέων του Μπουένος Άιρες.

Το έργο του έχει χωριστεί σε τρεις χρονολογικές περιόδους με βάση τα ζητήματα που ο Jakob εξέταζε, τις μεθόδους που κυρίως χρησιμοποιούσε και την οπτική που υιοθετούσε σε κάθε μία από αυτές. Έτσι, στην πρώτη περίοδο της σκέψης του (1890–

1912), ο Jakob επικεντρώθηκε στη διεξαγωγή ανατομικών μελετών για τον εντοπισμό των ανώτερων λειτουργιών στο φλοιό των εγκεφαλικών ημισφαιρίων. Τον απασχόλησε ιδιαίτερα ο ρόλος του μετωπιαίου λοβού και έθεσε σε αμφισβήτηση την αδιαπραγμάτευτη και δεδομένη ανωτερότητά του. Προς επίρρωση της θέσης του, παρουσίασε ευρήματα παθολογοανατομικών, ιστολογικών, παθοφυσιολογικών, συγκριτικών, αναπτυξιακών και πειραματικών μελετών. Περιέγραψε, ακόμη, το ‘σπλαχνικό’ (συναισθηματικό) εγκέφαλο – μεγάλο μέρος του κυκλώματος Papez – έχοντας προηγηθεί κατά 25 και πλέον χρόνια του ιδίου του Papez. Στην πρώιμη περίοδο της σκέψης του διατύπωσε μία πρωτότυπη εξελικτική θεωρία για τη διπλή οντο-φυλογενετική προέλευση του φλοιού των εγκεφαλικών ημοσφαιρίων και την καθολική αισθησιο-κινητική λειτουργία του.

Στη μέση περίοδο (1913–1935) αποκρυσταλλώθηκε η δυναμική προσέγγιση του Jakob με την οποία διαποτίστηκε όλο το έργο του. Μέσα σε αυτό το πλαίσιο διατύπωσε τη νευροδυναμική εξελικτική θεωρία του για την ψυχογένεση και έθεσε τις βάσεις για την αναπτυξιακή νευροδυναμική θεωρία την οποία ολοκλήρωσε στην ύστερη περίοδο. Επιπλέον, ασχολήθηκε με τη μη τυπική γνωστική ανάπτυξη και προσπάθησε να θεμελιώσει την επιστημονική, ολόπλευρη αντιμετώπιση των αναπτυξιακών διαταραχών εισάγοντας, έτσι, αρχές της εκπαιδευτικής νευροεπιστήμης και της ειδικής αγωγής. Ορόσημο της μέσης περιόδου αποτελεί, ακόμη, η θεωρία του πάνω στη μνήμη, η οποία παρουσιάζει πολλαπλές φιλοσοφικές προεκτάσεις.

Η φιλοσοφική σκέψη του Jakob ωρίμασε και κορυφώθηκε στην ύστερη περίοδο του έργου του (1936–1949). Μέσα από τις εργασίες αυτής της περιόδου προώθησε τη διάχυση της γνώσης που προκύπτει από την έρευνα του εγκεφάλου στη φιλοσοφία και σε ένα ευρύ φάσμα επιστημών. Έτσι, υπήρξε ένας πρωτοπόρος της νευροφιλοσοφίας και της φιλοσοφίας των νευροεπιστημών. Ολοκλήρωσε, επιπλέον, την αναπτυξιακή νευροδυναμική του θεωρία, η οποία στηρίχθηκε στη μετουσίωση των φιλοσοφικών του επιρροών, της κλινικής του εμπειρίας και της έρευνας του εργαστηρίου του. Στην ύστερη περίοδο, επανήλθε στη μελέτη του μετωπιαίου λοβού τον οποίο εξέτασε εκ νέου κάτω από το πρίσμα της ανατομίας και της φιλοσοφίας για να αναδείξει τελικά τον ‘ανθρωποποιητικό’ του ρόλο.

Οι συνεισφορές του Jakob διαχέονται στις επιστήμες και τη φιλοσοφία. Στις νευροεπιστήμες της συμπεριφοράς, ο Jakob συνεισέφερε στη δημιουργία ενός επιστημονικού, βιολογικού υποβάθρου για την ερμηνεία των νοητικών φαινομένων. Προσέφερε, ακόμη, μία δυναμική προοπτική στην αλληλεπίδραση του εγκεφάλου με το περιβάλλον προαναγγέλλοντας τις θέσεις της κυβερνητικής, προδρόμου των γνωσιακών επιστημών.

Στη γνωστική νευροεπιστήμη, προώθησε μία διεπιστημονική προσέγγιση στη μελέτη των γνωστικών διεργασιών συνδυάζοντας τη φιλοσοφία με μεθόδους από την νευροπαθολογία, τη νευροανατομία, τη συγκριτική νευροανατομία, την αναπτυξιακή νευροεπιστήμη και την κλινική νευρολογία. Ανέδειξε τη συνθετική ικανότητα του μετωπιαίου λοβού και τη διπλή αισθησιο-κινητική του φύση. Υπογράμμισε τη δυναμική και ενορχηστρωμένη δράση του εγκεφάλου ως αποφασιστικό παράγοντα στην ανάδυση της συνείδησης.

Ο Jakob εξέφρασε την πεποίθηση ότι το συναίσθημα μαζί με τη νόηση δημιουργούν το συνειδητό εαυτό. Έθεσε τα θεμέλια της συναισθηματικής νευροεπιστήμης, εντοπίζοντας τα κύρια συστατικά του κυκλώματος Papez και περιγράφοντας τη δομή και τη λειτουργία του σπλαχνικού εγκεφάλου.

Συνέθεσε τις ιδέες του πάνω στην εξέλιξη και την ανάπτυξη σε μία πρωτότυπη θεωρία για τη διπλή οντο-φυλογενετική προέλευση του φλοιού των εγκεφαλικών ημισφαιρίων και τη διάχυτη, γενικευμένη αισθησιο-κινητική του δράση. Οι προτάσεις του στην εξελικτική νευροεπιστήμη απορρέουν από τις συγκριτικές μελέτες που διεξήγαγε. Η εξελικτική προοπτική, ωστόσο, είναι φανερή σε όλο το φάσμα του έργου του.

Μία από τις σημαντικότερες συνεισφορές του Jakob θα μπορούσε να θεωρηθεί η εισαγωγή φιλοσοφικών ιδεών στις νευροεπιστήμες και, αντίστροφα, η χρησιμοποίηση νευροεπιστημονικών εργαλείων για την απάντηση φιλοσοφικών ερωτημάτων. Ωστόσο, ο Jakob δεν υπήρξε μόνο ένας πρωτοπόρος της νευροφιλοσοφίας αλλά και της φιλοσοφίας της νευροεπιστήμης, στην απόπειρα να ορίσει τις κατευθυντήριες γραμμές μίας τέτοιας διεπιστημονικής απόπειρας.

Συνεπής στην προσπάθεια διάχυσης των νευροεπιστημών, επιχείρησε να βασίσει την εκπαίδευση σε νευροβιολογικές βάσεις. Έτσι, προηγήθηκε κατά έναν αιώνα περίπου της συστηματικής διαμόρφωσης του πεδίου της εκπαιδευτικής νευροεπιστήμης. Στο ίδιο πνεύμα, υπερασπίστηκε την ιδέα της ειδικής αγωγής και εκπαίδευσης δίνοντας έμφαση στην επιστημονική αντιμετώπιση που απαιτούν οι εκπαιδευτικές και ψυχολογικές παρεμβάσεις για τα άτομα με μη τυπική ανάπτυξη.

Συμπερασματικά, ο Jakob άφησε μία παρακαταθήκη από έργα η μελέτη των οποίων θα μπορούσε να ρίξει φως στη λειτουργία του ανθρώπινου εγκεφάλου. Πέρα από τη συμβολή του Jakob στα επιμέρους επιστημονικά πεδία, το έργο του αποτελεί ένα υπόδειγμα διεπιστημονικότητας που έχει νόημα να ληφθεί υπόψη στη σύγχρονη αναζήτηση απαντήσεων για το γρίφο του εγκεφάλου.

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CONTENTS

Sol y cerebro son los creadores de nuestros mundos.

Christfried Jakob, 1943

INTRODUCTION

The present dissertation examines the culmination of Christfried's Jakob (1866–1956) neurobiological, neurophilosophical and neuroeducational ideas. In all, Jakob's legacy comprises 30 books and 250 articles that cover developmental, evolutionary, anatomical and pathological issues in neurobiology (Moyano, 1957; Triarhou & del Cerro, 2006a, 2006b; 2007). Apart from his contributions to 'classical' neuroscience, Jakob's pioneering works 'touch upon' modern scientific fields, such as educational neuroscience and neurophilosophy. Despite the quantity and quality of Jakob's work, such contributions, written in German and Spanish, have not been dealt with in the English scientific literature until fairly recently.

Until 2006 a search in the database http://www.ncbi.nlm.nih.gov/pmc/, the standard archive of biomedical and life sciences journal literature at the U.S. National Institutes of Health's National Library of Medicine, would yield 0 returns on Jakob, with the exception of a Spanish article[1]. From 2006 and onwards an endeavor to retrieve and revive Jakob's work has been initiated by Triarhou (cf. Triarhou & del Cerro, 2006a, 2006b; 2007; Vivas, Tsapkini, & Triarhou, 2007; Tsapkini, Vivas, & Triarhou, 2008; Triarhou, 2008, 2009, 2010a, 2010b).

My research has been focused on the review of references covering a time period from 1896 to 1949. The papers of Jakob on which the present thesis is based have been discovered and made available to me by my mentor, Professor Lazaros C. Triarhou, who, over the past seven years, has been tracing and compiling an archive of the complete books and articles of Christfried Jakob from private sources and academic libraries worldwide, in his ongoing effort to revive Jakob's ideas and to

[1] Meyer, L. (1981). *Cristofredo Jakob: A veinticinco años de su muerte*. Acta Psiquiátrica y Psicológica de América Latina. 27, 13–14.

make evident their relevance in a modern neuroscience perspective. Dr. Triarhou personally visited and gathered material from the Library of Congress, Washington, DC; the National Library of Medicine of the United States, Bethesda, MD; the Smithsonian Institution Libraries and the National Zoological Park Library, Washington, DC; the Ruth Lilly Medical Library of Indiana University, Indianapolis, IN; the Bernard Becker Medical Library of Washington University, St. Louis, MO; the Öffentliche Bibliothek der Universität Basel, Switzerland; the Ibero-Amerikanisches Institut and Staatsbibliothek Preussischer Kulturbesitz zu Berlin, Germany. Additional papers have been obtained through the courtesy of interlibrary services from the Universiteitsbibliotheek, Universiteit van Amsterdam, Netherlands; the British Library; the Library of the National Academy of Medicine of Buenos Aires and La Biblioteca de Humanidades, Universidad Nacional de La Plata, Argentina.

In a broad framework, new English translations of such works are meaningful since they will make them accessible by a wider audience. Studying Jakob's papers helps to correct and reconstruct important episodes in the history of the neurosciences (Théodoridou & Triarhou, 2011a). As Triarhou (2008) points out, using frequent citation of a work as a criterion of correctness especially with articles written in languages other than English or not easily accessible carries the innate danger of reproducing inaccuracies.

Furthermore, given that the riddle of the human brain remains unsolved Jakob's views may still provide meaningful clues. Through this study I aimed at retracing the evolution of Jakob's avant garde thought and the connection of his still timely works with the modern literature.

Jakob's work can be divided into three periods. During the 'early' period (1890–1912), Jakob mostly carried out anatomical work. In his 'middle period' (1913–1935), he formulated his psychobiological ideas. In the 'late' period (1936–1949), he proposed synthetic neurobiological and neurophilosophical theories.

The structure of the present dissertation follows the course of Jakob's thought. In the first chapter I present biographical information along with a brief overview of the historical context. The next three chapters correspond to each stage of his thought. Within each chapter I firstly focus on the central question of the period. I further expose Jakob's views on relevant issues that help to clarify his viewpoint in the given time period. Subsequently, I discuss Jakob's theories and I consider them under the scope of the knowledge available at the time and the evidence available today. Thus, I attempt to draw parallels and to provide evidence of convergence between the ideas of Jakob and other great thinkers of the 20th century.

The second chapter examines the early period of Jakob's thought and career. The main issue that occupied his thought during this period is the localization of higher cognitive functions in the human brain and their relevance to the frontal lobe. Jakob's views on the structure and function of the emotional brain as well as the phylogenesis, the ontogenesis and histophysiology of the cerebral cortex are discussed.

The third chapter deals with the formulation of Jakob's neurodynamic postulate. In addition, I shed light on the emergence and the development of his dynamic approach and certain aspects of his neurodynamic framework; precisely, the degenerative psychogenesis and memory functions.

In the fourth chapter his revised neurodynamic postulate is presented. Furthermore, his ideas on the diffusion of neuroscientific knowledge into philosophy and vice versa along with his final views on the frontal lobe are detailed.

Finally, in the sixth chapter Jakob's most important contributions are summarized and discussed.

1. BIOGRAPHICAL NOTE

The son of Godofredo and Babette (née Körber) Jakob, Christfried Jakob (Fig. 1) was born on December 25, 1866 in Bavaria (Orlando, 1966). His father, who was a cultivated teacher, recognized and encouraged his son's inclination in the natural sciences (Orlando, 1966; Théodoridou & Triarhou, 2012a). Jakob completed his medical studies in 1890 at the University of Erlangen with a prize of 1,000 DEM, offered to the most distinguished student (Moyano, 1957). Afterwards, he carried out his doctorate under the supervision of Friedrich Albert von Zenker (1825–1898), studying aortitis syphilitica (Triarhou & del Cerro, 2007).

Figure 1

Christfried Jakob (1866–1956). Jakob's photo is from Orlando (1966). Reprinted from Triarhou & del Cerro (2006a). Courtesy: Library of Congress.

In the early 1890s he worked as an assistant to Adolf von Strümpell at the Erlangen Medical Clinic and privately practiced medicine in Bamberg (Orlando, 1966).

Jakob made a name for himself through his first brain atlas (Figs. 2 and 3), which was translated into several languages (for details, see Triarhou & del Cerro, 2006a). In 1899, Jakob accepted an offer made to him by Domingo Cabred (1859–1929), the Argentinian Professor of Psychiatry, to direct the Laboratory of the Psychiatric and Neurological Clinic of the Hospital of Mercedes at the National University of Buenos Aires (Orlando, 1966). He went to Argentina having signed a three-year contract. The prospect of having 300 brains available for pathological study annually played a crucial role in his decision to leave Europe (López Pasquali, 1965).

At that time, the Argentine population as well as the country's economy grew fervently as a result of immigration and a decreasing mortality (Véganzonès & Winograd, 1997), as Argentina was emerging as one of the ten richest countries in the world. Under such circumstances, Jakob had produced a dozen works in anatomy, neurology, psychopathology and anthropology by 1910 (Triarhou & del Cerro, 2007).

Then, his Argentinean contract expired and Jakob returned to Germany in 1910, where he promoted his original idea on the ubiquity of the sensory-motor dual function of the cerebral cortex (Jakob, 1911, 1912a, 1912b; Triarhou, 2010b). The works of his 'early' period (1890–1912) mostly centered on neuroanatomy, reflecting Jakob's training in the German tradition (López Pasquali, 1965).

The 'middle' period of Jakob's work (1913–1935) began with his permanent move to Argentina, where he assumed a triple role consisting of clinical, research and teaching duties (Théodoridou & Triarhou, 2012a).

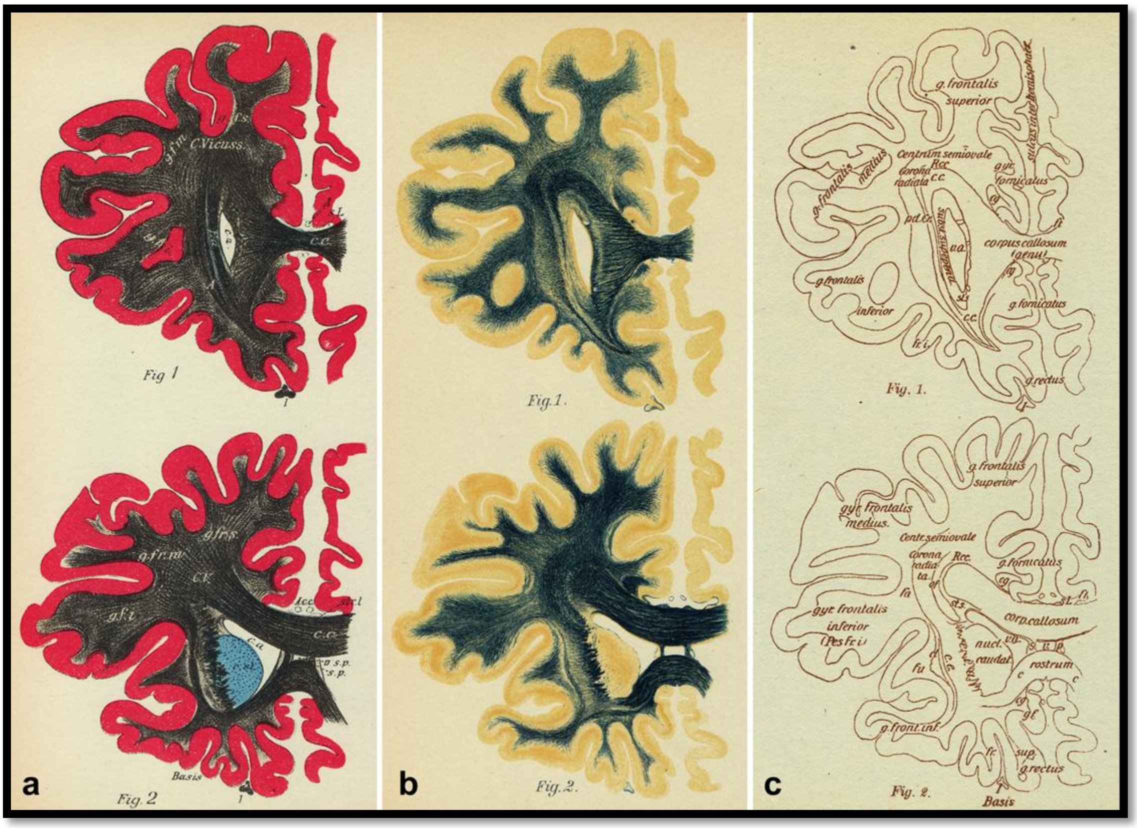


Figure 2

Drawings of coronal sections of the frontal lobe by Jakob for his early brain Atlases. Reprinted from Théodoridou & Triarhou (2011a). (a) Plate 24 from the first edition (Jakob, 1895, 1896): Frontal sections through the knee of the corpus callosum and the anterior segment of the frontal lobes (upper) and through the head of the caudate (lower). Abbreviations: g.f.s., superior frontal gyrus; g.f.m., middle frontal gyrus; g.f.i., inferior frontal gyrus; c.a., anterior horn of lateral ventricle; f.a., lateral association bundles; C.Vieuss., centrum semiovale; I, olfactory bulb; s.p., septum pellucidum; c.st., head of the caudate nucleus; c.i., anterior limb of the internal capsule. (b, c) Plate 28 from the second edition and explanatory diagram (Jakob, 1899, 1901). Abbreviations: Rcc., radiation of corpus callosum; pd.Cr., base of corona radiata; ft, tangential fibers; st.s, central gray matter of the ventricle; v, ventricle; of, occipitofrontal fasciculus; cg, cingulum; fa, arcuate fasciculus; fu, uncinate fasciculus; ce, external capsule; cl, claustrum; pes fr.i., foot of inferior frontal gyrus; sL, nerves of Lancisi; st.a., central gray matter.

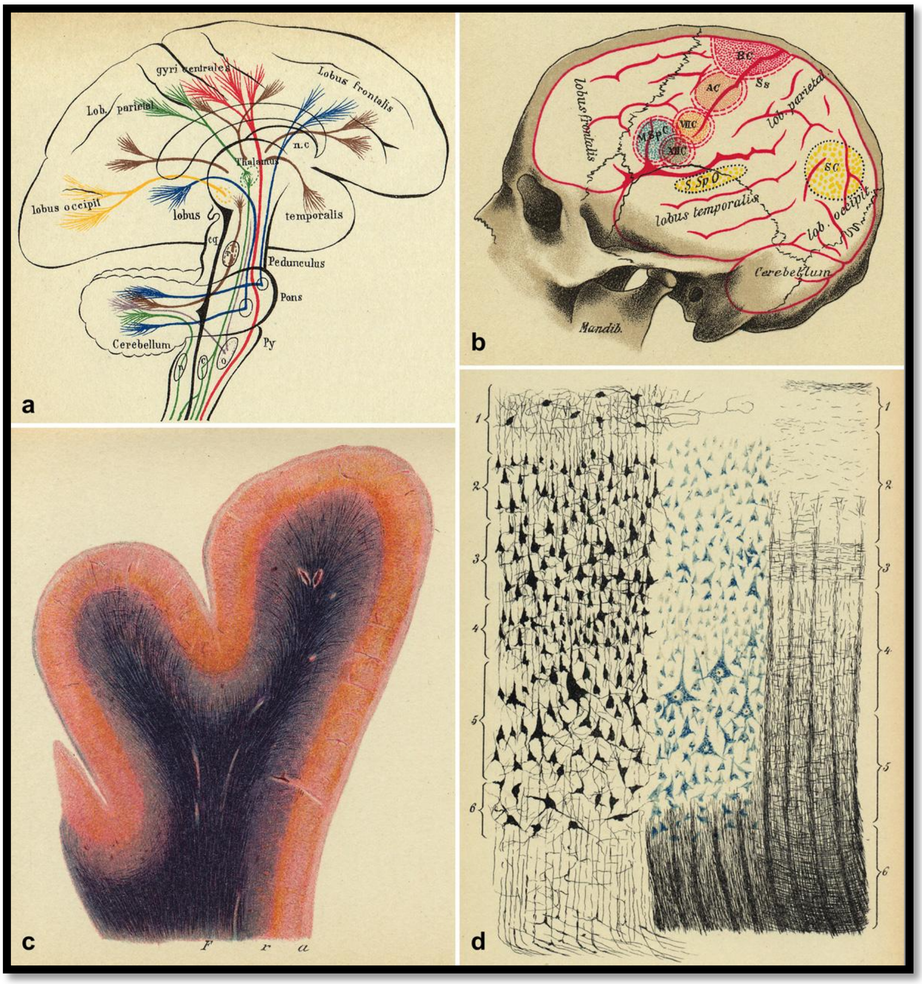


Figure 3

Additional drawings by Jakob from the second edition of his early brain Atlas (Jakob, 1899, 1901). Reprinted from Théodoridou & Triarhou (2011a). (a) Plate 56.1 showing a general view of projection paths. Fibers forming the corona radiata enter the optic thalamus (brown). The frontal and temporal pontine pathway reaches the cerebellum through the contratateral middle cerebellar peduncle (blue). The pyramidal tract appears red, the sensory tract of the fillet green, the cerebelloolivary tract violet, the optic radiation yellow, and the brachia brown. (b) Plate 21.3 depicting the position of psychomotor and psychosensory cortical centers in the cavity of the skull. Abbreviations: BC, motor center for lower extremities; AC, motor center for upper extremities; VIIC, XIIC, centers for muscles innervated by the facial and hypoglossal nerves; MSpC, SSpO, motor and sensory speech centers; SC, visual center. (c) Plate 20.1 showing a section from the center of the anterior central gyrus (carmin myelin sheath stain). White matter (F) appears blue-black; radial bundles (r) radiate in all directions and end in the cortex; a, outermost subpial layer. (d) Plate 19 showing the arrangement of cells (left and middle, stained with silver and methylene blue, respectively) and fibers (right) in the cerebral cortex. Cytoarchitectonic layer nomenclature: (1) Stratum zonale; (2) first layer of small pyramidal cells; (3) layer of medium-sized and large pyramidal cells; (4) second layer of small closely packed pyramidal cells; (5) second layer of medium-sized and large pyramidal cells with a few giant pyramidal cells; (6) layer of polymorphous cells. Myeloarchitectonic layer nomenclature: (1) stratum zonale with superficial layer of tangential fibers; (2) superradial reticulum and Bekhterev-Kaes stripe; (3) coarser tangential fibers (stripes of Baillarger, Gennari, Vicq d'Azyr); (4) interradial reticulum of tangential fibers; (5) closely packed radial bundles; (6) medullary layer with radiating white fibers (projection, commissural, and long association tracts) and transverse short association bundles (arcuate fibers of Meynert). For the most part, nerve fibers pass from the cerebral white matter into the cortex; collected in bundles, they enter the second layer of cells, where their terminal fibrils end. These radial bundles (radii) therefore have a vertical arrangement. They are crossed at right angles by other fibers running parallel with the cortical surface and forming the plexus of tangential fibers – the superradial reticulum above the radii, and the interradial reticulum with the radii.

He was appointed Chief of the Neuropathological Institute at the National Psychiatric Hospital for Women in the Federal Capital, and Professor and Director of the Institute of Biology at the Faculty of Philosophy and Letters of the National University of La Plata. In 1922, Jakob was appointed Professor of Neurobiology at the Faculty of Humanities and Educational Sciences of the National University of La Plata (Triarhou & del Cerro, 2006b). From 1921 to 1933, he held a joint appointment as Professor of Pathological Anatomy at the School of Medical Sciences of La Plata (Triarhou & del Cerro, 2006b).

The development of Jakob's 'dynamic approach' emerged in a 1918 article entitled 'From the Mechanism to the Dynamics of the Mind: A Critical Historical Study of Organic Psychology' (Théodoridou & Triarhou, 2012a). He further built on his original psychobiological ideas in his 1919/1921 work on gnoses and praxes as fundamental factors in cerebral cortical dynamics (Jakob, 1919, 1921). Two subsequent studies (Jakob, 1935a, 1935b) have been considered by his colleague and biographer Braulio Moyano (1957) as essential elements of Jakob's psychobiological theorizing; they were entitled, 'On the Biological Bases of Memory' and 'The Phylogeny of the Organization and the Evolutionary Dynamics of the Kineses' (Théodoridou & Triarhou, 2012a).

In the 'late' phase of his life, Jakob's thought became more synthetic. Through his works he promoted an integrated approach and he materialized interdisciplinarity. He coupled his philosophical background with the clinical and research experience, maintaining that the utmost problem of science and philosophy converges in cerebral function (Théodoridou & Triarhou, 2012b). He suggested a scientific psychology and a corpus of philosophy (López Pasquali, 1965).

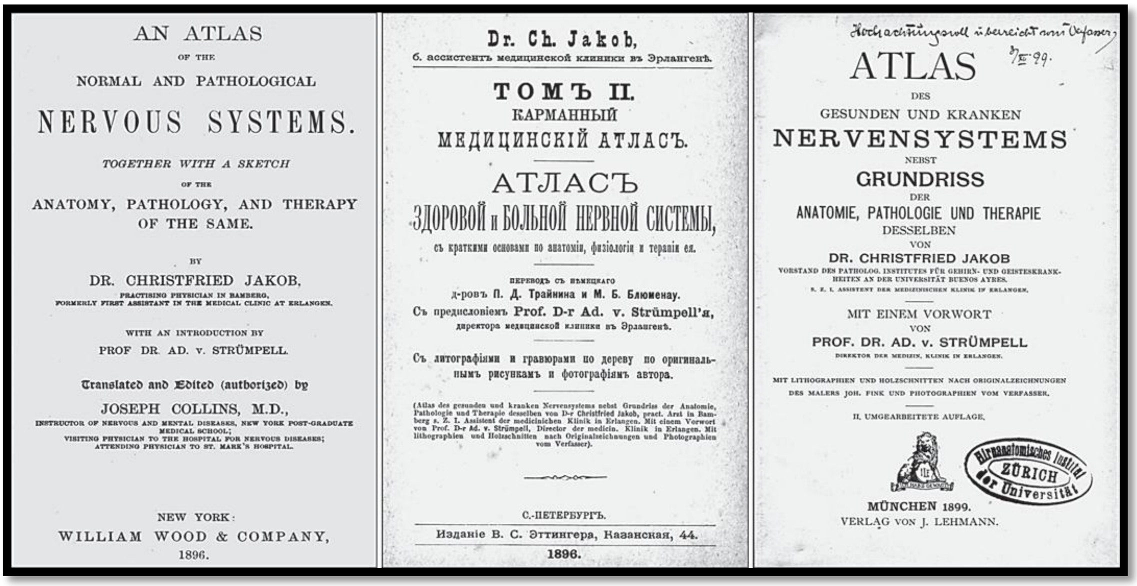
Jakob retired in 1945 (Orlando, 1966). However, he kept his formal appointment in Buenos Aires as Chairman of Pathological Anatomy and continued to work in his laboratory at the National Psychiatric Hospital for Women until 1954. He died in Buenos Aires in 1956 at the age of 90 (Triarhou & del Cerro, 2006a, 2006b).

In all, Jakob authored 30 monographs and about 250 papers that span over development, evolution, anatomy, pathology, psychology and philosophy in relation to neurobiology (Triarhou & del Cerro, 2006a). He is viewed as the father of Argentinian neuroscience (Pedace, 1949) and one of the great thinkers of the 20th century. His scientific caliber was such that Economo and Koskinas (1925) express the view that future research on the cortex would have to be based on the fundamental works of three investigators: Theodor Kaes (1852–1913), Santiago Ramón y Cajal (1852–1934) and Christfried Jakob, further considering Jakob's ideas on cortical phylo-ontogeny as 'ingenious' (Triarhou & del Cerro, 2006a).

2. THE EARLY PERIOD (1890–1912)

2.1. Opening remarks

The early period of Jakob’s work covers the years from 1890 to 1912 when Jakob commenced his fervent research activity. At the same time, he was practicing medicine in Bamberg (López Pasquali, 1965). Having developed a keen interest on general medicine and neurology, he showed his excellence on these domains through two works: an atlas of the normal and pathological anatomy of the nervous system (1895) that resumed all the available neurological knowledge and a text book of internal medicine (1897) that included his laboratory experience (López Pasquali, 1965). Both works, written in German, were translated in many languages (Fig. 4).


AN ATLAS
OF THE
NORMAL AND PATHOLOGICAL
NERVOUS SYSTEMS.
TOGETHER WITH A SKETCH
OF THE
ANATOMY, PATHOLOGY, AND THERAPY
OF THE SAME.
BY
DR. CHRISTFRIED JAKOB,
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FORMERLY FIRST ASSISTANT IN THE MEDICAL CLINIC AT ERLANGEN.
WITH AN INTRODUCTION BY
PROF DR. AD. v. STRÜMPELL.
Translated and Edited (authorized) by
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NEW YORK:
WILLIAM WOOD & COMPANY,
1896.

Dr. Ch. Jakob,
б. ассистентъ медицинской клиники въ Эрлангенѣ.
ТОМЪ II.
КАРМАННЫЙ
МЕДИЦИНСКІЙ АТЛАСЪ.
АТЛАСЪ
ЗДОРОВОЙ и БОЛЬНОЙ НЕРВНОЙ СИСТЕМЫ,
съ краткими основами по анатоміи, физіологіи и терапіи ея.
переводъ съ нѣмецкаго
д-ровъ П. Д. Трайнина и М. Б. Блюменау.
Съ предисловіемъ Prof. D-r Ad. v. Strümpell'я,
директора медицинской клиники въ Эрлангенѣ.
Съ литографіями и гравюрами по дереву по оригинальнымъ рисункамъ и фотографіямъ автора.
(Atlas des gesunden und kranken Nervensystems nebst Grundriss der Anatomie, Pathologie und Therapie desselben von D-r Christfried Jakob, pract. Arzt in Bamberg s. Z. I. Assistent der medicinischen Klinik in Erlangen. Mit einem Vorwort von Prof. D-r Ad. v. Strümpell, Director der medicin. Klinik in Erlangen. Mit lithographien und Holzschnitten nach Originalzeichnungen und Photographien vom Verfasser).
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S. Z. I. ASSISTENT DER MEDIZINISCHEN KLINIK IN ERLANGEN.
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MIT LITHOGRAPHIEN UND HOLZSCHNITTEN NACH ORIGINALZEICHNUNGEN DES MALERS JOH. FINK UND PHOTOGRAPHIEN VOM VERFASSER.
II. UMGEARBEITETE AUFLAGE.
Hirnanatomisches Institut der Universität ZÜRICH
MÜNCHEN 1899.
VERLAG VON J. LEHMANN.

Figure 3

Title pages of various editions of the Atlas of the Nervous System. English (left) and Russian (centre) translations of the first edition, and second German edition (right), the latter with the author’s handwritten inscription from the personal archive of Lazaros Triarhou. Reprinted from Triarhou and del Cerro (2006a).

In 1899, when he was 33 years old, Jakob moved to Argentina (Orlando, 1966). As the Chief of the Laboratory of the Psychiatric and Neurological Clinic of the Faculty of Medicine he was in charge of organizing the Laboratory of Pathological Anatomy of the Nervous System. Within this period, Jakob struggled to materialize his innovative ideas. For example, in 1906, encouraged by the visionary minister of Public Education, Joaquín González, Jakob asked for permission from the University of Buenos Aires to introduce a new course under the title ‘The nervous system and its relations to education’ (Orlando, 1966). However, he found resistance and it took about 15 years for such an initiative to come true.

In the following section I shed light on Jakob’s writings on the frontal lobe that constitute landmark works of this period. In order to give a complete overview of the first period, Jakob’s original theory on the dual onto-phylogenetic origin and the ubiquitous function of the cerebral cortex (Jakob, 1911, 1912a, 1912b) as well as his pioneering contributions in affective neuroscience (Jakob, 1907/1908, 1911; Jakob & Onelli, 1913) are also briefly discussed.

2.2. Localization of higher functions in the frontal lobe

Jakob developed a passionate concern on the frontal lobe. Between 1906 and 1909 he published 11 papers (Jakob, 1906a, 1906b, 1906c, 1906d, 1906e, 1906f, 1906g, 1907a, 1907b, 1907c, 1909b), which address biological, anatomo-clinical, pathophysiological and psycholinguistic aspects of the frontal lobe (cf. Théodoridou & Triarhou, 2011a).

Having studied the frontal lobe in its various developmental stages, and in neuropathological conditions, Jakob (1906e, 1907a) cast doubt on its ‘supremacy’ (Fig. 5).

He argued that *"the question concerning superior human functions cannot be answered pointing out their localization in one or another brain lobe but, instead, taking into account issues of another kind"* (Jakob, 1906c, p. 1373).

Jakob pointed to potential historical reasons – linked to classical Greek philosophy – that might account for the importance attributed to it (Théodoridou & Triarhou, 2011a). He considered the 'Olympian forehead', artistically expressed in the sculptures of Zeus, as the symbol of 'humanization' (Jakob, 1943c). He further explained how physical characteristics, such as the upright posture, the extremities, and the extended forehead, distinguish humans from animals.

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1053) **La légende des Lobes Frontaux en tant que Centres supérieurs du Psychisme de l'Homme,** par CRISTOFREDO JAKOB (de Buenos-Aires). *Archivos de Psiquiatria y Criminologia,* Buenos-Ayres, an V, p. 679-698, novembre-décembre 1906.

L'auteur donne plusieurs observations de lésions des lobes frontaux sans déficit psychique d'aucune sorte. La conclusion de son travail est que les lobes frontaux n'exercent aucune hégémonie sur le reste du cerveau; ce qui est perdu de la personnalité psychique à la suite des lésions étendues des lobes frontaux n'est qualitivement, ni quantativement différent de ce qui est perdu à la suite de la destruction étendue de tout autre lobe cérébral. F. DELENI.

Figure 5

Jakob's 1906 paper abstracted in French in the prestigious Revue Neurologique (Jakob, 1907c). Reprinted from Théodoridou & Triarhou (2011a). The summary reiterates Jakob's conclusion, based on observations that lesions in the frontal lobes do not lead to any substantial mental deficit: "The frontal lobes do not exert any hegemony over the rest of the brain. Any mental deterioration after damage to the frontal lobe does not differ qualitatively or quantitatively from that seen after damage to any other cerebral lobe".

2.2.1. Jakob's views

Jakob constantly viewed morphology in a functional context (Tsapkini et al., 2008). He believed that the elucidation of the anatomical connectivity of the frontal lobe would decipher its functions (Théodoridou & Triarhou, 2011a). Such a principle is depicted in his early brain atlas (Jakob, 1895) where Jakob describes a plan of five research approaches that he considered meaningful in order to better understand the nervous system: (1) histological staining and serial section reconstruction of the adult human brain; (2) neuropathological changes and their sequels; (3) comparative neuroanatomy and comparative neuroembryology; (4) human brain development and myelination; and (5) experimentally-induced lesions in animals.

Jakob emphasized the importance of studying anatomical connections. In studying the structure of the frontal lobe, he did not see any substantial differences from the remaining lobes of the cerebral hemispheres:

> *"The frontal lobe has three categories of fibers just like the other lobes: afferent and efferent projection fibers, association fibers and commissural fibers... Through the study of the afferent pathways we understand that in the major part of the frontal lobe, covering the whole of its convexity lies the great center of the muscular senses of a higher order".* (Jakob, 1906f, pp. 1327–1328)

Concerning the connections between the frontal gyri and the Rolandic motor areas via 'U' fibers (Fig. 6), Jakob (1906f, p. 1329) wrote:

> *"These fibers join the superior frontal gyrus with motor foci that innervate the lower extremities, relate the middle frontal gyrus with the foci of the arms, and the inferior frontal gyrus with facial-lingual movements... Moreover, there exist short association fibers that connect the three gyri among them, and commissural fibers that, passing through the corpus callosum, enable the communication*

between the frontal gyri of the two sides... Thus, we come across the existence of an apparatus inserted between the muscles of the periphery and the cerebellum on one side and the Rolandic centers on the other".

Jakob (1906c) described the sensory-muscular pathways which arrive at the frontal lobe via the cerebellum, the red nucleus and the thalamus concluding that although it is doubtful whether tactile senses arrive at the frontal lobe, it is true that numerous muscular sensory inputs enter the frontal lobe.

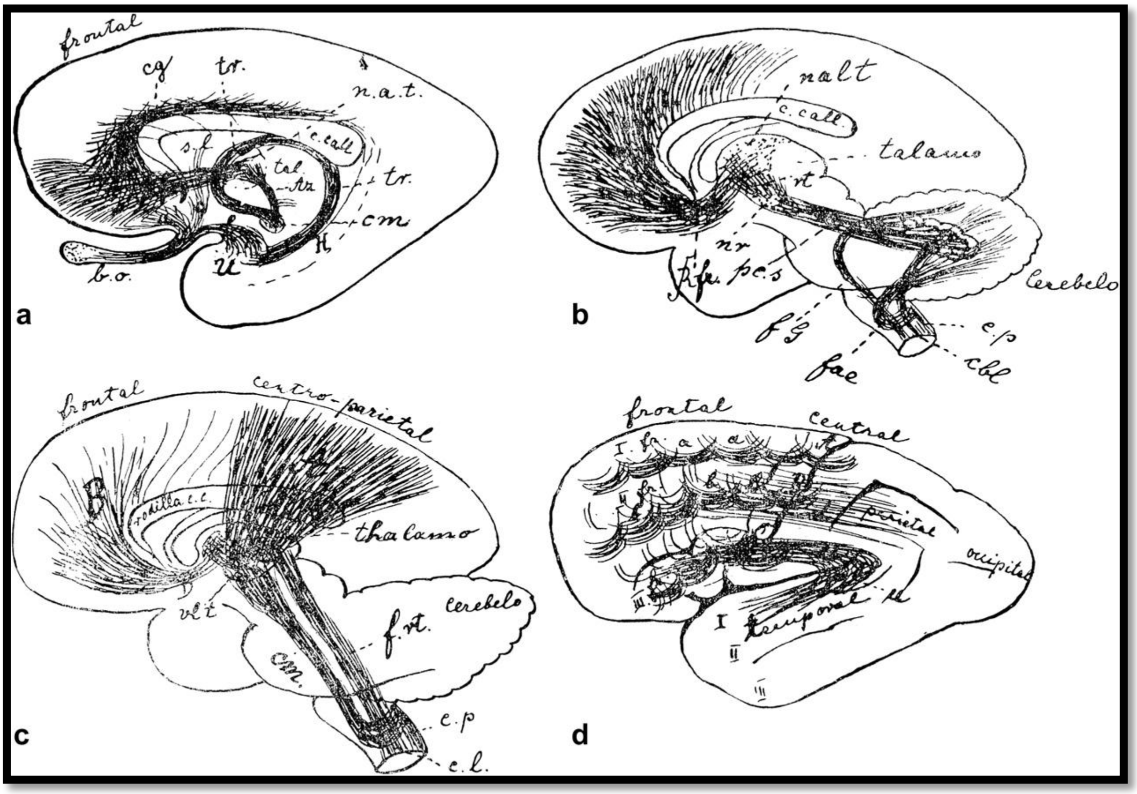


Figure 6

Schematic drawings by Jakob (1906f) showing: (a) Olfactory pathways in the frontal lobe. Abbreviations: b.o., olfactory bulb; a, internal root; b, lateral root; sl, septum pellucidum; u, uncus; h, hippocampus; tr, trigonum; cm, mamillary body; Az, bundle of Vicq d'Azyr; nat, anterior nucleus of thalamus; Rf, thalamo-frontal radiation; cg, cingulum. (b) Cerebello-frontal pathways. Abbreviations: cp, posterior spinal fasciculus; cbl, lateral cerebellar bundle; fG, bundle of Gowers; pcs, superior cerebellar peduncle; nr, red nucleus; rt, rubro-thalamic pathway; nalt, anterior lateral thalamic nucleus; Rfr frontal radiation. (c) Direct medullo-thalamo-frontal pathways. Abbreviations: cp, posterior spinal bundle; cl, lateral bundle; frt, reticular formation; cm, median band of Reil; vlt, ventral nuclei of thalamus; A, thalamo-Rolandic pathway; B, thalamofrontal pathway. (d) Association pathways in the frontal lobe. Abbreviations: A, Rolandic center of crus; a, Ufibers of superior frontal gyrus (I); B, brachial center; b, U-fibers of middle frontal gyrus (II); C, facio-lingual center; c, U-fibers of inferior frontal gyrus (III); u, uncinate fasciculus; d, superior longitudinal fasciculus. Reprinted from Théodoridou & Triarhou (2011a).

Based on his anatomical observations, Jakob (1906c) viewed the major part of the frontal lobe as a central station with multiplier and combinatorial characteristics, constantly receiving stimuli from all the motility organs via multiple pathways. A few years later, Jakob (1911) put forth an original theory on the dual onto-phylogenetic origin and the ubiquitous sensory-motor function of the cerebral cortex, based on the observation that the various centripetal pathways course into all sectors, thus the cerebral cortex has a perceptive activity over its entire extent (cf. Triarhou, 2010b).

Jakob's phylogenetic studies, from the human brain to over 100 species of the Patagonian fauna (Jakob, 1912a, 1912b; Jakob & Onelli, 1913; Triarhou, 2010b), provided him with the material for formulating the following ideas on evolutionary neuroscience:

> *"The development of the frontal lobes increases from lower to higher mammals in a continuous and constant relation, whereas in other vertebrates there are no hemispheres with a cortex comparable to those of mammals. It is obvious that the region located in front of the cruciate sulcus (a structure homologous to the central sulcus) increases in size and in the number of gyri it possesses from the marsupial to the rodent, from the rabbit to the dog, from the dog to the monkey,*

and approaches the size and complexity of humans only in anthropomorphous apes...[2] *Although the external morphology progresses from lower to higher scale in a constant manner, the same process does not occur in the internal structure... We see, then, that what is true about the process of comparative development in the frontal lobe is true in all the other lobes as well. Perhaps there are greater variations in one structure than another; but such variations are slight and it would be a highly difficult, if not impossible, venture to find a fundamental exception for the frontal lobe".* (Jakob, 1906e, p. 683–684)

Elsewhere, he wrote:

"When the frontal lobes of the different mammals, of ape and man are compared, the concord of the fine cortical structure strikes our attention; it is hard to encounter well defined differences... I myself noticed that the radiating fibers of the frontal lobe in apes are of a smaller calibre in comparison to other regions, a fact that has already been mentioned for humans. As far as the pyramidal cells are concerned ape shows all the different human types... What distinguishes the human frontal lobe is only the number of large and giant pyramidal cells... If the frontal lobe were such a superior center that it would differentiate by its functions humans from animals, then we should have met more evident differences in histological structure. According to my studies, I am inclined to believe that the similarities between the frontal cortical regions of some higher animals (for example apes) and humans are greater than the differences." (Jakob, 1906c, p. 1376)

Jakob further studied frontal lobe cytoarchitecture to sum up his research as follows (1906c, p. 1376):

[2] This, was not a new observation: it can be found, for instance, in the anatomy of Richard Owen (1866–1868).

“The frontal cortex is organized in the same cell layers, in the same associations of pyramidal cells which are differentiated only by their size, as we notice in the parietal and temporal lobe as well. The only thing that distinguishes the frontal cortex is the restricted variation of the size of the pyramidal cells due to the lack of large and giant pyramidal cells. My studies allow me to admit that toward the feet of the frontal gyri appear the large pyramidal cells covering the background of the precentral sulcus. Moreover, I managed to prove that the frontal cortex contains more cells per square millimeter compared with the Rolandic and the temporal regions. I could not deduce from this fact that the absolute number of cells would be greater in the frontal region compared to the Rolandic or the temporal regions, because the latter have a very high density.”

Having studied preparations with the Weigert method (Fig. 7), Jakob (1906c, p. 1376) argued:

“As far as frontal myeloarchitectonics is concerned I notice the same disposition of radiating fibers as in other regions... The so-called association layers are identical to the ones of the other lobes and the tangential layer is well developed. On the contrary, the supraradial layer stands out in showing remarkably fewer myelinated fibers... I am inclined to see a structural inferiority, an idea that is reinforced by the following facts: a diminished total density and density of the various layers, a smaller average cell volume and a less developed supraradial layer.”

Regarding Flechsig’s proposal of a parallel development of myelination pathways and intellect, Jakob wrote:

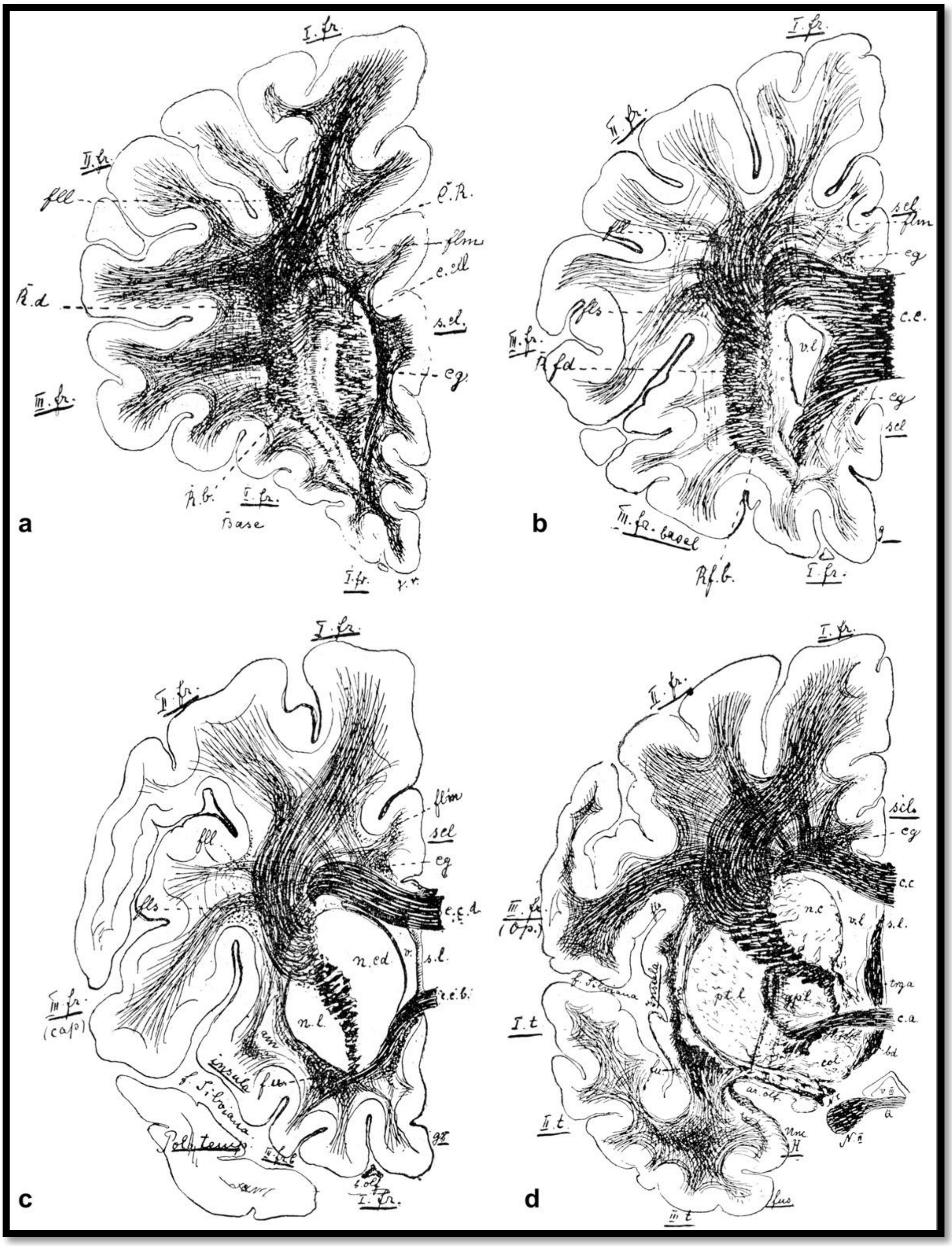


Figure 7

Schematic drawings by Jakob (1906c) based on a complete series of serial sections through the frontal lobe; Weigert method to depict fiber pathways. (a) Frontal section (no. 1154) in front of the corpus callosum. (b) Long projection, commissural and association pathways; section (no. 1076) through the knee of the corpus callosum. (c) Projection and commissural pathways and the formation of the internal capsule (frontal radiation); section (no. 948) through the corpus striatum. (d) Section (no. 882) through the posterior region of the frontal lobe with all its long frontal pathways. Abbreviations: fr, frontal; t, temporal; v, ventricle; l, lateral; nc, caudate nucleus; ptl, putamen-lenticular nucleus; gpl, globus pallidus; CR, corona radiata; RD, dorsal radiation of internal capsule; Rb, basal radiation of internal capsule; gr, rectal gyrus; cg, cingulum; flm, fll, fls, medial, lateral and superior longitudinal fasciculus; fu, uncinate fasciculus; cc, corpus callosum; sl, septum pellucidum; am, claustrum; scl, supracallosal gyrus; nl, lenticular nucleus; ca, anterior commissure; vIII, third ventricle; NI, olfactory nerve; NII, optic nerve; ar.olf, olfactory area; trga, anterior pillars of trigonum; col, coliculi of corpus striatum. Reprinted from Théodoridou & Triarhou (2011a).

> *"While the central tracts of the frontal lobe are not completed until several months after birth, Flechsig demonstrated that other regions of the brain develop in a similar fashion, for instance parts of the parietal and temporal lobes, the insula, and the so-called associative centers... Any chronological difference is not of much importance since a child has his frontal center perfectly myelinated before reaching six months of age. However, a newborn infant and one of six months are not easily differentiated with respect to their cognitive development."*
> (Jakob, 1906e, p. 686)

For the most part of the 19th century, the literature emphasized the role of the frontal lobe based on cases of damage that resulted in profound personality changes (Théodoridou & Triarhou, 2011a). Having studied human brains with frontal lobe tumors, injuries and degeneration Jakob pointed to the rareness of 'pure cases' (1909b); he highlighted the characteristics that may render pathological specimens inappropriate for drawing secure conclusions. He emphasized that (a) the appearance of symptoms does not necessarily coincide with the onset of the disease; therefore, progression may be difficult to determine; (b) tumors compress the brain parenchyma;

(c) lesions of vascular origin lead to widespread degeneration; and (d) brain damage may cause either inflammation or concussion that may affect the entire brain (Jakob, 1906c, 1909b).

Another one of the most vivid battlefields in the localizationist-antilocalizationist controversy have been the laboratories where experiments on animals were conducted (Théodoridou & Triarhou, 2011a). The experimental confirmation of motor cortex in dog brain by Fritsch and Hitzig (1870) was a landmark in the history of functional localization. This tradition continued with new mosaicists and holists. Jakob points out (1906e, p. 687–688):

"Goltz, Ferrier, Hitzig and Bianchi observed that animals that had both frontal lobes removed present remarkable alterations in intellect and character, such that they become irritable and have an increased tendency to bite... These experimenters did not sufficiently prolong their observations, and neither were they able to exclude as an explanation the consecutive inflammation or infections caused by the operation. New experimental verification, performed with meticulous care by Munk, Grossglik, Horsley and Schaeffer, did not absolutely verify any of the previous observations. They found that once the animals had passed the first moments of postoperative excitation, they all returned to their status quo."

According to Jakob's theorizing, intelligence, memory and the like are needed for handling abstract concepts (Jakob, 1906c). Similarly, the view that psychical terms do not have localizable physiological correlates was expressed by Jackson and embraced by Freud, Goldstein, Pick, and Head (Meyer, 1974).

In 1906 Jakob (1906f, p. 1326) wrote:

"Consciousness is formed gradually as a result of the chaining of different

cortical operations. It is impossible to view it as a localizable, special power separate from such processes. Consciousness is the manifestation of the synchronization of its component since it is afflicted whenever any of such components is afflicted. Intelligence is a quality par excellence that represents the rapid and safe function of the sensory, motor and associative apparatus. It cannot be localized, because it is a phenomenon inseparable from the overall cerebral process. Character is a mode of motor reactions congenitally imprinted on cortical elements. It intervenes in the transformation of the sensory and the motor functions and it is manifested in every action. Character is a quality, not a substantial power; therefore it could not be localizable. With the word 'memory' we designate an essential function that touches upon all the biological processes in the wider sense and especially upon the cortical processes. Will is the result of the inhibitory or productive influence that is exerted by gradually acquired associations on the inferior reflex actions via the motor centers. It has its origin in the association centers that cover the whole cortex. Only a determined voluntary act may be limited in a specific portion of the grand apparatus; nevertheless, for the production of such an act all the hemispheric regions intervene with greater or lesser intensity."

2.2.2. Discussion

The issue of functional localization has been at the core of neuropsychological research, as well as of philosophical delving, since the 19th century (Théodoridou & Triarhou, 2011a). Although the idea of specific cerebral localizations of physiological functions was adopted before 1861 by several researchers including Gall and Bouillaud (cf. Finger, 2000), it was Broca's 1861 lecture to the Paris Anthropological

Society (Broca, 1861) that brought it forcefully to the scientific world (Lorch, 2008). The second of ‘the two liveliest debates in the history of aphasiology’ took place when Marie questioned Broca’s views, while Déjerine defended localization at a special joint meeting of the New York and the Philadelphia Neurological Societies and at the Neurological Society in Paris two years later, triggering a debate that spread internationally (cf. Tsapkini et al., 2008). At the same time, Jakob would adopt an integrative approach in his attempt to elucidate cortical function.

After more than a century of cortical research, frontal lobe function still poses challenges (Théodoridou & Triarhou, 2011a). Its complexity has led authors to consider it anything from ‘the apparatus of civilization’ to an organ the removal of which may not always lead to behavioral deficits (Teuber, 2009). The fact that the human frontal cortex covers about 30% of the total cortical surface has prompted clinicians and basic scientists to hope that unraveling frontal lobe function might eventually explain human behavior (Raichle, 2002).

Jakob remained skeptical towards the frontal lobe superiority (Théodoridou & Triarhou, 2011a). Regarding his concerns about his contemporary pathophysiological and clinical literacy that supported such a superiority, Constantin von Monakow (1904, 1910) as well underlined certain factors that had been overlooked by investigators who studied lesions, i.e. the effects of inflammation, the lack of aseptic conditions during surgery, and the distant effects of local damage over time (Finger, 1994). The vulnerability of certain experiments was also highlighted by Jacobsen, (1936) who attributed it to (a) the lack of objective measures of the degree and nature of behavioral deficits and (b) the lack of the demonstration that lesions of equal extent in other cortical regions do not cause dementia of the same severity. Further caution has been expressed by Teuber (2009) about the contradictions found in the clinical literature; case studies may involve either massive lesions extending beyond the frontal lobe or small, unilateral, or asymmetric lesions with correspondingly small and easily compensated effects.

From an anatomical viewpoint, Alfred W. Campbell (1905), a pioneer of cortical cytoarchitectonic parcellation, expressed similar views to Jakob regarding the comparatively moderate structural development of the prefrontal cortex, in terms of the low fiber numbers and their delicate nature, as well as the absence of an association system. Campbell (1905) further considered that cell representation is on a similar scale and that the cortex is shallow. Brodmann's 1909 opus magnum changed the view of histological localization in the human cerebral cortex once and for all (cf. Garey, 2006). Brodmann (1913) also produced a subsequent study concentrating on the frontal cortex (Elston & Garey, 2004). At about the same time, Campbell (1905) compiled clinical, anatomical and physiological evidence as a guide to function (ffytche & Catani, 2005).

As far as myeloarchitectonics are concerned, Zülch (1975) credits Jakob for demonstrating that, at the direct corticospinal level, the pyramidal pathway is not yet myelinated in the newborn human; as Flechsig (1927) had described, only pathways that pass from motor cortex to the midbrain are myelinated at birth. Myelination in humans continues well into the second decade of life (Yakovlev & Lecours, 1967). Structural magnetic imaging studies have shown gray matter changes in the frontal lobe from adolescence to adulthood (Sowell, Thompson, Holmes, Jernigan, & Toga, 1999). In support of Flechsig's claim, the myelination of the frontal lobe has been repeatedly correlated with the development of higher cognitive functions, such as working memory (Nagy, Westerberg & Torkel, 2004) and language (Pujol, Soriano-Mas, Ortiz, Sebastian-Galles, Losilla, & Deus, 2006), while incomplete myelination has been blamed as the underpinning of weak decision-making skills in adults (Giedd, 2004).

Jakob's emphasis on the study of anatomical connections is consistent with the current hodological trend (cf. Catani & ffytche, 2005; ffytche & Catani, 2005). One of Jakob's merits was to draw attention to the U-shaped fibres of the frontal lobe and its connections with subcortical nuclei of the thalamus and medial temporal lobe introducing an hodological approach to the study of the frontal lobes (Catani & Stuss, 2012). In particular, Jakob (1906) described a system of longitudinal U-shaped fibres connecting adjacent frontal gyri as well as a 'brachial center' and a 'facio-lingual center' in the pre-central gyrus (PrCG) connected to parietal post-central cortex through direct U-shaped connections (Catani, Dell'Acqua, Vergani, Malik, Hodge, Roy, Valabregue, & de Schotten, 2012).

Furthermore, his writings on connections seem attuned to more recent theories of frontal systems and neural networks, such as Alexander, de Long and Strick's (1986) influential concept of parallel but segregated frontal-subcortical circuits that has been put into a clinical framework (Théodoridou & Triarhou, 2011a). An in-depth discussion of the association between frontal-subcortical circuits and neurobehavioral disorders can be found in Chow and Cummings (1999).

Jakob's (1906c) observations on fronto-thalamic pathways are in concordance with modern literarure (Theodoridou & Triarhou, 2011a); Cappe at al. (2009) demonstrated the existence of thalamic projections to the cerebral cortex using neuroanatomical track-tracing markers. Furthermore, Goldman-Rakic and Porrino (1985) showed that the prefrontal cortex is defined by multiple specific relationships with the thalamus. Performing retrograde tracing experiments, Mitchell and Cauller (2001) examined the corticocortical and thalamocortical afferents to layer I of the rat frontal cortex and affirmed the existence of afferent projections from thalamic nuclei to the frontal lobe.

Jakob’s (1906c) consideration of the frontal lobe as a central station with multiplier and combinatorial characteristics is not incompatible with modern views on the function of the anterior parts of the human brain (Théodoridou & Triarhou, 2011a). The prefrontal cortex is considered a locus of synthesis of the outputs of various brain systems that provides the basis for the orchestration of complex behavior (Duncan & Miller, 2002). Furthermore, the role of the frontal lobe in integrating information from multiple brain areas supports its crucial involvement in learning, comprehension and reasoning (Baddeley, 2002). Frontal and prefrontal regions have been linked to visual, auditory and somatosensory inputs (Fogassi, Gallese, Fadiga, Luppino, Matelli, & Rizzolatti, 1996; Graziano, Yap, & Gross 1994; Graziano, Reiss, & Gross, 1999; Wallace, Meredith, & Stein, 1992). Sensory, mnemonic and response signals that a single neuron displays provide strong evidence that prefrontal neurons behave as sensorimotor integrators (Goldman-Rakic, 2000). Prefrontal cortical neurons are considered to be a part of integrative neural systems that subserve cross-modal interactions across time (Fuster, Bodner, & Kroger, 2000). According to Fuster’s (2006) theorizing, actions related to human behavior, reasoning, and language are organized by means of interactions between prefrontal and posterior networks at the top of the ‘perception-action cycle’ (see also, pp. 55–56). In non-human primates, multisensory integration takes place in frontal, parietal and temporal areas (Avillac, Denève, Olivier, Pouget, & Duhamel, 2005). Thus, mounting evidence shows that much if not all of the neocortex is involved in multisensory integration (Ghazanfar & Schroeder, 2006).

From the beginning of the 20th century, the extraordinary human cognitive development has been attributed to the large size of the frontal lobes (Théodoridou & Triarhou, 2011a). Modern cytoarchitectonic studies show a very similar organization between human and macaque monkey prefrontal cortex (Petrides, 2005). Magnetic resonance imaging studies (Semendeferi, Lu, Schenker, & Damasio, 2002) show that the frontal cortex of humans and great apes occupies a similar proportion of the cortex of the cerebral hemispheres. Accordingly, the enlargement of the human brain has generally preserved the relationship between its major lobes (Risberg, 2006). A relative increase of association cortex due to encephalization cannot lead to a regional expansion of the frontal association areas since all four cerebral lobes have both primary and association cortices; therefore, such an expansion should be common to all (Allen, 2009).

A long-lasting debate has been taking place with regard to the functional localization of higher neurocognitive processes in the frontal lobe (Théodoridou & Triarhou, 2011a). Modern theoretical stances fall into a continuum that ranges from fractionated approaches to central concepts; at the same time, attempts are being made to reconcile contrasting views. The common denominator of fractionated approaches (cf. Koechlin, Ody, & Kouneiher, 2003; Shallice, 2002; Shallice & Burgess, 1996; Stuss, Alexander, Floden, Binns, Levine, McIntosh, Rajah, & Hevenor, 2002) is the assumption that there is no unitary frontal lobe process. The anterior part of the brain rather subserves multiple distinct control processes that underpin executive functions (Godefroy, Cabaret, Petit-Chenal, Pruvo, & Rousseaux, 1999). Within such a framework, modularity and fractionation may even pertain to higher human abilities (Baddeley, 1996; Stuss et al., 2002). A more central concept has been proposed by Duncan and Miller (2002), who reject a fixed functional specialization and highlight the adaptability of select regions of the prefrontal cortex in order to complete a goaldirected activity. Finally, Stuss (2006) argues that the debate between fractionation and adaptability is a false debate and suggests that brain networks may be both locally segregated and functionally integrated. Marshaled evidence showing the recruitment of the same frontal regions for different cognitive demands (Duncan & Owen, 2000) suggests that in spite of the fractionation, frontal processes are applicable to many domain-specific modules, and therefore are domain-general (Stuss, 2006).

2.3. Evolution and development of the cerebral cortex

In 1910 Jakob returned to Germany (Orlando, 1966). In 1911 he made a key presentation at the Second Annual Meeting of the International Society for Medical Psychology and Psychotherapy, organized in Munich by Oskar Vogt (Triarhou, 2010b). Jakob’s communication appeared in print the following year in two German variants (Jakob 1912a, 1912b). He kept revising those concepts (Jakob, 1916b) to develop an original theory on the dual onto-phylogenetic origin of the cerebral cortex and the ubiquitous cortical function.

2.3.1. Jakob’s views

According to Jakob (1912a, 1912b, 1916b) the most meaningful questions for a synthetic conception of the mental apparatus concern (Triarhou, 2010b):

(a) The nature of human and animal cerebral cortex, i.e. whether there are exclusively receptive, motor and neutral sectors, and if so, which are the characteristics that they render them distinguishable?

(b) The evolutionary course of such sectors and whether there exist fundamental differences that characterize the human cerebral cortex or there is just gradual differentiation.

(c) The origin of the cerebral cortex: Is it mono- or poly-phyletic?

Jakob (1912a, 1912b, 1916b) examined a collection of human brains histopathologically (degeneration methods), and of animal brains both experimentally in apes (Cebus from Paraguay), and comparatively anatomically in species of the South American fauna, to reach the following conclusions (Triarhou, 2010b):

(I) All regions of the human and animal cortex, with no exception, have receptive elements. The most part of such receptive radiations terminates at the external cortical layer.

(II) All regions of the human and animal cortex, with no exception, have an effector function. The most part of such radiations terminates at the cortical inner layer.

(III) Both fundamental layers have a uniform double origin in mammals up to humans (monophyletic evolution) and in various classes of lower vertebrates (reptiles in particular).

(IV) A cortex that is neither receptive nor effector, i.e. an 'association cortex', does not exist.

Thus, Jakob claimed that most receptive pathways end up in an 'outer fundamental layer', which derives from the rhinencephalic apparatus, whereas the 'inner fundamental layer' contains effector elements and derives from the striatum; in the course of evolution the two fundamental layers become intermingled (Triarhou, 2010b).

By attributing a functional homogeneity to the cortex, Jakob contradicted the theories of Flechsig and Cajal on 'association' and 'mnemonic' areas. Jakob challenged Flechsig views and Cajal's three-order system of neural networks that subserve associative functions anew in his 1919/1921 article on gnoses and praxes as fundamental factors in cerebral cortical dynamics (see pp. 58–72).

Jakob (1912a, 1912b, 1919/1921) supported that higher functions have a dynamic nature. He argued that each individual elementary process in the domain of will or perception must carry from the outset a similar 'mixed' character (Triarhou, 2010b). Therefore, there is no part of the cortex that acts solely as receptive or as effector, as the histological and experimental findings have documented. Such an argumentation culminated in the middle period with the formulation of his dynamic theory (see pp. 54–57) that fall within his evolutionary postulate (Jakob, 1935a).

Jakob expressed the view that the outcome of such findings constitute a new important biological basis for the study of the mental functions in the clinic, in psychology and in physiology which would contribute to bridging the gap between biological and mental phenomena. He further pointed out (1912a, 1912b) that such results, which derive from brain research, are attuned with the views of the contemporary philosophy (cf. Wundt's apperception theory, the doctrines of the subconscious etc.) emphasizing that the findings of mental research no more contradict those of brain research (Triarhou, 2010b). Thus, the germs of his ongoing effort on such a connection that peaked in his late period are already obvious in his early writings (Jakob, 1913a).

2.3.2. Discussion

As we have seen earlier (see p. 39) mounting evidence on the neural underpinnings of cognition lend support to the idea that neocortical operations are essentially multisensory at all levels of cortical processing, against the older notion that senses operate independently, i.e. in unisensory terms (Ghazanfar & Schroeder, 2006); in most likelihood, neither the brain nor cognition develop one sensory modality at a time (Triarhou, 2010b).

Triarhou (2010b) points out that a vindication of Jakob's views is echoed in the classic British edition of Gray's Anatomy (Warwick et al., 1973, as cited in Triarhou, 2010b), where it is argued:

"Even the simpler differentiation of the cortex into sensory areas receiving afferent projection fibres and motor areas projecting efferents – the remainder being regarded as 'silent' or associational – can no longer be considered appropriate, being itself an inaccurate over-simplification. Evidence has accumulated during the last three decades to show that the areas receiving or originating projection fibres are much more extensive than the initial classical studies indicated. Furthermore, the division into receiving and originating projection areas is by no means so distinct as first appeared ... It is hence more appropriate to speak of the pre- and post-central areas as being sensory-motor; and since a mixture of afferent and efferent connexions has been shown to exist also in respect to the projection fibres of the acoustic and visual sensory areas, they also are more accurately described as sensory-motor in character ... It is this afferent-efferent character of most, and probably all, the sensory-motor areas which makes the concept of distinguishable motor and sensory parts of the cortex anatomically invalid and functionally misleading. It is clear from the above remarks that much less of the cerebral cortex remains to be dubbed as associational, in the vague but well-established meaning of the term."

2.4. Localization of affective functions in the visceral brain

Jakob preceded by 25 years at least the concept of 'visceral brain', the 'Papez circuit' and parts of the 'limbic system' with a series of articles written in German and Spanish between 1894 and 1913 (Triarhou, 2008). His original writings constitute a pioneering contribution in affective neuroscience as they shed light on the evolution, development, sectorization, formation and hodology of the visceral brain. To formulate his ideas on the affective functions of the visceral brain he was based on experimental operations in apes and dogs, clinical and neuropathological observation as well as histopathological analyses of human brains. He mainly used the Weigert and Nissl stains to study myelination and retrograde degeneration.

2.4.1. Jakob's views

Jakob discovered the cingulate gyrus as a brain structure receiving stimuli from muscles and viscera (proprioception and interoception) as it is documented in his 1907/1908 article (Triarhou, 2008). Furthermore, Jakob discussed the involvement of the mamillary bodies, anterior thalamic nucleus, cingulated cortex and hippocampus in a brain circuit that he named 'visceral brain' in his 1911 and 1913 monographs on human and comparative neuroanatomy well before Papez's descriptions of the anatomical correlates of emotion that called after him 'circuit of Papez'.

Jakob published the findings that he obtained after a long investigation that begun in Germany before 1890 and was continued in the Neurological Clinic of the Unoversity Hospital of Buenos Aires from 1899 and onwards in numerous occasions both in Castilian and in German (Besada, 2010). He conceived and articulated his theory based on his arsenal of knowledge on zoology, comparative anatomy, embryology and pathology, coupled with his deep understanding of clinical phenomenology (Orlando, 1966).

Jakob (1909a) described the limbic cortex as an ano-vesico-genital center (Triarhou, 2008). In his article entitled 'The Cortical Cell in Madness' (Jakob, 1910 as cited in Triarhou, 2008), he wrote that "the great superior limbic (supracallosal) gyrus is connected via afferent pathways that derive from our body (visceral sensations: thoraco-abdominopelvic)”.

A year later, in 1910, Jakob presented his ideas at the International Scientific Congress in Buenos Aires (Triarhou, 2008). Subsequently, he published his three large brain atlases (Jakob, 1911; Jakob & Onelli, 1911; Jakob & Onelli, 1913 (Triarhou, 2008).

In 1911 and 1913 (Jakob, 1911, 1913a) Jakob described the thalamocingulate projection. Together with Onelli (Jakob & Onelli, 1911, 1913), Jakob further shown that the mamillary body establishes the union of the hippocampal impulses with those that arrive at the diencephalon via the mamillary peduncle that carries visceral information (Triarhou, 2008).

Jakob (1910) highlighted the division of the cerebral cortex into two regions, one lateral, receiving stimuli from the evironment, and one medial, at which arrive stimuli from visceral musculature and the sympathetic nervous system. In 1911, Jakob and Onelli further described the basic concept of hemispheric wall function, i.e. the association of the lateral aspect with somatic function and the medial aspect with visceral function (Fig. 8).

Jakob continued to study the emotional mechanisms of the human brain until his late period struggling to

> *“... achieve a constructive synthesis for the creation of those inner affective mental phenomena in their relation to external cognitive phenomena ...[since] ... the associative process between both systems creates the conscious and total personality: affect and cognition, respectively located at the medial fornical-limbic and at the lateral pyramidal systems.”* (Jakob & Copello, 1949, as cited in Triarhou, 2008).

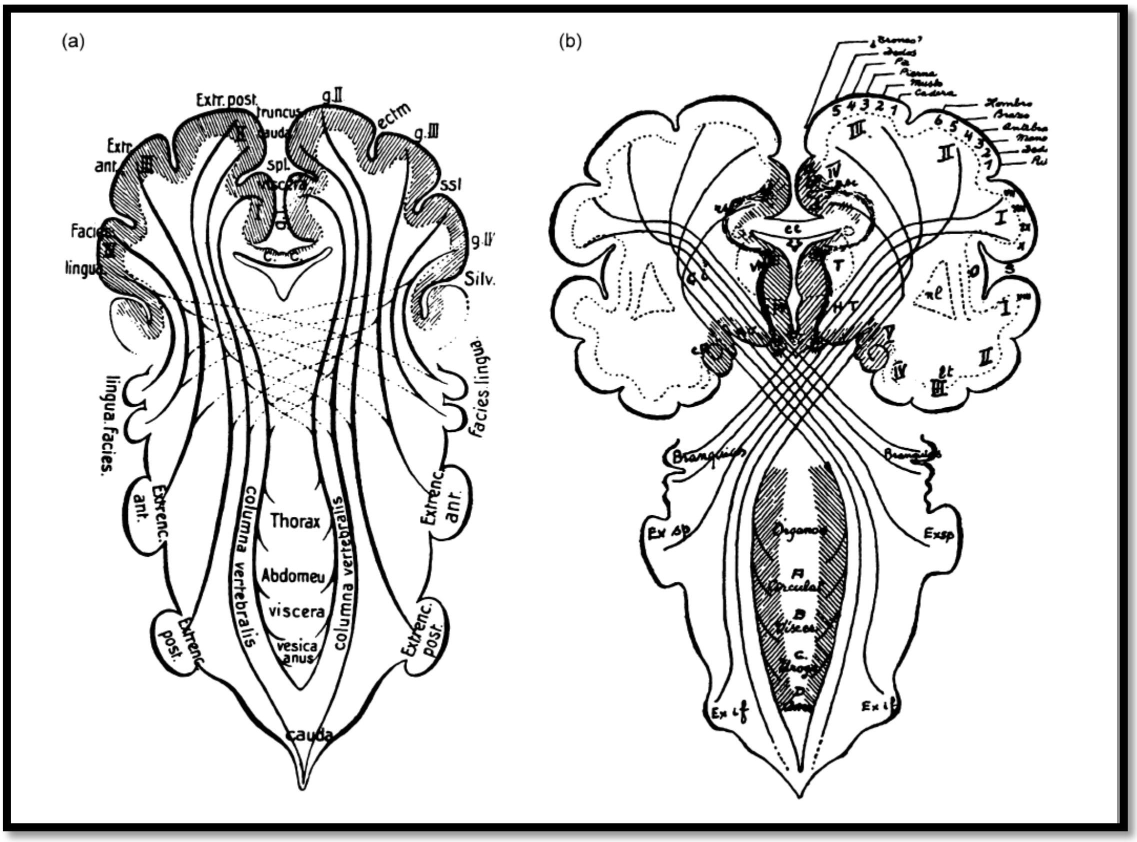


Figure 8

(a) Scheme of the trunco-cortical projections from the viscera to the cingulate cortex, and from the extremities to the lateral cortical areas; originally Fig. 22 in Jakob and Onelli (1911), Fig. 51 in Jakob (1911) and unnumbered figure on page 21 in Jakob and Onelli (1913). (b) An updated version, originally Fig. 13 in Jakob's later article on the philosophical significance of the human brain (Jakob, 1945a). Sympathetic system projections carrying endogenous signals occupy the medial aspect of the human cerebral hemisphere (oblique hatching) and somatic capsular projections (ci) carrying exogenous signals the lateral aspect contralaterally. Reprinted from Triarhou (2008).

2.4.2. Discussion

Affective neuroscience deals with the neurological understanding of the basic emotional operating systems of the mammalian brain and the various conscious and unconscious internal states that they generate (Panksepp, 1998). William James (1884) and Charles Darwin (1872/1965) are considered as historical forerunners to the field (Triarhou, 2008). According to Dalgleish (2004), the bases of modern affective neuroscience can be found in the early functional neuroanatomical models of emotion of Walter Cannon (1927, 1931), Philip Bard (1928), James Papez (1937), and Paul MacLean (1949).

However, a number of studies (reviewed by Triarhou, 2008) in the Argentinian and in the Castillian literature have presented arguments in terms of Jakob's precedence in proposing a cerebral circuitry that subserves emotion, and also in making the benchmark discovery of the 'visceral brain' and its association with the cingulate gyrus. The fact that Jakob identified already in 1906 all the tracts of the limbic circuit, leads one to speculate on any possible relationship between him and Papez (1937) (Catani & Stuss, 2012).

Jakob realized the first interpretation of the limbic or 'internal' brain as a viscero-emotional mechanism, describing the connections of the anterior nucleus of the thalamus with the cingulate cortex in the neural circuit that underpins instinctive and emotional life (Triarhou, 2008). The thalamocingulate projection as well has been described by Jakob in 1911 and 1913 (Jakob, 1911, 1913a) although it is commonly attributed to a 1933 study by Le Gros Clark and Boggon (Triarhou, 2008). The view of Jakob and Onelli (1911, 1913) that the mamillary body establishes the union of the hippocampal impulses with those that reach the diencephalon via the mamillary peduncle that carries visceral information was supported by Goldar's (1975) anatomical studies (Triarhou, 2008).

The basic concept of hemispheric wall function has constituted a central concept of Papez theory (Lautin, 2001). Kleist (1934), as well, assigned the 'somatic ego' to the median facies of the cerebral hemisphere based on the observations on cortical morphology (Triarhou, 2008). Such a concept is consistent throughout Jakob's works. For example, it is evident in Jakob's neurophilosophical model where he highlighted the relevance of an integrated system consisting of an internal ('introyental') aspect of the frontal lobe connections, responsible for the elaboration of elementary notions of vegetative well being and discomfort, conferring it an affective value and associating it with the limbic system as its neural substrate and an "environmental-praxic" one (Barutta, Hodges, Ibáñez, Gleichgerrcht, & Manes, 2010). Both aspects are considered to contribute to the individual elaboration of conscious experiences and the execution of conscious actions.

Such a theorizing resembles in many ways Damasio's (1994, 1996) somatic marker hypothesis (Barutta et al., 2010). The somatic marker hypothesis entails notions that can be found in Jakob's line of thought, namely evolution, homeostatic regulation, and organism. Within such a framework, not only does emotion assist reasoning, but is further viewed as an embodiment of the logic of survival (cf. Damasio, 1999).

2.5. Recapitulation

In this chapter I followed the evolution of Jakob's ideas in the early period of his career, from his graduation from Erlangen Medical School in 1890 to his second and permanent move to Argentine in 1913. Within this period, the frontal lobe emerged as a major issue in his thought.

Having understood the limitations and misdirections involved in any attempt to decipher the brain-mind relationship, Jakob tackled the 'terra incognita' of cognition with a multi-level approach in order to avoid bias (Théodoridou & Triarhou, 2011a).

Being aware of such limitations, he searched for diverse clues largely relying on the anatomo-clinical approach and he was critical of oversimplifying localization explanations. His approach that highlighted the role of anatomical connections to brain functions is still considered at the cutting edge of neuroscience as the revival of the ‘hodological trend’ implies. His views on the frontal lobe functions are further compatible with modern views that issue from sophisticated tracing and imaging techniques.

The evo-devo interface occupied his mind leading him to the formulation of an original theory. Jakob, thus, attempted to introduce an evolutionary perspective in brain processes constructing a multi-component framework for the understanding of higher mental functions.

Jakob’s observations on the visceral brain and the hypotheses concerning its action heralded the emergence of affective neuroscience. By attributing such a crucial role to the emotional functions and their neuronal underpinnings Jakob certainly preceded his era.

3. THE MIDDLE PERIOD (1913–1935)

3.1. Opening remarks

The 'middle' period of Jakob's work (1913–1935) began with his second and permanent move to Argentina, where he assumed clinical, research and teaching duties (Théodoridou & Triarhou, 2012a). He was appointed Chief of the Neuropathological Institute at the National Psychiatric Hospital for Women in the Federal Capital, and Professor and Director of the Institute of Biology at the Faculty of Philosophy and Letters of the National University of La Plata. In 1922, Jakob was appointed Professor of Neurobiology at the Faculty of Humanities and Educational Sciences of the National University of La Plata (Triarhou & del Cerro, 2006b). From 1921 to 1933, he held a joint appointment as Professor of Pathological Anatomy at the School of Medical Sciences of La Plata (Triarhou & del Cerro, 2006b).

During this period, Jakob developed his dynamic approach. In the following section an analysis of Jakob's neurodynamic postulate concerning the evolution and the development of human psychogenesis has been carried out. His writings on gnoses and praxes, the fundamental factors in cerebral cortical dynamics (Jakob, 1919, 1921) that constitute a milestone of this period are detailed. In addition, essential concepts for the understanding of his psychobiological thought are discussed: the emergence of Jakob's dynamic approach as it is described in his 1918 paper 'From the Mechanism to the Dynamics of the Mind: A Critical Historical Study of Organic Psychology', his 1913 pioneering neuroeducational perspective on degenerative psychogenesis (developmental disorders), and its biological treatment – that couples with the central issue of this chapter, which is the normal psychogenetic development –, and his views on the biological basis of memory that issue from his neurodynamic postulate (Jakob, 1935b).

3.2. The emergence of a dynamic perspective

Jakob's twist in dynamics is crystallized in his 1918 article entitled 'From the Mechanism to the Dynamics of the Thought: A Critical Historical Study of Organic Psychology', a directional, programmatic introduction to biological psychology. At that time dynamic concepts prevailed in physics. However, it took some time for such concepts to be applied to brain sciences. York (2009) argues that an era's broader historical, political and cultural framework is reflected in scientific trends. Thus, theoretical dynamic approaches became popular in many fields only after the 1940s. To our knowledge, the first reference to neurodynamics is attributed to Trigant Burrow (1943).

3.2.1. Jakob's views

Jakob (1918) defined thought as a 'biophylactic' (<Gk. βίος=life and φυλάσσω=guard) phenomenon with a triple function. Thought is at the same time the material, the instrument and the constructor of experience. Such an important process, Jakob (1918) claimed, remains constantly under the microscope of philosophy, especially logic, psychology, biology, and physiology. The consideration of thought in mechanistic terms has been transformed into a dynamic consideration. Thus, in the domain of biology for example, the central problem of thought consists in the examination of a biologic function of the creative amalgamation between the contents of the individual experience that have been formed through a series of sensory, affective, and voluntary reactions stored in the nervous system and the collective experience that has been condensed into heredity, language and tradition. Therefore,

thought is an energetic process of assimilation of experience that guarantees the dynamic stability, analogous to the biological phenomenon of assimilation. Since experience is a function of constant correlations that secures the dynamic equilibrium of an organism, mentality can by no means be a ‘tabula rasa’. Jakob (1918) underlined the fact that even in the intrauterine life the organism perceives certain stimuli. He bolstered his dynamic perspective with examples from physics and chemistry.

Jakob (1918) rejected the consideration of experience as a passive, sensory-perceptive process arguing that it is impossible a sensation that causes an alteration to the internal environment not to be compensated by a corresponding modification of the external environment. As it is manifested in natural sciences, action and reaction are only artificially separate serving the purpose of human observation. Thus, he thought that we do not experience sensations and perceptions but senso-reactions and percepto-reactions (Fig. 9).

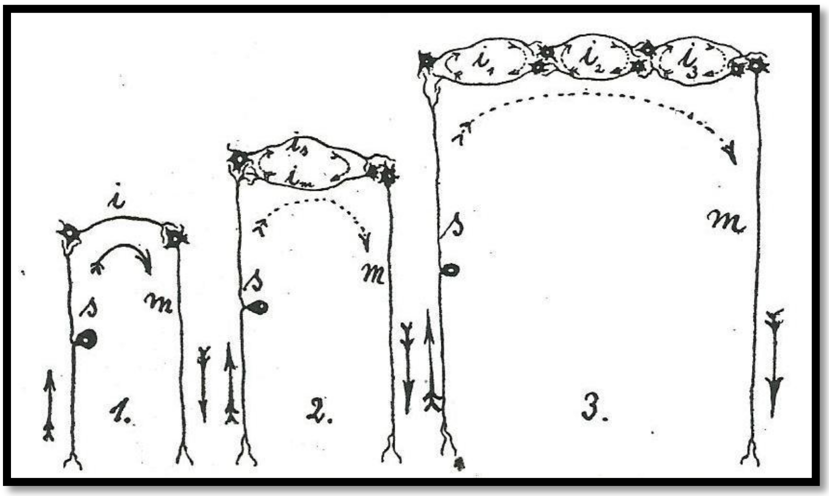


Figure 9

Drawing of the dynamism of a reflex action (1), of a simple cortical action (2), and of a complex cortical action (3) made by Jakob (1918). Abbreviations: s, sensory element; m, motor element; i, intercalated element.

Such an argument becomes evident in the domain of developmental psychology; a sensation without a reaction is hollow. A child does not store passively the future capital of experience but only the stimuli that trigger some kind of reaction either through reflexive or through voluntary actions. Thus, the senso-reactions that receive enough significance through the stimuli (e.g. internal, visceral, and muscular) that caused them form the psychological equivalents for the creation of the vegetative self. Accordingly, peripheral stimuli, such as tactile and thermic, set the ground for the orientation in time and space leading to the emergence of the physical self. Senso-reactions to sequential external stimuli eventually generate the dynamic equivalents of the external environment and its contents. With the crescent extension of the field of experience arises the reactive receptivity. Then, the association of objects of the internal and the external environment with their dynamic equivalents allows the appearance of the individual self that eventually elevates to the objective self. The elaborations of the objective self are particularly favored by the connections made between the individual and the collective experiences. Such connections are rendered possible by language functions.

3.2.2. Discussion

Jakob's hypothesis on the integrated function of perception and action may have parallels in different fields, such as philosophy, biology, psychology and neuroscience (Théodoridou & Triarhou, 2012b). The concept that higher processes enter at the most elementary stage of sensation was introduced by Kant; perception is then far from a simple construct following on passively received sensory reception (Ochs, 2004).

The French physiologist Claude Bernard, a pioneer of cybernetics, argued that "the fixity of the milieu supposes a perfection of the organism such that the external variations are at each instant compensated for and equilibrated” (Bernard, 1878/1974, as cited in Gross, 1998) indicating this equilibrium as the necessary condition for the free and independent life.

The idea of a perception-action cycle has been expressed in various frameworks. Jakob Johann von Uexküll (1864–1944) was a Baltic German biologist and pioneer of biosemiotics interested in how living beings subjectively perceive their environment. His functional cycle of perceptual and motor field (Uexküll, 1934) is considered as an early account of Biocybernetics. Within his theory, perceptual and effector fields together form a closed unit, the *Umwelt* (Uexküll, 1934). The object and the subject are, then, dovetailed into one another to constitute a systematic whole (Uexküll, 1934).

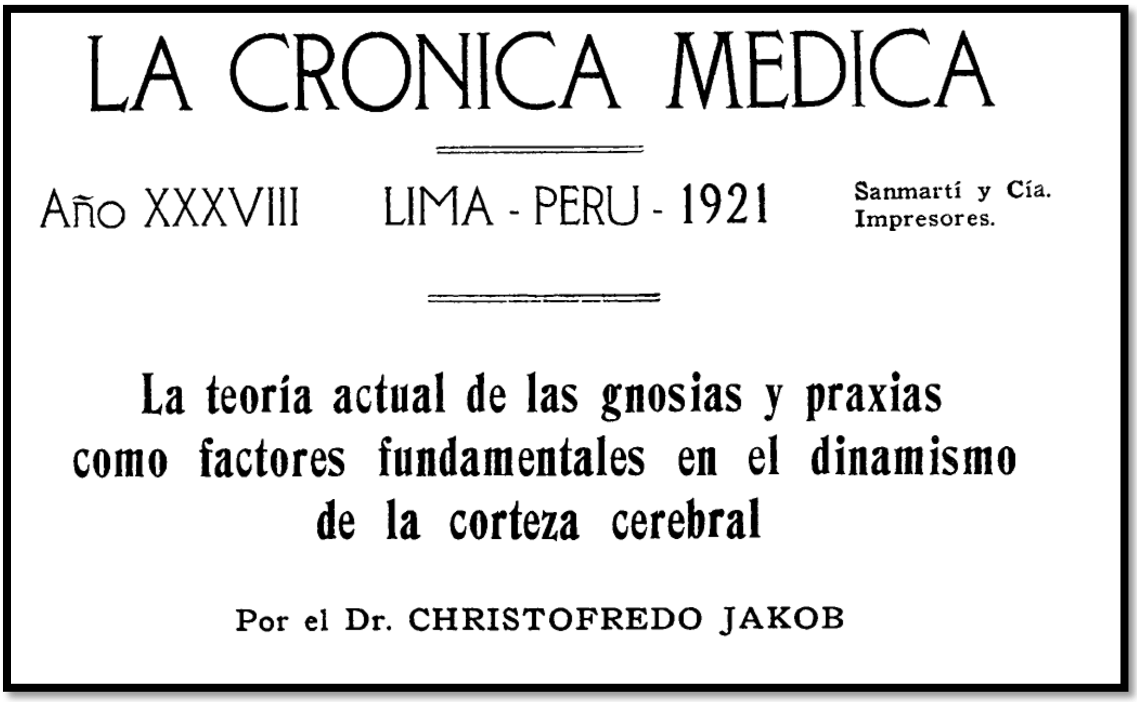
The German physician and physiologist Viktor Freiherr von Weizsäcker (1886–1957) attempted to represent the unit of perception and movement in a theoretical basis introducing the concept of Gestaltkreis (Weizsäcker, 1950), an elaboration of Gestalt psychology.

James Jerome Gibson (1904–1979), one of the most important 20th century psychologists in the field of visual perception and father of ecological psychology, saw perception in dynamic terms and emphasized the importance of sensory feedback from movement (Hurley, 2001). Perception and action are interdependent creating a continuous circle of causes and effects of action (Gibson, 1986).

Michael A. Arbib (1981) put the concept into the framework of computational neuroscience. However, it was Joaquin Fuster (2006) who is credited with the designation of the perception-action cycle that represents the behavior of an organism into a continuous circular flow of information between itself and its environment. In the cerebral cortex, the upper stages of the biocybernetic cycle constitute what he calls the perception-action cycle where, the sensory information is analyzed in the context of existing perceptual cognits and processed in the context of existing executive cognits.

3.3. An onto-phylogenetic neurodynamic postulate

In his 1919/1921 work on gnoses and praxes as fundamental factors in cerebral cortical dynamics Jakob further built on his original psychobiological ideas (cf. Théodoridou & Triarhou, 2011c). The original article, written in Spanish, was published in the Peruvian journal 'La Crónica Médica' (Fig. 10). It includes the essence of Jakob's work on cortical dynamics. When it was published, the 55-year-old Jakob was at the prime of his neurobiological thought (Triarhou & del Cerro, 2006b).



LA CRONICA MEDICA

Año XXXVIII LIMA - PERU - 1921 Sanmartí y Cía. Impresores.

La teoría actual de las gnosias y praxias como factores fundamentales en el dinamismo de la corteza cerebral

Por el Dr. CHRISTOFREDO JAKOB

Figure 10

Frontispiece of Jakob's original 1921 article on gnoses and praxes. Reprinted from Théodoridou & Triarhou (2011c).

This work carries special weight because it underscores the emergence of Jakob's foremost theories regarding (a) the biological basis of memory and (b) the phylogeny of the kineses. Both of these theories were published in 1935 (Jakob, 1935b, 1935a) and are considered essential in understanding his psychobiological thought (Moyano, 1957).

3.3.1. Jakob's views

Gnoses and praxes, as neurodynamic processes, represent a component of Jakob's evolutionary theory. Within such a framework, gnoses play a key role as the preparatory acts, and praxes as the productive acts, of all psychogenetic processes (Jakob, 1941a). According to Jakob, psychogenesis (<Gk. ψυχή=soul and γένεσις=origin) refers to a structuralistic developmental process taking place in the human cortex and leading to the formation of abstract thought (Jakob, 1941a).

Such a neurodynamic phylogenetic postulate was put forth by Jakob in his article under the title 'The Phylogeny of the Organization and the Evolutionary Dynamics of the Kineses' (Jakob, 1935a; Théodoridou & Triarhou, 2011b). Jakob continued to update his theory throughout his career until 1946 (cf. Jakob, 1946a, 1946b). Viewing psychogenesis from a phylogenetic perspective (Fig. 11), Jakob (1923) suggested that its evolution occurs in two phases, the plasmodynamic and the neurodynamic.

The first or 'plasmodynamic' phase (plasmopsychisms) entails elementary biological phenomena such as tropism, taxism and pulsatility. The second or 'neurodynamic' phase (phylopsychims or neuropsychisms) is divided into three biophylactic stages: the archikinetic, the paleokinetic and the neokinetic.

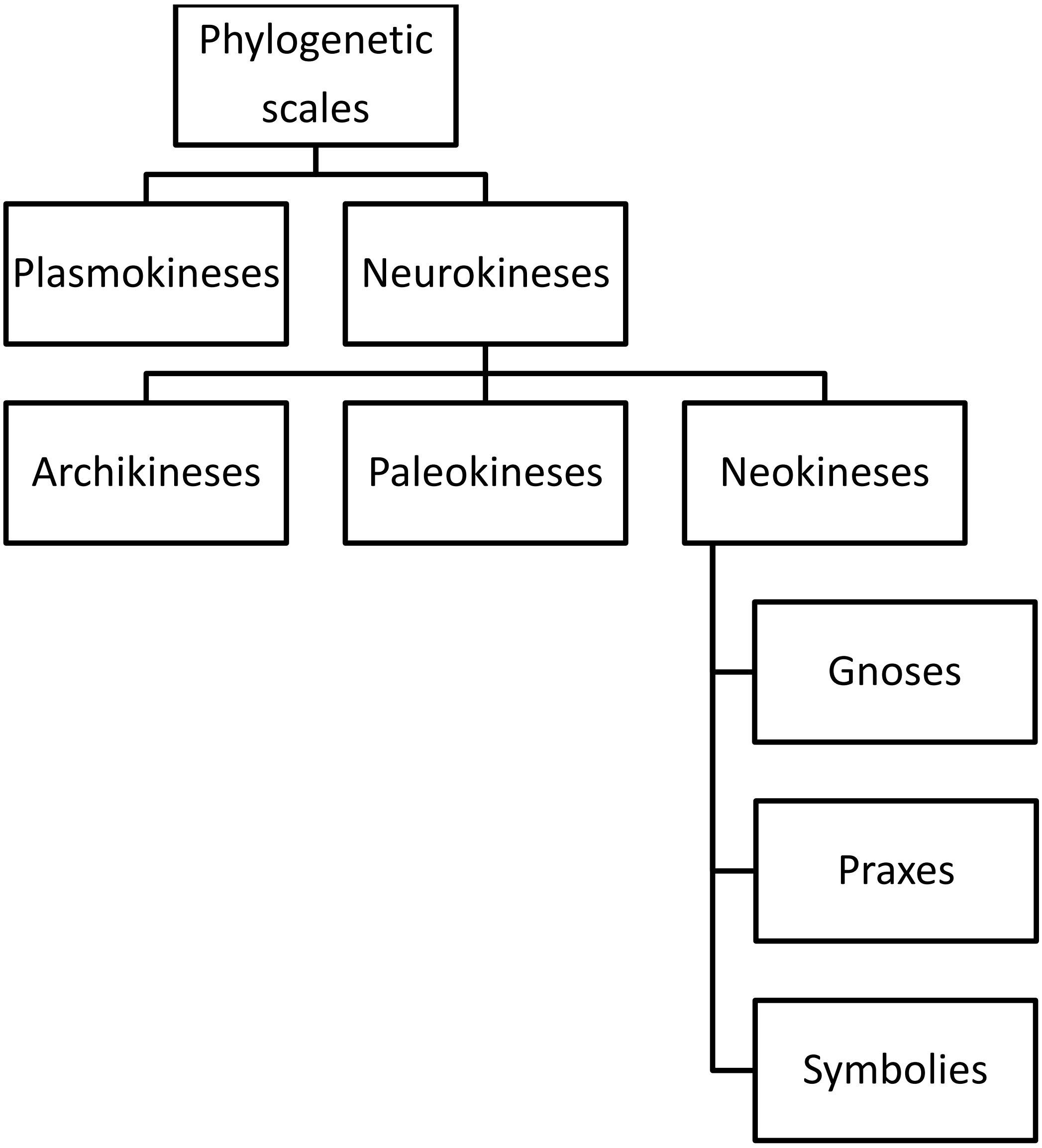


Figure 11

According to Jakob's evolutionary postulate, archikineses represent hereditary reflex actions of psychism, paleokineses correspond to instinctive reactions, and neokineses – which represent the phylogenetically most recent type of the kineses – form the core of human consciousness.

The psychisms are diffused among living organisms in varying combination: in plants, protozoa and sponges we encounter only *plasmopsychisms*; in metazoa with ganglionic nervous systems through the inferior vertebrates we can find both *plasmopsychisms* and *neuropsychisms*; elemental functions of *ontopsychisms* might be encountered in insects that have a cerebral ganglion and fishes that have mesencephalon; in amphibians through the higher vertebrates, including humans, all three categories exist in a combined manner, though ontopsychisms dominate (Jakob, 1923; Triarhou, 2009).

The three biophylactic stages of the neurodynamic phase correspond to different levels of organization in the vertebrate CNS: the 'archikinetic' stage corresponds to the archineuronal level; the 'paleokinetic' stage corresponds to the paleoneuronal level; and the 'neokinetic' stage corresponds to the neoneuronal level (Jakob, 1935a). Within the neurodynamic phase emerges the potential of the *ontopsychic dynamism*, which in humans has culminated into the symbolic psychisms (intellect, aesthetics and ethics), maintaining though the qualities of the more elemental levels (Triarhou, 2009).

The phylogenetically older, archikinetic stage entails reflex actions similar to the invertebrates and it comprises simple visceral and somatic reflex arcs. Archikinetic time responses are estimated to 20–30 msec (Jakob, 1941b). The paleokinetic stage is characterized by the appearance of instinctive reactions. Within this stage emerges the chronotropic ability (Jakob, 1923, 1935a). The neokinetic stage is responsible for the elaboration of conscious responses, in other words it underpins 'neopsychism'. Neokinetic time responses are estimated to 200–300 msec; the major distance can be established through a central or volitional neokinetic transformation in a reaction time of 110–120 msec ('the fourth dimension of thought') (Jakob, 1941b). Neopsychism consists of two sectors, the endogenous that lies in the limbic cortex ('introyente' in Jakob's terminology) and the external that lies in the lateral cortex ('ambiente' in Jakob's terminology).

Three kinds of neurocognitive processes are elaborated in the neopsychic stage: (a) *gnoses*, which secure the conscious orientation in one's environment; (b) *praxes*, which underlie active individual intervention; and (c) *symbolisms*, which subserve the communication of abstract ideas by means of human language.

Jakob (1919, 1921) studied gnoses and praxes as well as their pathological correlates, i.e. agnosias and apraxias, both clinically and anatomically in order to shed light on the cortical dynamics from a structural, functional and evolutionary viewpoint (Théodoridou & Triarhou, 2011c).

Jakob (1919, 1921) argued that among the numerous problems that occupy modern physiology the most important, complex and at the same time interesting is that of the cerebral cortical dynamics and their relation to the mental faculties. For such a reason, he considered that a scientific concept on the psychophysiological conditions of cortical functions is equally necessary in psychology and physiology, as well as in the neuropsychiatric clinic.

According to Jakob (1919, 1921), one may see how psychological concepts gradually disappear, and become replaced with clinical-physiological, and finally biological terms, thus, gradually turning from theoretical and fictitious into more natural concepts, capable of being subsequently subjected to a critical scientific study. The clinic brought useful concepts to psychophysiolology such as the pathological phenomena described as agnosias and apraxias, such as astereognosis or stereoagnosia that appears in certain cases of injuries to the parietal lobe and has been already known for a long time through the work of Wernicke, Déjerine, Horsley, Starr, and others. The clinical-anatomical analysis of such cases has shed new light on normal cortical dynamics.

Astereognosis or *stereoagnosia* is described by Jakob (1921) as an inability of the patient to recognize only by tact and grasp, objects that are given to him to hold, despite the fact that his tactile sensitivity is not substantially altered. The patient feels that he takes something in his hand, but he cannot remember with his eyes closed if this object is long, short, round, smooth, etc. Visual, auditory, olfactory, gustative agnosias, etc. have been described in an analogous form. In such cases, the respective sense is not abolished, though injured. Thus, it is impossible for the patient to integrate the sensory information – that someone normally gets by a certain number of isolated perceptions of distance, color, forms, intensity, etc., – which characterizes an object that has seen, heard, tasted, etc. Through this integration the person normally arrives at a state of 'apperceptive condensation and associative correlation' for the analogous impressions that eventually allows the construction of 'the notion of the object', namely its complete gnosis.

To Jakob (1921), it is evident that agnosias result from injuries of complex cortical dynamics of momentary perceptions with previously fixed associations. Thus, gnosis, that is the normal process, consists in the synthetic condensation of a previous experience with an analogous current situation. In brief, it results from an intricate game of sequential cortical elaborations.

Tactile (haptognoses), thermal, tactile-muscular (stereognoses), visual, auditory, olfactory gnoses, etc. work then with isolated, experienced, correlated and repeated senses. They distribute and organize them in order as the securing of orientation in space and time demand it. Therefore, they stabilize one's experience of the external environment. The gnosic dynamics rest fundamentally on the similarity of the analogous sensory-affective reactions. Similar percipient situations produce equal central reactions regarding the corresponding location, association and attention. Thus, they raise essentially equal affective states. Gnosis, then, is elaborated on the basis of the parallelism of outer and inner experiences through the matching of an identical perceptive situation with an analogous affective tone. The intensity of the affection, i.e. the interest or attention, during the elaboration of a gnosis of a new object loses gradually its initial tension and finally maintains a much reduced value in numerous gnosic acts that are then called automatic. Still, attention can always return to its initial value.

Gnosic (or cognitive) processes are not naturally the result of a special cortical power of gnosis. Jakob (1921) thought that such an assumption would bring us back to the old error, i.e. the theory of projection and association centers where memory, consciousness, will and intellect were considered as substantiated powers. On the contrary, it is only modalities here that accompany all cortical neurobiological processes to a greater or smaller intensity and extent. According to Jakob, the gnosic mechanism, like all nervous processes, is made up of a trilogy of elements: receptors, assimilators and combined effectors. Their receptive factors represent all sensory systems which, directed by the posterior half of the basal and dorsal thalamus, radiate towards the posterior half of the hemispheres. Thus, they include the entire cortex behind the central sulcus of Rolando: parietal, temporal and occipital (thalamo-parietal, temporal and occipital radiations). Their assimilator elements are formed by short and long inter- and intra-cortical pathways, and the association of these regions. Their effector elements represent the motor apparatus of attention, which, from auditory, visual, olfactory, tactile centers etc., stimulates the movements of attention of the ear and its accessory apparatus, of the eyes and their motor apparatus, of the nose and the related respiratory movements; for the tactile and muscular regions the effector apparatus represents the same pyramidal tract with its motor impulse on the limbs and body. The exact boundaries among different cortical gnosic centers consisted for Jakob a question for future study.

The fundamental fact for Jakob (1921) is that all parieto-occipito-temporal cortical zones contribute in the elaboration of gnoses both in animals and in humans. Thus, though we can crystallize the localization of the gnoses as represented in the posterior half of the cerebral hemispheres, gnosis consists in the elaboration and condensation of sensory-motor acts, and not only sensory, as the old theory of the ‘association and projection centers’ claimed.

Specifically and in a detailed manner, Jakob (1921) distinguished different gnoses with different corresponding localizations, as follows: labial, lingual, digital etc. tactile-gnoses localized in the posterior central gyrus; thermo-gnoses localized in the superior parietal gyrus; oral, manual, ocular etc. stereo-gnoses localized in the supramarginal and angular gyri; visual-gnoses of form, color, perspective etc. localized in the entire occipital lobe and the angular gyrus; auditory-gnoses of noises, sounds, rhythm, melodies etc. localized in the posterior two-thirds of the temporal lobe; olfactory-gnoses localized in the hippocampus; and gustatory-gnoses, possibly localized in the temporal pole. In sympathetic areas (cingulate gyrus) he localized processes for visceral-gnoses etc. (condition of the bladder, of the stomach, endo-gnoses) (Fig. 12).

In such a way, Jakob suggested that all these regions are unlashed into projection and association areas simultaneously. This fact absolutely diminishes the possibility of localizing perceptive and associative process, which combined characterize gnosis, into different zones for each function.

To give Jakob’s example, when we have acquired the gnosis of a pencil, the momentary visual perception of a pencil evokes the acquired partial gnoses of form, color, surface, weight, hardness etc. The cortical constitutive elements reside in the nuclear complexes of visuoretinal, visuomotor, tactile-motor etc. centers, connected to each other in the certain combination that has been elaborated during childhood, the gnosic notion of the pencil. Then, we do not need special mnemonic centers, because what distinguishes the mnemonic image and the immediate sensory perception is only the degree of affective tension, lower in the former case and greater in the latter. Nevertheless, they are the same elements combined in the same form that with their dynamics produce the image or the sensation.

Jakob (1921) claimed that this can be proven experimentally in animals and in humans, when partial resections of cortical segments only lead to transient gnosic alterations. This means that the neighboring zones, according to the old 'associative theory', gradually compensate for the defect. That would be impossible *a priori*; they would only have the ability to receive and store gnosic functions in equal form, exactly like the area previously destined to carry out such work.

In an analogous form, the study of the apraxias has contributed to our understanding of cortical function, Jakob (1921) argued. Apraxia consists in the oblivion of an act or a series of necessary acts, previously learned, to make an intentional movement without a real paralysis of the respective muscle. Thus, an apraxic does not know how to take the pencil or to smoke etc., because he has forgotten the series of the necessary movements, coordinated to this end.

The complete analogy with the concept of gnosis can be immediately observed: the background of memory defects, objects or qualities, movements or their coordination. Like in the gnoses, different forms of apraxias can be distinguished, e.g. manual, digital, oral, labial, limb, etc. There is always a certain sequence of associated movements that the patient has forgotten. To apraxias belongs frontal ataxia, i.e. an inability to maintain balance in cases of changes in the superior frontal gyrus (frontal astasia-abasia without paralysis).

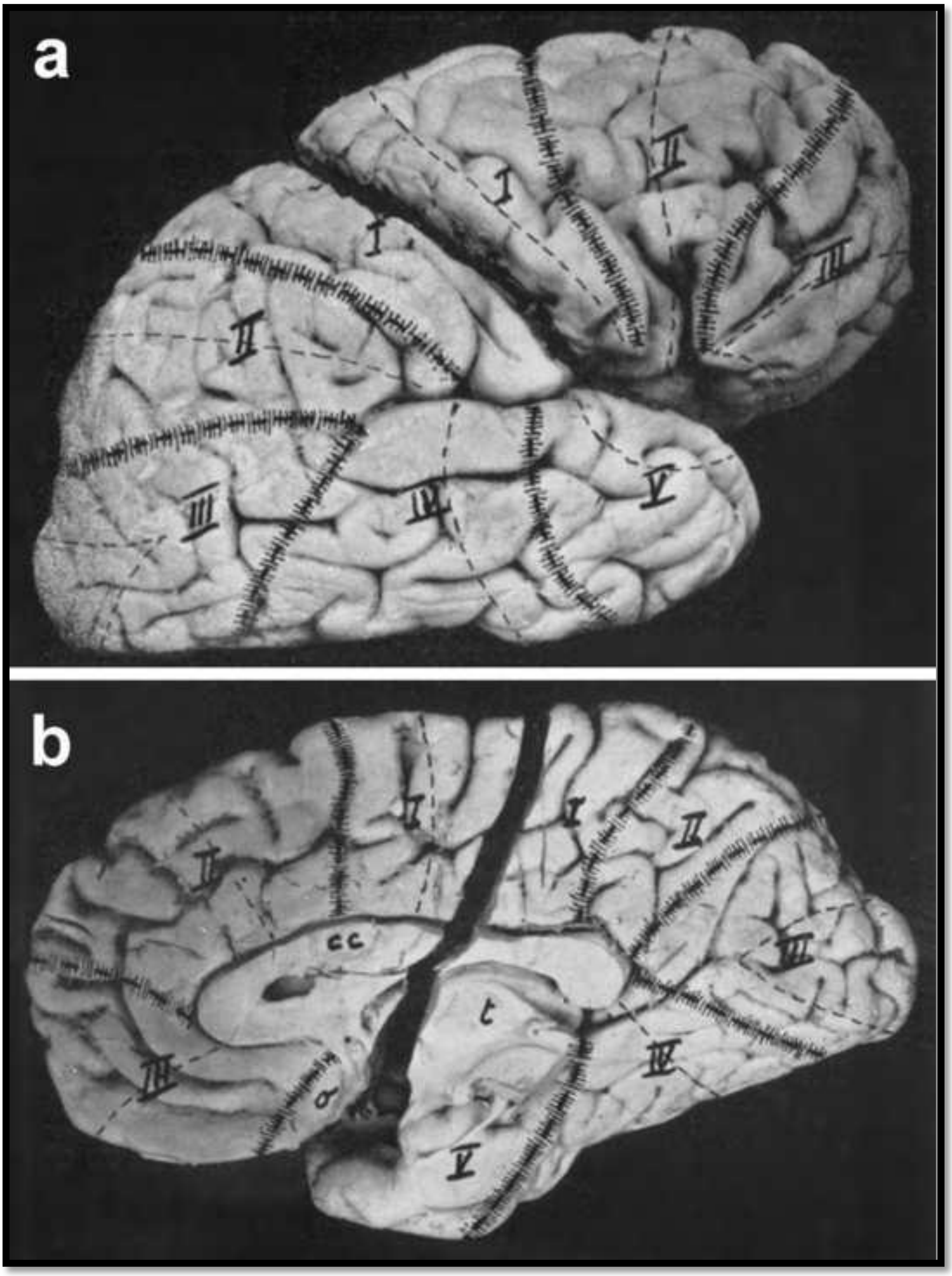


Figure 12

'Golden section' of the human cerebral hemisphere (frontal praxic sectors I, II, III; gnosic sectors I, II, III, IV, V) according to Jakob (1943b, p. 37). Lateral (a) and midsagittal (b) views. Reprinted from Théodoridou & Triarhou (2011c).

Furthermore, the motor aphasia of Broca type following injury of the inferior frontal gyrus, whereby the patient, without having paralysis of his articulator apparatus, does not find the necessary movements to produce the previously well-known word. The case of agraphia seems to belong to the apraxias as well.

As far as the corresponding normal function is concerned, Jakob (1921) named as praxis the cortical process that associates in different combination the series of motor acts that have been developed during the long learning process in infancy and childhood, to guarantee a determined movement of the limbs, the tongue, the lip, and the trunk or the entire body. Thus, praxes are walking, jumping and dancing regarding the lower limbs (localization in the superior frontal gyrus); the use of the fork and knife, writing, and every technical-manual work etc. for the hands (superior and mainly middle frontal gyrus); mastication, imitation, language, singing and whistling for the mouth and tongue (middle frontal gyrus).

The mechanism of praxis is formed by the apparatus of three systems, receptors, assimilators and effectors, just like the mechanism of gnoses. Its receiving systems formed by indirect pathways of cutaneous sense muscle (kinesthetic) crossing the cerebellum project via the red nucleus to the anterior thalamus; from there, the anterior, frontal and central radiations of the thalamus penetrate towards the cortical areas in front of the central sulcus of Rolando. It is virtually undoubted that it is the whole anterior half of the cerebral hemispheres, that is the anterior Rolandic and the entire frontal lobe with its related associative systems, the seat of the elaboration of praxes.

Their effector pathways are represented by the fronto-hypothalamic and pontine systems on the one hand, destined to strengthen the muscular coordination en bloc.

Especially the pyramidal and the operculo-bulbar tract serve as effector systems as well. These turn out to be at the disposition of the two great cortical powers: gnoses and praxes become mainly discharged by means of the pyramidal tract. From this fact results the great importance of such motor pathways among other secondary pathways.

Jakob (1921) argued that praxes also become gradually automatic. The affective tone that initially accompanies and stimulates their acquisition finally occurs with a lesser effort. Thus, the gnosic and praxic cortical automatism cannot be explained, as it has been claimed by physiology and psychology [the famous polygon of Grasset (1912) shown in Fig.13], through a mechanism of special location, but through dynamics different from its constitutive elements.

Jakob (1921) believed that with the theory of the gnoses and the praxes, clinical neurological studies have found a new potential in analyzing pathological, nervous and psychological phenomena. The complete mental process results from the assimilating, energetic gnosic-praxic condensation. Gnoses and praxes are then neither sensory nor motor, but concomitantly sensory-motor processes, a view that falls within Jakob's dynamic approach that has been described above (pp. 44–47). Their a priori connection with the functions of the pyramidal tract give us the possibility of satisfactorily explaining the passage of gnosis and praxis to the definitive voluntary movement; a passage that the old physiology, and psychology to a lesser extent, had never been able to explain (Jakob, 1921).

Jakob argued that mental functions cannot have localizations determined in such-and-such associative areas of the first or third order, as he had already shown in his evolutionary postulate (Jakob, 1912a, 1912b). Rather, their characteristics reside in the transcortical dynamics that reunite isolated sensory-motor acts.

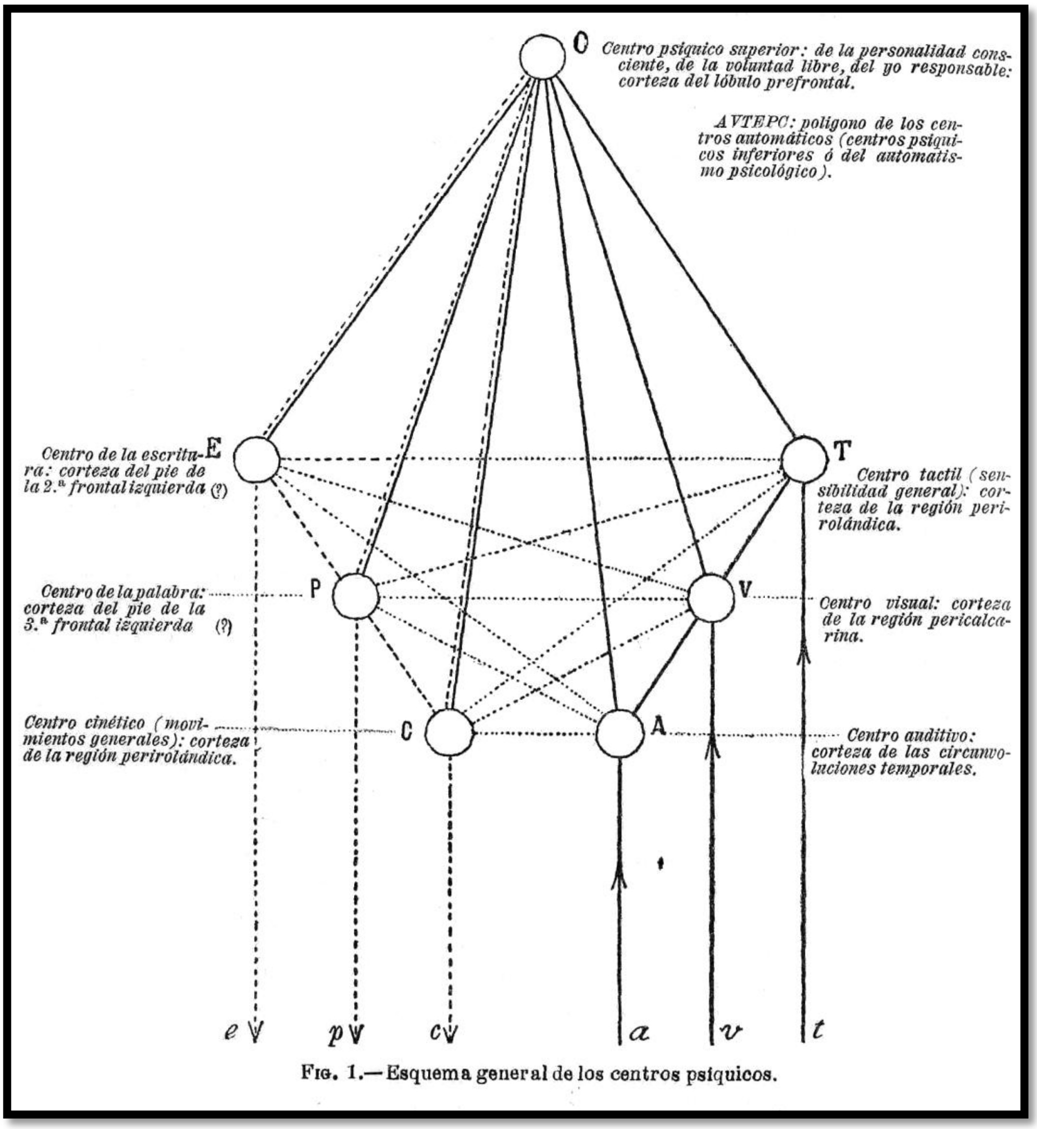


Figure 13

General scheme of the higher anatomical centers (inferior and superior ‘psychical’ centers) according to Grasset (1912, p. 68). Abbreviations: O, superior psychical center of conscious personality, free will and responsible ego (prefrontal cortex); AVTEPC, polygon of automatic centers (inferior psychical centers) or of psychological automatism; A, auditory center (cortex of temporal gyri); V, visual center (cortex of pericalcarine region); T, tactile center or general sensitivity (cortex of perirolandic region); C, kinetic center or general movements (cortex of perirolandic region); P, language center (cortex of foot of left inferior frontal gyrus); E, writing center (cortex of foot of left middle frontal gyrus). Reprinted from Théodoridou & Triarhou (2011c).

Therefore, the only and true localizable elements of the process are physiological and exist primarily in gnoses and praxes; they then create the psychic phenomenon, through the integrative fusion of both dynamics. The intervention of language and its explanation by identical gnosic and praxic processes completes the objective and abstract mental elaboration.

Regarding the phylogeny of praxic gnosic centers Jakob (1921) held that gnosic centers are much older, and presently exist in all animal species with cerebral cortical matter. On the contrary, praxic cortical dynamics developed much later and appear more extended in higher mammals and especially primates. This in turn means that the intensity of mental elaboration rests essentially with the praxic components that complete the gnosic cortical product.

Such a clue, Jakob (1921) claimed, teaches us about human psychology in an incomparable way that productive (praxic) mentality predominates over the merely representative (gnosic) mentality.

3.3.2. Discussion

Advances in aphasiology made during the second half of the 19th century onwards enabled the research on cortical localization of mental functions. Concomitantly, the description and study of several types of agnosias and apraxias have equally contributed to that end.

The term ‘agnosia’ was introduced by Sigmund Freud (1856–1939) in his monograph ‘On Aphasia’ (1891) to denote functional disturbances between the concept of an object and the concept of the word corresponding to it (Macmillan, 2004; Goldberg 2005). The first use of the term ‘apraxia’ is generally attributed to the German psychiatrist Hugo Karl Liepmann (1863–1925) (Devinsky & D’Esposito, 2004; Etcharry-Bouyx & Ceccaldi, 2007); in his classical paper 'Das Krankheitschild der Apraxie', Liepmann (1900) defined motor apraxia and distinguished it from agnosia and sensory apraxia (Théodoridou & Triarhou, 2011c). It is also written (Cockburn, 2008; Liepmann et al., 1988) that the term was coined much earlier, in 1871, by Heymann Steinthal (1823–1899), who used it in the same sense as Liepmann.

Thus, the idea of studying pathological conditions in order to shed light on normal brain functioning was not new when Jakob (1921) worked on the agnosias and the apraxias. His ingenuity rests on the adoption of combined approaches, which allowed him to formulate an integrated theory of cortical dynamics (Théodoridou & Triarhou, 2011c).

From an evolutionary perspective, Jakob conveyed the idea, still valid today, that productive mentality derives from the frontal lobes. In contemporary terms, *"Homo sapiens, knowing man, is issued from Homo habilis, handy man"* (de Duve, 2002, p. 192). Jakob pointed out that this brain region evolved and expanded in a unique way in primates. He wrote (Jakob, 1943c, p. 89) that *"The great development of the frontal lobes is typical of the brain of primates and in no way an exclusively human characteristic"*. Jakob's extensive studies on human and animal brains (over 100 species of the Patagonian fauna) helped him suggest a theory of cortical phylogeny (Jakob, 1912a, 1912b; Triarhou, 2010). The fact that humans and great apes share a large frontal cortex is bolstered by contemporary research. The possibility of a parallel functional reorganization of this region may account for the special cognitive abilities that distinguish those species from others (Semendeferi et al., 2002). The evolutionarily older gnosic centers are thought to reside in the postcentral 'microdynamics' (Capizzano, 2006).

As far as the ontogeny of gnoses and praxes is concerned, Jakob placed their development in infancy and childhood. One herein encounters a striking similarity between Piagetian and 'Jakobian' concepts. The term 'assimilation' was introduced by Jean Piaget (1896–1980) to describe *"structuring through incorporation of external reality into forms due to the subject's activity"* (Piaget, 1952, p. 6). Nonetheless, an early use of the term appears in the present article, being subsequently refined by Jakob (1935a, 1945a, 1945b), to imply the process of changing of qualities, modalities and relations through which the individual incorporates the external and internal world of objects, processes and situations.

With regard to localization theory, Jakob defended the existence of Broca's area from an anatomical-clinical standpoint (Jakob, 1906g; Tsapkini, et al., 2008). In the 1921 paper, he argued that every gnosic and praxic mechanism comprises localizable elements, such as receptors, assimilators and effectors. On the other hand, Jakob considered the strict localization of mental function or dysfunction as misleading. By attributing apraxias to the disturbance of transcortical dynamics, Jakob highlighted the role of cortical communication. He paralleled neurocognitive functions to electrical current where it is only possible to localize the source (Jakob, 1941a). Wernicke opposed the localization of higher functions to specific regions as well, stressing the importance of association areas (Catani & ffytche, 2005) and claimed that apraxia results from the separation of brain regions (Finger, 1994). Wernicke's line of thought influenced Heinrich Lissauer (1861–1891), assistant in the Breslau Psychiatric Clinic (Shallice & Jackson, 1988). Lissauer (1890; Lissauer, & Jackson, 1988) subdivided visual agnosia into two subtypes, 'apperceptive' and 'associative'. Such a distinction is considered to be the most influential in the history of research in agnosia (Shallice & Jackson, 1988). Apperceptive agnosia is accompanied by impaired object recognition due to deficits in perceptual processing, whereas in association agnosia the primary deficit lies in difficulties in accessing the relevant knowledge about objects from memory (Eysenck, 2004). Jakob seems to converge to Lissauer's work when he refers to a dual premise for the construction of a complete gnosis: 'apperceptive condensation and mnemonic correlation' (Théodoridou & Triarhou, 2011c). Associationist models produced disconnectionist accounts of disorders of higher functions. Liepmann's apraxia model and Déjerine's pure alexia description fall into this tradition, which was revived with Geschwind's neo-associationism. Geschwind (1965a, 1965b) attributed higher function deficits to disconnections that result either from white matter lesions or lesions of association areas, whereas, more recently, Catani and ffytche (2005) updated that model into a hodotopic framework.

Jakob recorded in detail the various types of gnoses, including tactile, thermal, tactile-muscular (stereognoses), visual, auditory and olfactory, each one being further classified into subtypes. For example, labial, lingual and digital gnoses fall into the category of tactile gnoses. Accordingly, Jakob held the view that gnosic processes are accompanied by modalities, a concept not too far from the modern interpretation of the pathological condition of agnosia, which is considered a modality-specific inability to access semantic knowledge of an object or any other stimulus which cannot be attributed to an impairment of basic perceptual processes (Greene, 2005).

Jakob (1921) argued that 'gnoses and praxes are neither sensory nor motor, but concomitantly sensory-motor processes'. In his renowned work 'Matter and Memory' (1896), the French philosopher Henri Bergson (1859–1941) argued that it is impossible to define where perception ends and movement begins (Blumen & Blumen, 2002). Similarly, the idea of *"occasionally fluid boundaries"* between agnosia and apraxia has been developed by several authors (c.f., Liepmann, Lange, Pötzl, & Brown, 1988, p. 176). Contemporary researchers seem to agree with this view; for example, limb apraxias are considered higher-order disorders of sensory-motor integration (Leiguarda & Mardsen, 2000). Since apraxia is viewed as a type of motor agnosia, Jakob (1921) aptly notes that it is impossible for the patient to integrate sensory information.

An interesting point of Jakob's work concerns the localization of sensory and associative functions in relation to cortical plasticity (Théodoridou & Triarhou, 2011c). Jakob clearly rejected the separation of the cerebral cortex into independent projection and association areas (Triarhou & del Cerro, 2006a). Specifically, he claimed that there are no special associative centers apart from sensory areas, where a stimulus is both perceived and revived, thus arguing against Cajal's theoretical views on higher mental functions – which seem to have been largely overlooked (Azmitia, 2007) – namely, a three-order system of neural networks that subserve associative functions.

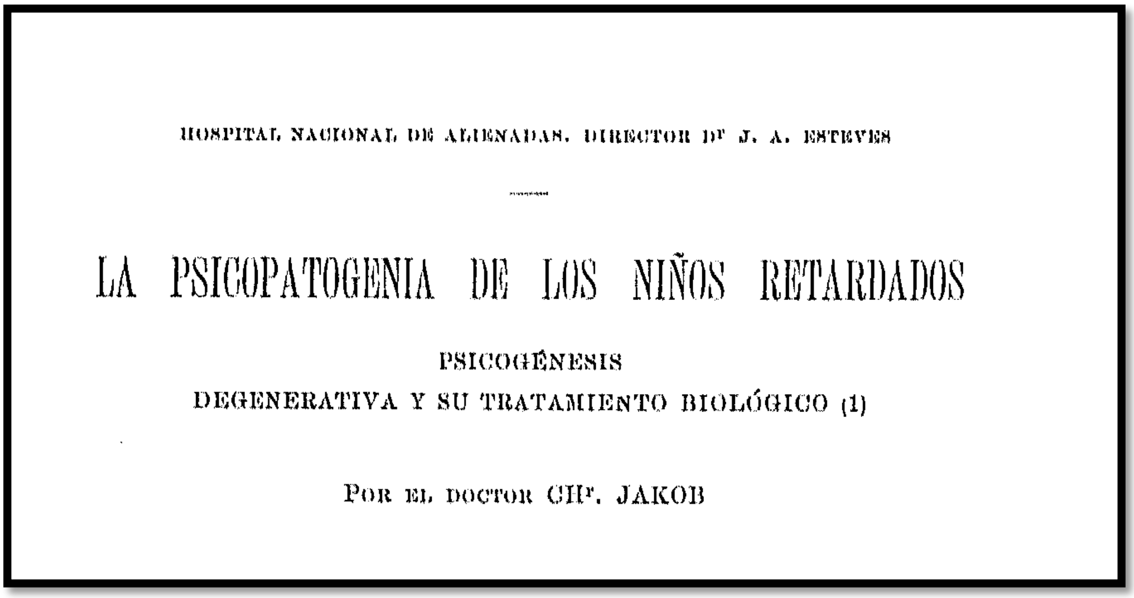
Based on his own assumption, Jakob (1921) explained the compensatory functions of the cerebral cortex by arguing that a functional take-over is only possible whenever brain regions show a certain equipotentiality as far as the elaboration of modality-specific stimuli is concerned (Théodoridou & Triarhou, 2011c). Experimental data compiled after the advent of sophisticated imaging methods lend credence to Jakob's reasoning: for example, contemporary authors (c.f., Grafman, 2000) attribute primary and secondary functional assignments to cortical regions; secondary functional assignments are inhibited until the normally responsible area suffers a damage that renders necessary the activation of the backup region. Neuroimaging techniques further shed light to cases of cross-modal plasticity (Fujii, Tanabe, Kochiyama, & Sadato, 2009; Sadato, 2005). In view of those considerations, one may understand how Jakob's pioneering theorizing ability counterbalanced the technical limitations of his time (Théodoridou & Triarhou, 2011c).

Scientists today highlight the importance of the study of praxis in relation to the (a) localization of function, (b) hemispheric potential for praxis and (c) ability of the brain to compensate for injury (Goldmann-Gross & Grossman, 2008). Jakob tried to shed light into these problems and to further formulate an integrative theory of gnosio-praxic systems' function (Théodoridou & Triarhou, 2011c). Some of his views may have points in common with Wernicke and Lissauer; one important difference is the multi-level approach of Jakob, involving anatomo-functional and evolutionary-developmental considerations.

Influenced by computer science, modern theories use the metaphor of cognition as a dynamic system sustained on spatiotemporal topology (Ibañez & Cosmelli, 2008). Wiener's (1948) critical work in cybernetics opened up new vistas (François, 1999). Francisco Varela, a herald of modern brain dynamics and cybernetics, argued against 'brain-bound neural events' that constitute the mind (Rudrauf, Lutz, Cosmelli, Lachaux, & Le Van Quyen, 2003); he supported the view that *"consciousness depends crucially on the manner in which brain dynamics are embedded in the somatic and environmental context of an animal's life"* (Thompson & Varela, 2001, p. 425). Such trends are not far from Jakob's views: López Pasquali (1965) emphasizes the fact that certain aspects of Jakob's work seem to anticipate cybernetics. The relationship between Jakob's ideas and cybernetics is discussed in depth elsewhere (see pp. 54–55, 84, 93–94, 109).

3.4. Degenerative psychogenesis and its biological treatment

With the firm belief that the cognitive and socio-emotional development goes hand in hand with cerebral development in a course that he named ‘psychogenesis’ (Jakob, 1913c), Jakob viewed mental retardation as the result of a degenerative process that demands a biological treatment (Fig. 14). Such a treatment would be based on the establishment of principles for a biological classification. He criticized the existing classifications for being insufficient and ineffective for psychological as well as educational interventions.



HOSPITAL NACIONAL DE ALIENADAS. DIRECTOR Dr J. A. ESTEVES

LA PSICOPATOGENIA DE LOS NIÑOS RETARDADOS

PSICOGÉNESIS
DEGENERATIVA Y SU TRATAMIENTO BIOLÓGICO (1)

POR EL DOCTOR CHr. JAKOB

Figure 14

Frontispiece of the 1913 article published in the ‘Revista de la Asociación Medica Argentina’.

3.4.1. Jakob’s views

Jakob (1913c) attributed major importance to the elucidation of the internal and external causes of the inhibition of the normal cognitive development and their complex effects on the cerebral development. Such knowledge would enable the constraint of the extension and the intensity of the factors that harness the learning powers of the brain. Thus, Jakob (1913c) has looked for a classification with practical, functional value arguing that the outcome of a disorder is an energetic and dynamic condition defined by various components.

On these grounds, Jakob (1913c) divided the normal cognitive and socio-emotional development into the following psychogenetic stages:

1. Psychobiomolecular period, that is characterized by the irritability of the protoplasm;
2. Psychoneuromolecular period, when the elementary nervous organization is not differentiated though there is nervous irritability;
3. Elementary psychoreflexive period, that is signaled by the differentiation of the reflex, the gangionary, the spinal and the bulbar systems;
4. Complex psychoreflexive period, when the successive maturation of the instincts, impulses and subcortical arcs is realized along with the differentiation of afferent and efferent arcs;
5. Crepuscular period, when the reflexes and functions such as respiration, sucking, some movements and mimicking dominate as primary, diffuse, and preconscious cortical perceptions;
6. Period of provisory psychological fixations:
    a. Period of elementary temporary fixations, when the superior instincts, affections, active mimicking and combined voluntary perceptions and actions first appear.
    b. Period of complex temporary fixations, when elements of articulate language, concrete ideas, orientation in the environment in terms of space and time as well as affective and voluntary actions emerge.
7. Period of definitive psychoenergetic associations:

a. Period of permanent concrete associations, when an egocentric realism, the formation of personality, actions of affective inhibition, elementary consciousness as well as the perception of time, space and causality are observed.
b. Period of elementary abstract associations, when the conscious personality is formed with elements of self-critisism and egoism; judgment and reasoning and acts of intellectual inhibition are also evident in this period of infantile analytic empiricism.

8. Puberty, when the synthesis of ideas is possible and aesthetic and ethic tendencies are evident; and finally
9. Second puberty, when thought becomes rational and speculative.

Apart from the biological characteristics, Jakob (1913c) further provided the psychological profile that corresponds to each stage. He maintained that 'degenerative psychogenesis' runs through the same stages as normal psychogenesis. Subsequently, he made suggestions for suitable interventions according to the stage that the child with disabilities falls within. At this point, the discussion of the concept of 'patopedagogía' in times when special and remedial education had not been formally introduced is worth mentioning.

3.4.2. Discussion

The demand for a neuroscience-informed special education (cf. Goswami, 2004) has only recently ensued from the unification of the mind, brain and education sciences under the modern attempts defined as neuroeducation (cf. Battro, Fisher & Léna, 2008) and educational neuroscience (Petitto & Dunbar, 2004; Szüks & Goswami, 2007). Some of the earliest systematic attempts at opening up paths for the application of neurobiological findings to education can be traced to the works of the neurologist Henry Herbert Donaldson (1857–1938) and the educator Reuben Post Halleck (1859–1936), as reviewed by Théodoridou & Triarhou (2009). In the past 15 years progress has taken place in neuroeducation since Battro and Cardinali (1996) introduced the term (Théodoridou & Triarhou, 2009). Diverse disciplines that investigate human learning and development have been integrated, bringing together education, biology, and cognitive science years (Fischer, Daniel, Immordino-Yang, Stern, Battro, & Koizumi 2007). Additional terms used by authors in conjunction with this new branch of knowledge include 'neurolearning' (cf. Petitto & Dunbar, 2004), 'nurturing the brain' (Ito, 2004), 'developing the brain' (Koizumi, 2004), and 'pedagogical neuroscience' (Fawcett & Nicolson, 2007).

Learning and education can be viewed as a new field of the natural sciences with the entire human life span as its subject, including various problems such as the fetal environment, childcare, language acquisition, general and special education as well as rehabilitation (Koizumi, 2004). In this line of thought, Ito (2004) suggested that research should aim at providing new knowledge about the pathogenesis of the developmental disorders on the solid basis of neuroscience. Such new knowledge should aid in the appropriate assessment and treatment of patients on the basis of accurate identification of individual-specific deficiencies and of environmental factors that may be preventing these children from behaving appropriately. Therefore, it would be helpful in solving problems arising from the antisocial behavior of the students. Further advantages of the adoption of a biological perspective would include the early diagnosis of special educational needs; the monitoring and comparison of the effects of different kinds of educational input on learning; and an increased understanding of individual differences in learning and the best ways to suit input to learner (Goswami, 2004).

Studies based on such a perspective shed light on general and specific learning disabilities, language acquisition and language disorders, mathematical abilities and dyscalculia, normal and atypical socio-emotional development to mention just a few of the most promising areas of research.

3.5. Memory

In Jakob's neurodynamic theory, every system is an arc or circuit composed of long ramifications or afferent and efferent pathways, 'macrodynamics' of charge and discharge and of a center or an inserted formation of increasing complexity comprised by cells and short fibers that constitutes the 'microdynamics' or the 'associative and commissural systems' (López Pasquali, 1965). The first macrodynamic circuit, the reflexes, is only capable of responding in an instant and invariable form. The second macrodynamic circuit, the instincts, preserves the information and it mounts it up through the discharges. In the third macrodynamic circuit, whatever enters and exits gets registered and furthermore there are observed interfocal interactions. Afferent and efferent pathways constitute the macrodynamics of charge and discharge, in other words the projective systems. The microdynamics, intercalary formations with accumulating abilities and associative systems, constitute the neural substrate of memory (Fig. 15).

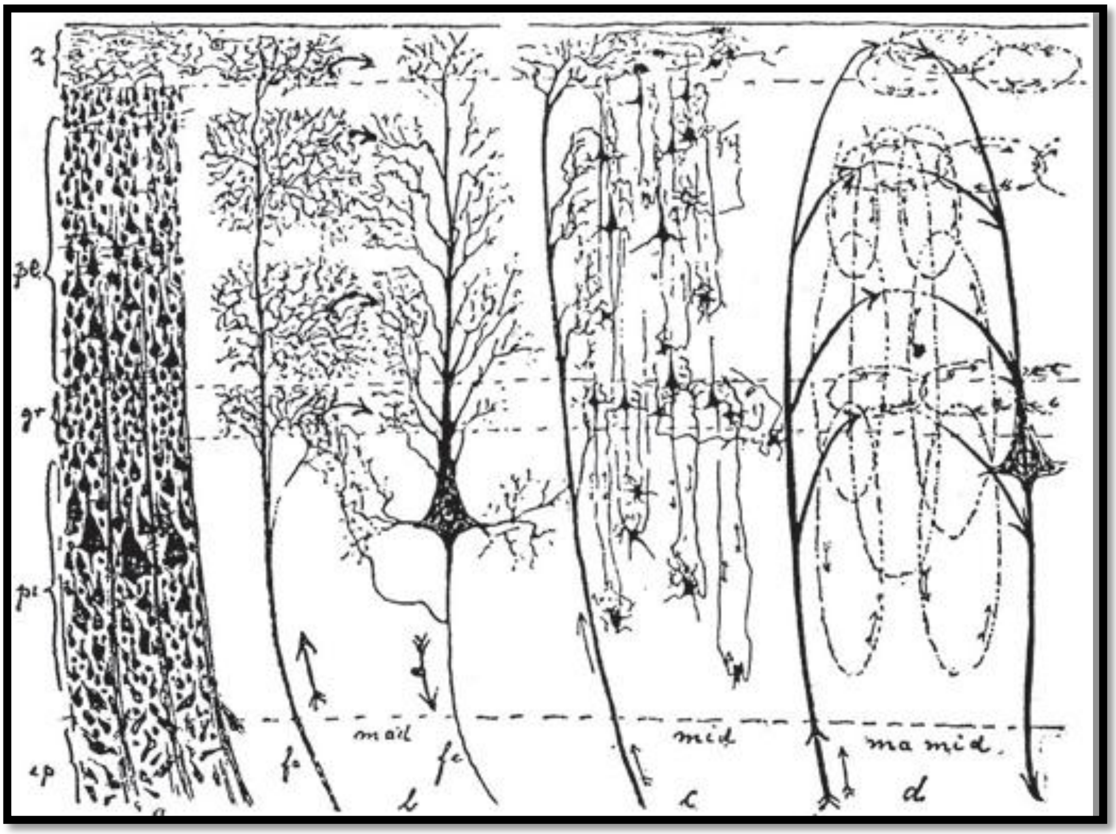


Figure 15

Drawing of the macro- and microdynamics of the human cerebral cortex by Jakob (1945a). Courtesy: National Library of Medicine.

3.5.1. Jakob's views

Considering memory as the indispensable basis for the creation and conservation of all the psychological phenomena, both sensory and motor, Jakob (1935b) attempted to shed light on its biological underpinnings. In doing so, he analyzed the constituents of the problem to end up with five major issues:

a) the epistemology of memory;

b) the biology of memory;

c) the physiology of memory;

d) the psychology of memory; and

e) the pathology of memory.

Jakob (1935b) argued that the existing theories, that are a) the psychological, b) the physical, c) the chemical and, d) the vitalistic, fail to explain how individual freedom issues from the unlimited and creative dynamism of individual memory. He suggested a 'neurobiodynamic' concept based on a) physiological, b) phylogenetic, c) ontogenetic and d) histological arguments.

According to Jakob, memory is the germinative plasma that potentially contains all the future inherited nervous functions of the organism, i.e. the phylopsychisms. However, such an endogenous memory is not enough for the commemorative elaborations. Thus, there exists a vital need for the gathering of exogenous material that obeys in sui-generis rules of organization explaining the variability and the infinity of ontopsychisms.

Jakob argued that the conmemorative elements consist in cortical dynamics of sensory-motor nature, qualitatively similar to a certain perception and its consequences. Given that every receptive act automatically induces an effector response, as Jakob suggested in his dynamic theory (Jakob, 1918), both gnosic, i.e. related to the orientation regarding a perceived situation, and praxic, i.e. related to the execution of a learned motor behavior, recollections are considered to be of a mixed nature.

In his late period, Jakob explained the association of the emergence of conscious processes with the appearance of the organ of consciousness, the cerebral cortex that allows the individual elaboration of the essential condition of memory (Jakob, 1945b). Jakob argued that the first commemorative sector and therefore creator of something conscious is the Ammonic cortex, termed 'paleocortex'. He attributed the commemorative ability of the Ammonic cortex to the fact that it houses two layers of cortical elements, one receiving stimuli (dentate area) and one effector (Ammon's horn), that form reciprocal sets of fixation, residual of elaborated experiences, in line with his theory on the ubiquity of the sensory-motor dual function of the cerebral cortex (Jakob, 1911, 1912a, 1912b).

By arguing that only in the human brain the commemorative cortical superiority enables the elevation of comparative thought to abstract reasoning, Jakob highlighted memory as a basic component and prerequisite for conscious processes. In fact, he claimed that the sense of continuity that is given by memory underpins the emergence of the conscious self. Jakob (1941a, 1946) tackled the development of such processes in his neuropsychogenetic postulate.

Stressing the importance of memory in the emergence of the conscious self, Jakob argued that

> *"it is mnemonic function that raises the cortical apparatus to its creative potential, its influence and dominant hierarchy in the psyche of the individual, liberates it from the ties of reflex law and elaborated instinct; that amplified expectation of action that we call volitional freedom consists of the possibility of anticipating the result of a given situation and selecting among various possibilities the one best suited to the momentary constellation and its individual advantage"* (as cited in Triarhou & del Cerro, 2006b).

3.5.2. Discussion

Jakob's theorizing about memory is evidently influenced by Exner and Monakow (Moyano, 1957). Jakob seems to have conceived ideas that were much ahead of his time; he anticipated the emergence of critical aspects in the incessant attempt to elucidate the neural correlates of consciousness.

For example, the idea that consciousness crucially depends on memory was expressed by Crick and Koch (1990) in their theory of consciousness, where attentional mechanisms render possible the firing of neurons in a coherent semi-oscillatory way, so that a global unity would be imposed on the brain with the subsequent activation of working memory.

Jakob's view of brain as a historical product the evolution of which is dictated by memory is not far from Damasio's proposition on the creation of consciousness (Damasio, 2010). In a framework that connects behavior, mind and brain events, Damasio (2010) places consciousness in a historical setting. Within such a framework, the emergence of consciousness is only possible when knowledge – that has been deposited residing either in memories inside the brain, held in convergence-divergence regions or in memories that have been recorded externally, in the instruments of culture – is categorized, symbolized in varied forms and manipulated by imagination and reason. Thus, the ultimate consequences of consiousness come by way of memory; this is memory acquired through a filter of biological value and animated by reason.

3.6. Recapitulation

In this chapter the middle period of Jakob's work was presented. In this period, Jakob rejected mechanistic concepts and adopted a dynamic approach in explaining cortical function. He kept developing his dynamic ideas from 1918, when he explicitly put them forth for the first time, until his last publications. His psychobiological thought was clearly depicted in his 1919/1921 articles on cerebral cortical dynamics where he highlighted gnoses and praxes as paramount neurocognitive processes in the introduction of his original theory. Having related the emergence and the preservation of such neurodynamic processes with an active exchange between the external environment and the adaptive brain he preceded certain aspects of cybernetics and neurophenomenology.

His writings on memory functions – carrying a remarkable philosophical background (cf. Jakob, 1914) – fall within such a dynamic theorizing, as well. In particular, Jakob's views on the involvement of memory in the emergence of consciousness are attuned with modern theories.

His neurodynamic theories clearly bear an evolutionary mark. The need of an evolutionary perspective in the study of brain and mind – though largely neglected by modern scientists – has been stressed by Damasio (2010). Evolutionary explanations about cognition have been also presented by Gerald Edelman (see, e.g., Edelman, 1989, 2000).

Jakob's perspective is consistent in the entire spectrum of his work. Accordingly, his ideas on developmental disorders contain evolutionary elements. His suggestions on the treatment of such conditions are far ahead of his time, heralding modern views that fall within the scope of the modern field of educational neuroscience.

4. THE LATE PERIOD (1936–1949)

4.1. Opening remarks

In the ‘late’ phase of his life, Jakob’s thought became more synthetic. Jakob’s later years reflect the integration of his thought through the clinical, research and educational experiences, in conjunction with his background in philosophy. Jakob retired in 1945 (Orlando, 1966.). However, he kept his formal appointment in Buenos Aires as Chairman of Pathological Anatomy and continued to work in his laboratory at the National Psychiatric Hospital for Women until 1954; he died in Buenos Aires in 1956 at the age of 90 (Triarhou & del Cerro, 2006a, 2006b). In the late phase of his career Jakob concluded that the utmost problem of science and philosophy converges in cerebral function (Theodoridou & Triarhou, 2012). Thus, he suggested a scientific psychology and a corpus of philosophy (López Pasquali, 1965).

In the following chapter I focus on the last revisions of Jakob’s neurodynamic postulate and its consideration into the clinical framework of Pick disease. The evolution of Jakob’s views on the frontal lobe, that occupied Jakob’s thought in a path of enquiry spanning over five decades, is also presented. Finally, the culmination of his neurophilosophical thought that picked within this period is highlighted. In particular, Jakob’s contributions to the philosophy of neuroscience as well as to the problems that traditional philosophy struggles to solve backed by the arsenal of brain sciences are discussed.

4.2. The revised neurodynamic postulate

Jakob delved once again into the neuropsychogenetic problem in his 1941 article entitled ‘The Psychogenetic Function of the Cerebral Cortex and its Possible

Localization: Aspects of Human Ontopsychogenesis'. He used much of the text in the second part of his 'Biophilosophical Documents' (Fig. 16) under the title 'An Essay on Organic Psychogenesis' (Jakob, 1946a). In his late period he further revised and updated his phylogenetic postulate in the clinical framework of Pick disease (frontotemporal lobar degeneration) (Jakob, 1946b; Théodoridou & Triarhou, 2012a, 2012b).

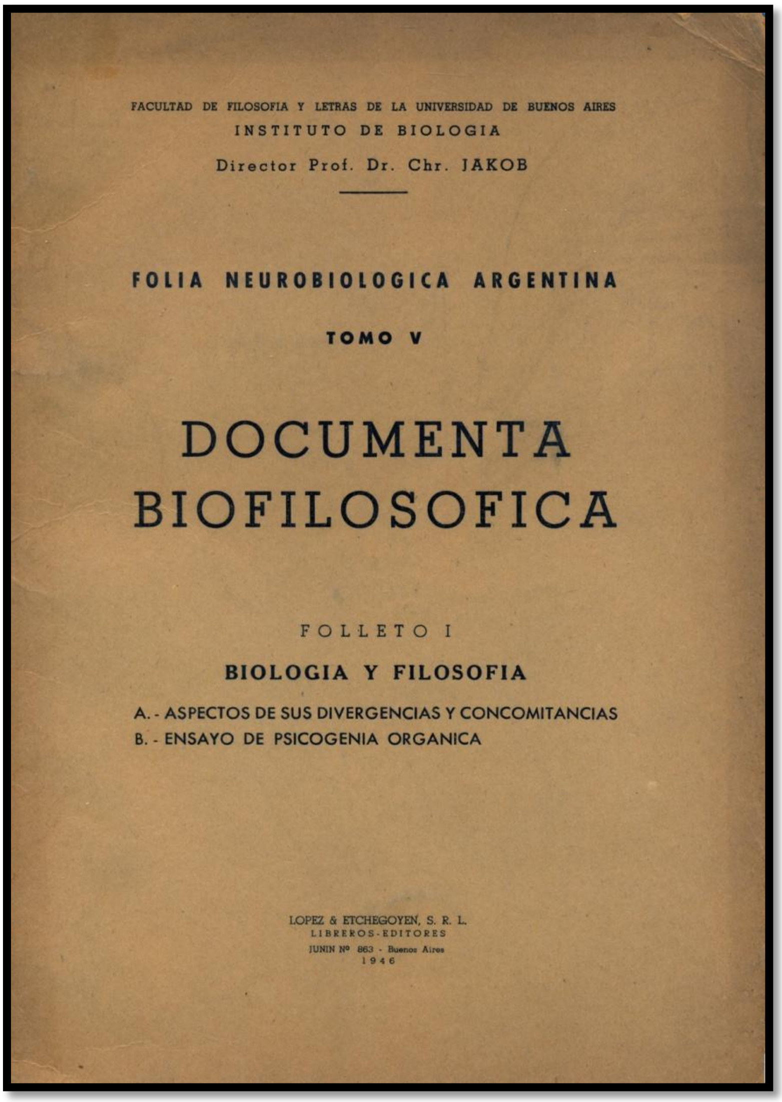


Figure 16

Frontispiece of Jakob's 1946 monograph Biophilosophical Documents, being volume 5 of the Folia Neurobiológica Argentina series. Reprinted from Théodoridou & Triarhou (2012a).

4.2.1. Jakob's views

Jakob (1946b) made the supposition that Pick disease represents a model for progressive disintegration of a hierarchical cognitive system (Barutta et al., 2010). In this revised view, Jakob (1946b) explained that by the Aristotelian concept of 'psyche' he refers to the integrative dynamics issued from sensory-motor regulations. The 'phylopsyche' involves brain activities inherited from phylogenetically older species; it is constituted by the 'archipsyche', which contributes to the reflex functions and the 'paleopsyche', which contributes to instinctual functions. The most recent phylogenetic acquisition and typical of the human brain is the 'ontopsyche' or 'neopsyche'. Ontopsyche is responsible for the elaboration of the individual brain activity mediated by individual experience processes. Ontopsyche is further divided into the trophopsyche, an internal milieu regulator whose activity is carried out by the limbic system; the somatopsyche, an external milieu regulator whose activity is performed by the suprasylvian gyri; and the logopsyche, mediator of our symbolization of the world, through the perisylvian gyrus (Barutta et al., 2010).

According to Jakob (1946b), Pick disease results in a 'diaschisis', a disruption between the paleopsyche and the neopsyche leading to intellectual and affective disorders. Such a disruption implies the dissociation between the internal and environmental aspects, the subjective and objective world, respectively (Barutta et al., 2010). Therefore, the creation of the most important human ideals is affected because – even though they become realized into the sphere of the intellect – they are rooted in the sphere of the emotions.

Jakob (1941a, 1946) theorized that two great worlds, 'like battle-fields', create our cortical organ during its ontogeny forming an a priori unit: the external *('ambiental')* and the internal *(introyental')* milieu (Théodoridou & Triarhou, 2012a).

The external, environmental factors act as stimulating material and the internal as hereditary germ capital, the maturation of which gives birth to the adequate central organic assimilation system. The external and internal domains were considered to enable the elaboration of personal and conscious experiences through a process of 'internal-environmental frontalization', whereas the 'commemorative accumulation' of such experiences was thought to allow an individual to plan and execute future actions (Barutta et al., 2010).

The endogenous sector is represented on the medial facies of the mammalian cerebral hemispheres, including the cingulate gyrus, and is charged with vegetative-autonomic functions, whereas the exogenous is represented on the convexity of the cerebral hemispheres and serves somatic functions (Triarhou, 2008).

The external and the internal milieu differentiate and complement each other via two essential psychogenetic acts, 'somatization', i.e. a course of action that leads to the formation of the position toward the external milieu, and 'sympathization', i.e. the course of action that leads to the formation of the position toward the internal milieu (Jakob, 1941a, 1946). A somatic act consists in a process of acceptance or rejection accompanied by the corresponding affective intonation. For example, when the infant encounters an obstacle (stimulus), unity becomes divorced: this 'object' will be 'environmental', and the organ that hits against the obstacle with all its neuromuscular organization will be 'internal'. On the other hand, a sympathetic act corresponds to a process of emotional intonation of pleasure or pain. For example, the infant satisfies its hunger by sucking. Milk, along with mother and chest, will be environmental; the tranquilization of the visceral needs, along with all of the glandulo-musculo-neural apparatus, belongs to the internal milieu.

Jakob (1941a, 1946) suggested that psychogenesis is effected in three developmental stages – an ‘infantile’, a ‘juvenile’, and a ‘mature’ stage – and eventually leads to the construction of the external milieu and the creation of the somatic ego (Théodoridou & Triarhou, 2012a). In the first or ‘infantile stage’, there is a primitive perception of constellations of objects and processes. This stage elaborates the elementary knowledge of experience via cortical macro-microdynamic successions and associations. Therefore, the elemental reflex formation is created through a process of cortical ‘synergy’. Memory provides accumulated material transferred via cortical elements organized in macro- and microdynamic systems (Fig. 17) for the emergence of orientation (gnosic) and intervention (praxic) processes.

For this to happen, constellations must be transformed into differentiated objects and processes, forming concrete phenomena of the experienced world through a process of comparison and identification in the second or juvenile stage. The third or mature stage reflects human consciousness, or according to Jakob’s terminology ‘neopsychism’. Within this phase objects and processes are organized in the dimensions of space, time and causality by means of complex neurocognitive processes, i.e. gnoses and praxes. The human mind then becomes capable of generating abstract ideas through the symbolic code of language, a human ability that Jakob termed ‘symbolism’.

In Jakob’s theoretical framework, the conscious self arises while one elaborates interacting internal sympathetic) and external (somatic) experiences; external experiences issue from the external milieu, the notion of which is created when a child realizes that their body is separate from the objects found in their environment (López Pasquali, 1965). Jakob (1941a, 1946) argued that the first notion of something external, the divorce between the self and the world, comes with the satisfaction of hunger, an internal need.

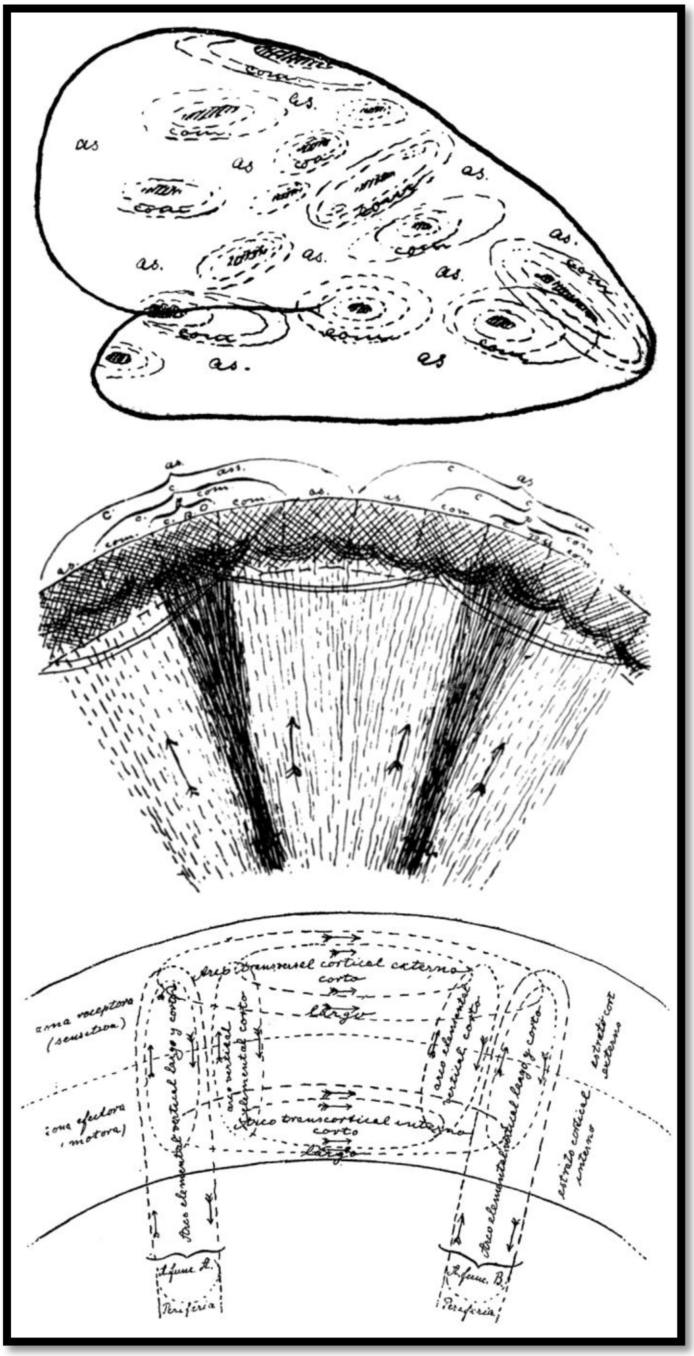


Figure 17

Upper: A schematic drawing of perception areas by Jakob (1908, p. 301), outlining the annular commemorative and the association centers. Middle: Schematic drawing by Jakob (1908, p. 304) of two adjacent centers of perception, v.o. and v.a., representing the central afferent pathways; within their confines, the other centripetal and centrifugal fibers of the commemorative (c. com.) and the association center (c. acc.); c.p.o. and c.p.a., perception (centrofocal) center. Lower: Outline of the major cortical streams (elementary long and short vertical arc, external or internal cross-arc, long and short) according to Jakob (1913, p. 694). Reprinted from Théodoridou & Triarhou (2012a).

In the first stage of the construction of the external milieu object and process are completely fused to form a single, joint complex consisting of blurred, moving or variable elements (Jakob, 1941a, 1946). Elsewhere (Jakob & Copello, 1948), he argued that neither in an evolutionarily primitive nor in a developmentally infantile stage do humans discriminate the 'inner' from the 'outer' being subjected to a 'genuine monism'. Such a monism turns into the dualism of the two milieux, internal and external, only by means of experience.

Jakob (1941a, 1946) described the second psychogenetic stage of the somatic ego as a process that enables the separation and differentiation of the stable and unaltered elements of a situation from the blurred, moving, or variable elements through the connection and comparison of the 'complexes' of the first stage. The complexes are thus transformed into objects and processes, and they create concrete ideas of the experienced objective world through a process of identification or differentiation within the juvenile phase.

The third psychogenetic phase of mental maturation elaborates the sequencing of objects and processes. Eventually, *"isolated complex situations, integrated concrete notions, and series of symbolized abstract ideas successively comprise the psychogenetic products of the gnosio-praxico-cortical work"* (Jakob, 1941a, p. 69). According to Jakob (1941a, 1946), our psycho-dynamic creation moves forward to three correlated dimensions: the spatial, the temporal, and the causal.

Jakob (1945b) described a cortical apparatus organized in such a way that accumulates and guards its traces in the form of cortical microdynamisms, linking them in a continuous and therefore conscious current (Théodoridou & Triarhou, 2012a). He argued that consciousness does not just emerge, but it is gradually formed as a result of cortical elaborations, attributing an adaptive character to the brain.

He thought that there is a circular, reactive process between the object and the subject. The dynamics of consciousness – stemming from his views on cerebral cortical dynamics – consist in the simultaneous evocation of somatic reactions orientated to the external environment and sympathetic reactions orientated to the internal environment. Their synthesis links the external with the internal world in a constant adaptation.

4.2.2. Discussion

Jakob's understanding of evolutionary anatomy (Fig. 18) and biological mechanisms led him into viewing the cerebral cortex as a historical product of the external environment and at the same time as the human organ of active adaptation (López Pasquali, 1965).

In a similar way, Ochs (2004) argues that the accumulated historical experiences have allowed the evolution of human social groups and subsequently the emergence of civilization. Viewing the human mind and behavior in the optic of evolution, Damasio (2010) suggested that apart from the basic homeostasis, that is nonconsciously guided, there exists the sociocultural homeostasis, which is created and guided by reflective conscious minds. Both basic and sociocultural homeostasis promote the survival of living organisms albeit in different ecological niches leading to changes in the genome.

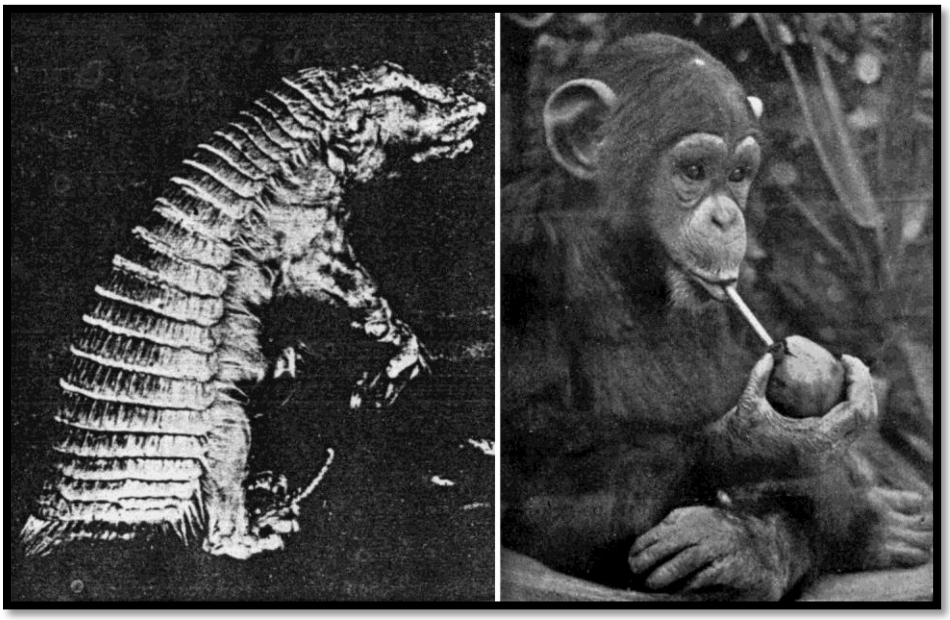


Figure 18

Left: The edentate 'pichiciego pampeano' (Chlamyphorus truncatus), the pink fairy of the armadillo species also known as ratoncito cascarudo, shown at a ½ scale (Jakob, 1943, p. 12). Right: Manual praxis in a chimpanzee (Jakob, 1943b, p. 22; photo by Clemente Onelli). Reprinted from Theodoridou & Triarhou (2012a).

Jakob's ideas on the communication between the brain and its environment remind certain aspects of cybernetics (cf., Wiener, 1948). In defining 'systemics and cybernetics' we follow François (1999, p. 203): *"a metalanguage of concepts and models for transdisciplinarian use still evolving within a slow process of accretion through inclusion and interconnection of many notions, which came and are still coming from very different disciplines"*. Some common points between Jakob's ideas and the theories of cybernetics are discussed next.

Jakob and Copello (1948, p. 63) wrote:

"Life in general and the human organism in particular receive stimuli for their reactive neuronal phylogeny and ontogeny from two sources: an endogenous,

generic, inner source that gives rise to the vegetative-sympathetic sphere, and an exogenous, individually orientated one that gives rise to the environmental-somatic sphere. They both create the neurodynamic nature and the personal consciousness of their carrier in a continuous reciprocal amalgamation. Neurobiology demonstrates that the same structurally bipartite and functionally integrated neural plan is applied as much on amoebae as on men. Even in protozoa there is a mutual contact of the organism with the external milieu and an internal regulatory mechanism that secures the preservation of the organism."

Furthermore, within the tripartite model that he presented in his neurodynamic postulate, Jakob conceived 'psychism' as *"the neurobiophylactic complex of neuroenergetic reception, assimilation and reaction, which regulates the organism's vital necessities against variable factors in the external and internal milieu"* (Jakob, 1939, p. 8). In addition, López Pasquali (1965) underlines the fact that Jakob's studies on assemblies of circuits might have anticipated the concept of autoregulation in cybernetics (Théodoridou & Triarhou, 2012a).

Claude Bernard (1878, 1974) had formulated his ideas on the internal environment to unify the explanations concerning the fundamental physiologies of the body under the general principle of the preservation of stability (Gross, 1998). Bernard's momentous pronouncements, including his final account of the conception of an internal environment *('le milieu intérieur'),* were gathered and published posthumously in the first volume of the 'Lectures on the Phenomena of Life Common to Animals and Plants' (Olmsted & Olmsted, 1952). At the time, the general concepts of 'living system' and 'regulation' were latent (François, 1999).

In a biocybernetic framework, Maturana and Varela (1980, 1987) developed the concepts of 'autopoiesis' and 'operational closure'. Autopoiesis, a multi-connected concept significant for problems of cognition but also for the self-reproduction of living systems, is associated with the concepts of self-closure, self-reference and self-production (François, 1999).

Varela introduced neurophenomenology arguing against 'brain-bound neural events' that constitute the mind (Rudrauf et al., 2003). Varela's conception of mind and ultimately of experience is concerned with the constraints exerted by the specific phenomenology of our concrete coping upon our internal dynamics as autonomous systems, and reciprocally, the effects of the latter upon the former, in a circular framework (Rudrauf et al., 2003). In this sense, one could argue that Jakob's views bear a strong resemblance to neurophenomenology (cf., Varela, 1996).

As far as the neuropsychogenetic problem is concerned, Jakob (1941a) perceived psychogenesis as a dynamic process leading to the formation of abstract thought. Piaget (1972) shared a common view relating 'psychogenesis' to cognitive development, maintaining the literal meaning of the word contrary to its wide and popular psychiatric use (Freud, 1920; Jung, 1960).

Further similarities are found between the mechanisms and laws that rule Jakob's stages of organic psychogenesis and concepts encountered in Piaget's formulations. For instance (Szirko, 1999), Jakob (1907/1908, 1922, 1948) and Piaget (1967, 1976) adopted a similar approach to the study of the procedure through which extramental organic regulations prolong themselves into certain cognitive processes (Théodoridou & Triarhou, 2011a).

Moreover, in his attempt to explain how the forms of intellectual activity are constructed at the sensory-motor level and subsequently how the world is constructed in the child's mind, Piaget (1952, 1954) conceived and described the functions of assimilation and accommodation that proceed from a state of chaotic undifferentiation to a state of differentiation with correlative coordination:

"At first the universe consists in mobile and plastic perceptual images centered about personal activity…The external world, therefore, begins by being confused with the sensations of a self unaware of itself, before the two factors become detached from one another and are organized correlatively" (Piaget, 1954, p. 351).

To Piaget (1954, pp. 351–352)

"assimilation ceases merely to incorporate things in personal activity and establishes, through the progress of that activity, an increasingly tight web of coordinations among the schemata that define it and consequently among the objects that such schemata are applied to. From this time on, the universe is built up into an aggregate of permanent objects connected by causal relations that are independent of the subject and are placed in objective space and time."

Jakob's second psychogenetic stage of the somatic ego that corresponds to a process of separation and differentiation of the stable and unaltered elements of a situation from the variable ones through the connection and comparison of the 'complexes' of the first stage seems to share a common element with Quine's (1960) 'similarity standard', i.e. the ability to relate things to the world as similar to or different from one another, according to their properties and the state of our perceptual scheme at the time.

The third psychogenetic phase of mental maturation elaborates the gnosio-praxico-cortical work (Jakob, 1941a, 1946) in three correlated dimensions: the spatial, the temporal, and the causal. Maintaining that inherited dynamics are organized in the dimensions of space, time and causality, Jakob (1921, 1943b, 1943c, 1945b) – like Piaget – adopted Kant's (1781) a priori conditions. However, this aprioristic conservative principle is counterbalanced by the aposterioristic flexible principle that rises due to the openness of the brain to the stimuli of the external world (Capizzano, 2006).

Jakob argued that the conscious self is born through the binding of the external and internal spheres and it becomes manifest by the synchronization of its components. Whereas proving the case for synchronization in the human brain is still considered technically demanding (Zeman, 2001), Jakob conceived the idea of synchronization of neuronal activity as the underlying mechanism of consciousness more than a hundred years ago (Théodoridou & Triarhou, 2011a).

Two landmark works particularly stand out with regard to the psychological and philosophical study of the experience of time (Andersen and Grush, 2009). These are William James' 'Principles of Psychology' (James, 1952), first published in 1890, and Edmund Husserl's (1928) papers on the 'Phenomenology of Inner Time Consciousness', compiled by Heidegger. They both convey the idea that the contents grasped by consciousness are built upon duration and therefore they are temporally solid (Andersen and Grush, 2009). In line with James' 'stream of consciousness' the 'Cartesian theater model' assumes that there is a locus of synthesis in the brain where experience enters consciousness (cf. Dennett, 1991).

On the other hand, the 'multiple drafts' model (Dennett, 1991), which appeared as an alternative to the dualistic 'Cartesian theater model', holds that neural events that discriminate various perceptual contents are distributed in both space and time in the brain (Théodoridou & Triarhou, 2012a). However, none of these temporal properties is thought to determine subjective order, since there is no single, constitutive 'stream of consciousness' but rather a parallel stream of conflicting and continuously revised contents (cf. Dennett & Kinsbourne, 1992).

It has been further suggested that the function of time in human consciousness primarily resides in systems that maintain synchrony and allow the ‘binding’ between the internal environment as it is shaped by the brain’s chemicals and the influence of the external environment (Dawson, 2004). Thus, time is considered as an organizing parameter to the binding problem (Dawson, 2004). The binding problem, i.e. the generation of the unity of conscious experience, may have made its first appearance in Kant’s ‘Critique of Pure Reason’ where the ‘principle of transcendental unity of apperception’ describes the synthesis of the ‘knowledge of the manifold’ (Mashour, 2007).

The richness and variety of mechanisms by which animals and humans, including infants, can represent the dimensions of space, time and number to integrate diverse sensory elements for the creation of conscious experience is complex and suggests the existence of evolutionary processes and neural mechanisms by which Kantian intuitions might universally arise (Dehaene & Brannon, 2010). The evolution of the concept of time carries special weight due to its role in promoting the biological ability of the species to survive and adapt to environmental demands. From a developmental viewpoint, its importance is further reflected in the consequences of temporal disorganization on consciousness as they are observed in psychopathological conditions (Broome, 2005), aging and drug use (Dawson, 2004).

4.3. The diffusion of neurobiological knowledge into philosophy

Throughout his career, Jakob struggled to bridge philosophy to biology. He had already presented his arguments for such a connection in two works (Jakob, 1913a, 1913c) entitled ‘The Organic Psychology and its Relation to Cortical Biology’ and ‘Biology in the System of Philosophical and Natural Sciences’.

Jakob (1945b, p. 345) considered himself *"a groundworker of a biocentric epistemology"*. He described the theoretical background and main points that a future philosophy of the brain would have to treat (Théodoridou & Triarhou, 2012a). Along this line, he suggested that such a future discipline should consist of a synthesis of proven as universally valid neuro-psycho-dynamic theories concerning: (a) a universal, central organization; (b) heredity; and (c) the evocation and transformation of physical processes into psychological phenomena by means of neurohistological and physiological processes (Jakob, 1945b).

In this endeavour, Jakob (1945b) considered the following issues of primary importance:

(a) The laws that govern cerebral phylogeny and ontogeny and their stages.

(b) The microoganization of neuroblasts and the dynamics of their functional derivatives in normal and pathological conditions.

(b) The polyenergetic transformation at cosmological, biological, neurological and psychological levels in the integrative creation of the external (objective) and the internal (subjective) environment (see also Jakob, 1920).

Moreover, Jakob (1945b) argued that a philosophy of brain should shed light on the 'neurobiogenetic', 'neurodynamic', and 'neuropsychogenetic' problems.

4.3.1. Jakob's views

In the first part of his 'Biophilosophical Documents' *('Documenta Biofilosófica')*, Jakob (1946a) presented the following arguments for the necessity of diffusing common and divergent aspects of neurobiology into philosophy (Théodoridou & Triarhou, 2012a):

(a) Issues concerning life, from general aspects of evolution to heredity and the diversity of the human species, form a justified base for an objective, rational and scientific development of the philosophical orientations.

(b) The scientific field of neurobiology that studies nervous structure and function (see e.g. Jakob, 1906b) under normal or pathological conditions, both evolutionarily and developmentally, is indispensable for psychology and its related sciences (cf. also Jakob, 1913a).

(c) The knowledge of the morphophysiological evolution of the human brain in correlation with psychogenetic maturation, as well as brain alterations and their sequelae on memory, behavior, language and other abstract processes form the natural foundation of a conscious learning science.

(d) The creation and the preservation of higher cognitive functions (intellect, volition and emotions), instincts and reflexes depend on our cerebral organization.

Jakob (1946a) argued that philosophical reasoning consists in elaborations stemming from a germ cell. Therefore, neurobiology should provide the organic basis of epistemology, logic, phenomenology, axiology, ethics, aesthetics and metaphysics.

In that respect, Jakob (1945a) maintained that sciences dealing with the empirically accessible reality and philosophy which examines the possibilities that arise beyond experience need a philosopher who would above all master the former in order to treat the latter with composure.

4.3.2. Discussion

With the progress effected in the brain sciences over the past 20 years, traditional philosophical questions have been steered into new directions (Churchland, 2008). Thus, the field of consciousness studies has been broadened up to attract a growing body of biologists, neuroscientists, psychologists and philosophers (Blackmore, 2005). The investigation of philosophical theories in relation to neuroscientific hypotheses falls within the ‘modern’ domain of neurophilosophy (Northoff, 2004). Formalized by Churchland (1986), the term ‘neurophilosophy’ denotes the interdisciplinary attempt at unifying cognitive neurobiology. In the years following its foundation, neurophilosophy has grown exponentially. Its main theses have centered on:

(a) psychological and neuroscientific theories, as well as intertheoretical relationships,

(b) the opposition to the autonomy of either psychology or functionalism alone and,

(c) a trend of rendering the cognitive neurosciences accessible to and comprehensible by a broader audience (Bickle, 2009).

On the other hand, philosophy of neuroscience has gradually become a distinguishable field reflecting *“an inquiry into foundational (especially epistemic and metaphysical) questions that apply to neuroscience”* (Bechtel, 2001, p. 7). Such questions can be approached either descriptively, i.e. by depicting how neuroscience proceeds, or normatively, i.e. by implying how neuroscience should proceed (Bickle, Mandik, & Landreth, 2010).

The fluidity of the boundaries between neurophilosophy and the philosophy of neuroscience has led Brook and Mandik (2004) and Bickle (2009) to use the term ‘Philosophy and Neuroscience’, which entails ongoing transdisciplinary interactions, accommodating both endeavours.

Not until recently have philosophers started paying close attention to the data provided by the neurosciences. A few exceptions prior to the 1980s include the work of Thomas Nagel (1971), Barbara von Eckardt-Klein (1975) and Daniel Dennett

(1978) as pointed out by Brook and Mandik (2004). The establishment and dissemination of reductionistic approaches in the 20th century, prompted to a great extent by Jacques Loeb (1859–1924) and Ivan P. Pavlov (1849–1936), relegated consciousness studies to philosophy, mysticism or ‘soft’ science, thus diminishing the influence of more integrated contemporary approaches, such as those of Sherrington and Lashey (Greenspan & Baars, 2005). As behaviorists were reacting to the earlier introspection – as exemplified e.g. in the thought of Wundt, James and Freud – with a desire for objectivity, they devised animal experiments, resolutely leaving the human mind out of the picture; only around the middle of the 20th century did psychological theorizing swing back to studying the mind in the realm of cognitive psychology (Ochs, 2004).

In spite of remarkable advances in neuroscience and the diffusion of biological evidence into philosophy in the modern field of neurophilosophy, the so-called ‘hard problem of consciousness’, i.e. the problem of explaining why and how cerebral elaborations give rise to conscious phenomenal experience (cf. Chalmers, 1995) remains a puzzle for scientists, philosophers and lay people to date (Théodoridou & Triarhou, 2012a). Jakob’s (1945b) stance towards such a puzzle is summarized in the following paragraph:

> *“The origin of errors and misconceptions in the attempt to explain consciousness lies in the excessive though inevitable specialization of the diverse scientific fields that are getting involved in this attempt. Given that the external and the internal spheres, the environment and the brain or macrocosmos and microcosmos, create a cycle, the answers can be found only in a synthetic approach. Therefore, physics, histology, physiology, psychology and philosophy should form a new arena of scientific exploration.”* (Fig. 19).

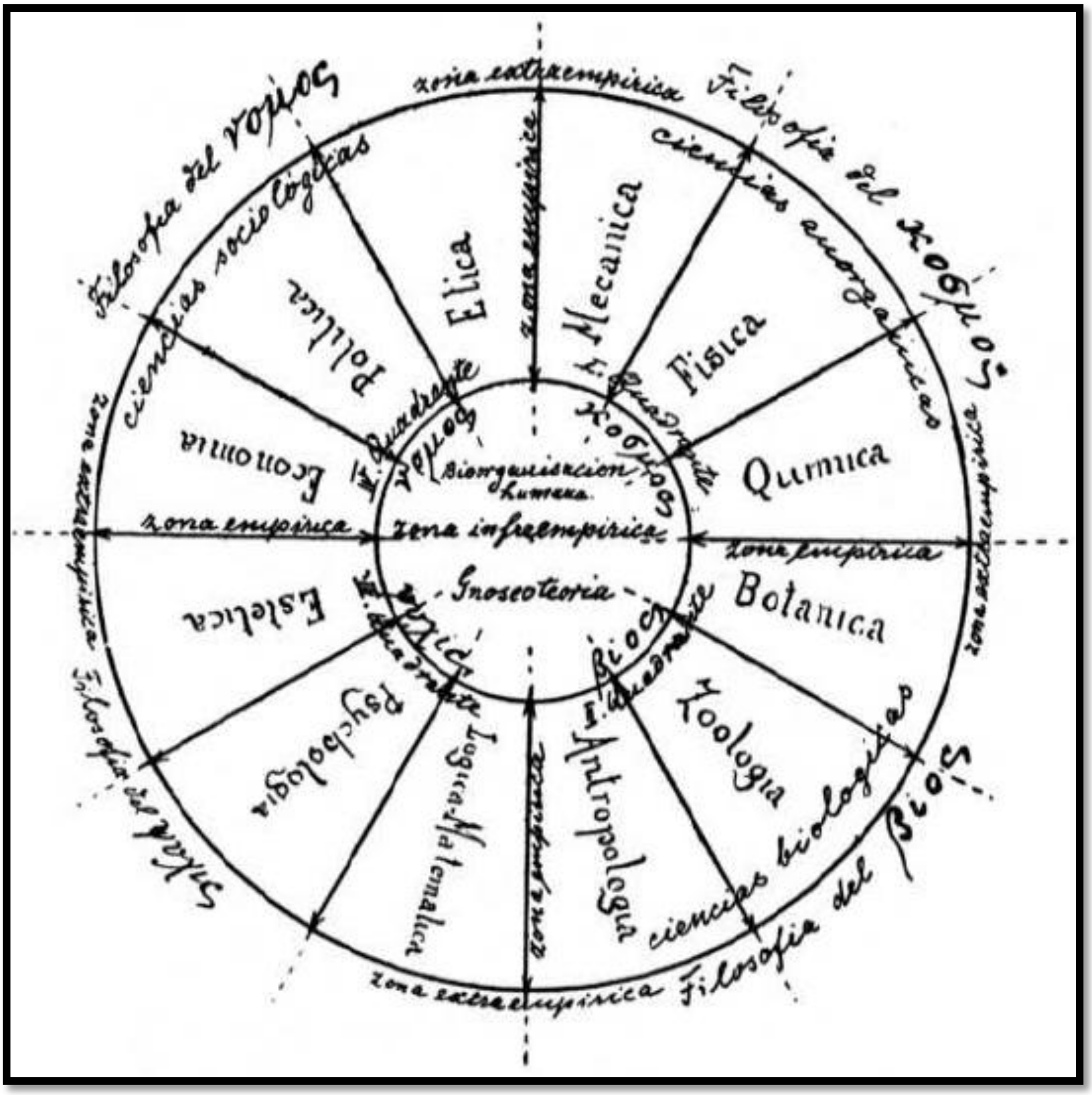


Figure 19

Schematic synopsis of the zone of experience with the four quadrants of the exact sciences and their infra- and extra-empirical philosophical projections according to Jakob (1920, p. 30). Reprinted from Théodoridou & Triarhou (2012a).

4.4. Late views on the frontal lobe

Frontal lobe research constituted a major issue in Jakob's theorizing (Théodoridou & Triarhou, 2012b). Recognizing the 'humanizing' role of the frontal lobe, Jakob (1943c, p. 9) described the meaning of its dynamics for science and philosophy in a monograph and left that work *“rather as a plan for future research and not as an essay with solutions”* (cf. Théodoridou & Triarhou, 2012b). He continued reflecting and writing on the frontal lobe until the end of his career. In fact one of the two Jakob’s last formal publications, co-authored with his pupil Eduardo A. Pedace and dated to 1949, is ‘The Task of the Frontal Lobe in Connection with a Synthetic Quantification of its Constitutive Elements’.

4.4.1. Jakob’s views

Jakob (1943c) related the progressive perfection that derives from frontal dynamics with the accumulated commemorative function, as far as biology is concerned. In neurology, frontal dynamics are thought to be expressed through the evolution from the brutal commands of the generic and irresistible, hereditary and universally obligatory instincts to an elevating liberation that results from an individually orientated intervention in the sphere of consciously caused aims. In psychology, the substitution of the media of communication, conveying exclusively affective information by other, conveying intellectual, was rendered possible by means of the concrete gnosio-praxic experience represented by abstract symbols in language. In sociology, frontal dynamics are related to the possibility of extension and intensification in time and space of the individual and the collective productivity that affects the economic, the cultural and the political spheres in order to progressively become more ‘human’. In education, the development of a social intelligence that will reinforce individual inclinations and will put emphasis on the active engagement of the student in the formation of concrete knowledge issues from the importance of frontal lobe functions. In neuropsychiatry, it leads to the emergence of objective neuro-psycho-analytical processes for the elaboration of the factors that derive from complex neuropsychological symptoms, reactions and phenomena.

Jakob maintained that the systematic application of anatomo-clinical methods on the study of physiological phenomena behind normal and pathological cortical localization and communication leads to the replacement of vague verbal constructions by histo-physio-pathological concrete concepts enabling, thus, the transition from a mechanic to a dynamic phase in neuropsychiatry. Our biopsychism has created unique intellectual, aesthetic and ethical values that enable the explanation of the nature, mental liberty and understanding of the demands and the limits of our mind, thus shedding light onto reality and representation. Praxic (motor) dynamics lead the course of life with the individual and the collective aims; the gnosic intellect, on the other hand, expresses the capability of orientating in one's environment.

Jakob further proposed that the frontal lobe underpins at the neuronal level the phylogenetic transition from 'blind' desires dictated by impulses to conscious aims planned and executed in order to bring a result.

Jakob's last publication on the frontal lobe (co-authored with his pupil Eduardo A. Pedace and dated 1949) is entitled 'The Task of the Frontal Lobe in Connection with a Synthetic Quantification of its Constitutive Elements' (cf. Triarhou, 2010a). Jakob thought that the frontal lobe reflects the latest acquisitions in the ascending neurophylogeny (Barutta et al., 2010). The fact that the frontal lobe represents 25% of the human brain, i.e. about 350–370 g of cerebral mass, solely considered from a quantitative standpoint, must alone confirm the higher task of their cortical functions (Jakob & Pedace, 1949). In the frontal lobe, Jakob (Jakob & Pedace, 1949) recognized the centers of experiential accumulation resulting from personal intervention, progressively elaborated for the elemental and highest human skills, stimulated by the corresponding affective manifestations.

Jakob – together with Pedace – (1949) viewed the frontal cortex as a locus of interaction between afferent and efferent pathways, the system of transformation of specific stimulations and reactions (endogenous-exogenous frontalization) and with it the final accumulation of its elaborations (frontalized commemorative function). Both areas, in close gnosio-praxic collaboration, execute the conscious activation of human mentality in its creative labor from the concrete to the abstract in an intimate synthesis between their endogenous and exogenous domains, i.e. from their affectivity and intellectuality, reciprocally (Jakob & Pedace, 1949).

4.4.2. Discussion

As the riddle of the frontal lobe function in relation to the emergence of consciousness remains central in modern neurobiology, Jakob's views are still meaningful. Current theories on the functional localization of cognitive processes in the frontal lobe range from fractionated approaches to central concepts, with concomitant attempts to reconcile contrasting views (Théodoridou & Triarhou, 2010a). Such theories have been discussed in detail previously (see p. 40). Jakob's work over 50 years clearly shows a trend that has been discovered anew by modern researchers.

Today, several theories still seek to elucidate the neural correlates of consciousness (cf. Crick & Koch, 1990). The so-called 'hard problem' lies in the consideration of consciousness as an 'emergent' property 'arising' from functional elements of the neurocognitive structure without attributing a dualistic character to it (Kouider, 2009). For example, according to Edelman and Tononi's model of a constantly shifting dynamic core (cf. Edelman, 1992; Tononi & Edelman, 1998), consciousness arises from the fast integration within a dynamic core of interacting elements. Other neurobiological theories, such as the global neuronal workspace (Dehaene, Kerszberg, & Changeux, 1998; Dehaene & Naccache, 2001) highlight the interconnection between multiple cerebral modules that enables the broadcasting of information (Kouider, 2009). Jakob impressively conceived the idea of synchronization of neuronal activity as the underlying mechanism of consciousness more than a hundred years ago. His interpretation is not inconsistent with the view that consciousness is to be correlated with a non-continuous event determined by synchronous activity in the thalamocortical system (Ribary, Llinás, & Joliot, 1994). The transient synchronization of brain operations is considered to have the potential to construct unified and relatively stable neural states that underlie conscious states (Fingelkurts, Fingelkurts, & Kähkönen et al., 2005). The perception of volition seems to be generated in specific networks with the parallel activation of the global neuronal workspace (Hallett, 2007).

4.5. Recapitulation

Jakob's involvement with philosophy was neither superficial nor based on improvisations (López Pasquali, 1965). Quite the contrary; obvious throughout his work, his philosophical thought crescents in the late period of his work. Jakob's contributions are related both to assumptions, foundations, methods and implications of neuroscience, touching thus issues related to the philosophy of science and to the application of neuroscientific concepts to traditional philosophical questions. In this sense, one could argue that Jakob heralded the views of Churchland and other scientists working in the domain of philosophy and neuroscience well before neurophilosophy become a distinguished field. Furthermore, Jakob's ideas seem to share common elements with certain philosophers, such as Husserl and Quine. Of course, the roots of Jakob's theorizing can be traced back to Kantian philosophy. Such a background may account for the similarities found in Jakob's and Piaget's concepts.

Jakob coupled his philosophical background with his deep knowledge of evolutionary neuroscience. The evolutionary perspective is also evident throughout Damasio's work. Jakob further shares with Damasio a neurophenomenological point of view. Another similarity between Jakob and Damasio is the adoption of cybernetic concepts. Thus, Jakob can be placed in a line of thought expressed by early (e.g. Bernard), pioneer (e.g. Wiener) and modern (e.g. Maturana, Varela) cyberneticians.

Moreover, Jakob's ideas on the frontal lobe are pioneering both from a theoretical and from a technical viewpoint. His insight into clinical practice may have contributed to the formulation of such ideas.

5. CONCLUDING REMARKS

Jakob entered into a wide range of domains in the brain sciences and left his mark in each one of them with his original ideas. From evolution to development, from anatomy to physiology, from pathology to normality, from human to animal and from strict scientific methods to philosophical theorizing Jakob devoted his life to the riddle of the brain. His most notable contributions are summarized below.

5.1. Behavioral neuroscience

Biological psychology, a.k.a. behavioral neuroscience, biopsychology and psychobiology, is the field that relates behavior to bodily processes, especially the workings of the brain (Breedlove, Watson, & Rosenzweig, 2004, p. 3). As a scientific discipline, behavioral neuroscience emerged from a brew of scientific and philosophical traditions in the 18th and 19th centuries. Within such a framework, Jakob formulated his dynamic theories on cortical functions and he tried to reform psychology by providing a biological basis to explain mental phenomena.

He supported the idea of a constant dynamic exchange between the internal and the external milieu, sensation and motion, perception and action (Theodoridou & Triarhou, 2012a). He had fervently developed such views especially throughout his ‘middle’ and ‘late’ periods. His dynamic approach of the ‘middle period’ that highlights a circular flow, wherein the brain gets informed, updated and finally orientated in its environment in order to actively intervene in it echoes concepts of cybernetics, which, in turn, is considered as one of the critical antecedents of contemporary cognitive science (Gardner, 1985).

5.2. Cognitive neuroscience

In studying the neural substrates of mental processes Jakob moulded an integrative approach having borrowed elements from neuropathology, neuroanatomy and comparative neuroanatomy, developmental neuroscience, a.k.a. neural development, and clinical neuroscience. His emphasis on such a transdisciplinary approach is compatible with current trends. Furthermore, the weight that he placed on the elucidation of anatomical connections is now backed by modern hodological studies.

Although Jakob highlighted the role of the frontal lobe in higher mental functions, he was careful not to 'phrenologize' any brain area. He viewed even the frontal lobe as a locus of synthesis that preserves combined sensory-motor characteristics. He based on such anatomical observations certain assumptions on cortical functions.

He claimed that the process that eventually leads to the emergence of consciousness through a long evolutionary and developmental course depends crucially on the dynamic, concerted action of the brain.

5.3. Affective neuroscience

With the assumption that affection and cognition create the conscious and total personality (Jakob & Copello, 1949), Jakob had studied the neurological underpinnings of emotional processes. Based on degeneration experiments in apes and dogs, and on human clinico-pathological correlations in neurodegenerative and inflammatory diseases such as senile and paralytic dementia (tertiary syphilis), Jakob described the entire circuitry encompassing the mamillary bodies, the anterior nucleus of the thalamus, the cingulate gyrus and the hippocampus, as well as the projection pathways that connect them, i.e. the components of the so-called 'circuit of Papez' (Triarhou, 2008).

Furthermore, although the observation that the limbic system (including the superior limbic lobe and the hippocampal formation) is the physiological common denominator of a variety of viscerosomatic and emotional reactions is attributed to MacLean (1955), marshaled evidence (cf. Triarhou, 2009) renders obvious the chronological precedence of Jakob in using the term 'visceral brain' to denote the functional attributes of the cingulate cortex or superior limbic gyrus. Apparently, Jakob's contributions in affective neuroscience justify his consideration as a pioneer of the field.

5.4. Evolutionary neuroscience

Jakob's proposition on the dual onto-phylogenetic origin and the ubiquitous sensory-motor function of the cerebral cortex reflects a 'triple-synthesis' concept – evolutionary, developmental and physiological – to explain the structure and function of the cerebral cortex (Triarhou, 2010b). Diego Outes, one of Jakob's 'descendents', paid a tribute to Jakob by revisiting the topic of the dual cortex *(Doppelrinde)* twice (Outes & Benítez, 1976; Outes, 2006). Many authors (Fontana, Belziti, & Requejo, 2002; López Pasquali, 1965; Lores Arnaiz, Maturana & Azzara, 2002; Meyer, 1981; Moyano, 1957; Orlando, 1966) have praised Jakob's onto-phylogenetic theory. Above all, the fact that Economo and Koskinas (1925) considered Jakob's ideas on cortical phylo-ontogeny as 'ingenious' (Triarhou & del Cerro, 2006a) reveals the value of Jakob's contribution in evolutionary neuroscience.

5.5. Philosophy and neuroscience

Jakob may be considered an 'early neurophilosopher' for the following reasons. His philosophical background is evident throughout his work. It peaked during his late years. Jakob published around 20 articles in philosophy and neuroscience, besides philosophical papers on Kant and Descartes (Jakob, 1926, 1937a, 1938). Thus, the introduction of philosophical ideas into neuroscience and vice versa can be considered as one of the most critical and pioneering among Christfried Jakob's contributions (Théodoridou & Triarhou, 2012 a).

Besides, Jakob (1943b) proposed the term 'psychophilosophy' in an imaginative conference of philosophical discussions among a small number of interlocutors ('Conferencia magistral de introducción a la psicofilosofía') that recalls the Socratic dialogues. Being the professor alongside six alumni, he deals with issues such as the existence and the perception of God by the human mind, the nature of philosophy and science, the scientific basis of psychology, the nature of ideas, and the existence of a priori conditions of our internal intuition viewed from a neuroscientific point.

5.6. Educational neuroscience

Jakob put forward the idea of teaching a course on 'The nervous system and its relations to education' already in 1906. Although such a groundbreaking idea did not find fertile soil at that time, still he was most likely one of the first academics to formally teach neurobiology in a School of Education, at the National University of La Plata, Argentina since 1922. Hence, Jakob introduced fundamentals of neuroeducation decades before that discipline was formalized in the current era. Thus, he realized the essence of its modern definition, i.e. "the quest for the integration of disciplines that investigate human learning and development bringing together education, biology, and cognitive science" (Fischer et al., 2007).

Besides, he opened up new paths in special education standing up for the right of handicapped children in an appropriate education (cf. Jakob, 1913c). Throughout his career, he had dealt with issues concerning the organization of various services, such as laboratories, clinics and university departments (Jakob, 1916a, 1937b, 1943a). Therefore, he anticipated modern attempts of bringing the cognitive sciences in the domain of administration (cf., Evers & Lakomski, 2000).

In a course of clinical practice, teaching and research Jakob further treated certain aspects of neurolinguistics, clinical neuroscience, psychopathology, history of the neuroscience, anthropology and biology. A final account of his contributions leads to the conclusion that Jakob left behind an invaluable legacy of works whose study may still provide meaningful clues for the elucidation of brain functions.

REFERENCES

Alexander, G. E., DeLong, M. R., & Strick, P. L. (1986). Parallel organization of functionally segregated circuits linking basal ganglia and cortex. *Annual Review of Neuroscience*, *9*, 357–381.

Allen, J. S. (2009). *The lives of the brain: Human evolution and the organ of mind*. Cambridge, MA: Belknap Press of Harvard University Press.

Andersen, H. K., & Grush, R. (2009). A brief history of time-consciousness: Historical precursors to James and Husserl. *Journal of the History of Philosophy*, *47*, 277–307.

Arbib, M. A. (1981). Perceptual structures and distributed motor control. In V. B. Brooks (Ed.), *Handbook of Physiology: Nervous System* (vol. II) (pp. 1448–1480). Bethesda, MD: American Physiological Society.

Avillac, M., Denève, S., Olivier, E., Pouget, A., & Duhamel, J. R. (2005). Reference frames for representing visual and tactile locations in parietal cortex. *Nature Neuroscience*, *8,* 941–949.

Azmitia, E. F. (2007). Cajal and brain plasticity: Insights relevant to emerging concepts of mind. *Brain Research Reviews, 55,* 395–405.

Baddeley, A. D. (1996). Exploring the central executive. *Quarterly Journal of Experimental Psychology, 49,* 5–28.

Baddeley, A. D. (2002). Fractionating the central executive. In D. T. Stuss & R. T. Knight (Eds.), *Principles of frontal lobe function* (pp. 246–260). Oxford: Oxford University Press.

Bard, P. (1928). A diencephalic mechanism for the expression of rage with special reference to the central nervous system. *American Journal of Physiology, 84,* 490–513.

Barutta, J., Hodges, J., Ibáñez, A., Gleichgerrcht, E., & Manes, F. (2010). Argentina's early contributions to the understanding of frontotemporal lobar degeneration. *Cortex, 47*, 621–627.

Battro, A. M., & Cardinali, D. P. (1996, July 16). Más cerebro en la educación [More brain in education] [Electronic version]. *La Nación*. http://www.byd.com.ar/cereln.pdf. Retrieved in November 20, 2011.

Battro, A. M., Fischer, K. W., & Léna, P. (2008). *The educated brain: Essays in neuroeducation*. Cambridge, UK: Cambridge University Press.

Bechtel, W. (2001). *Philosophy and the neurosciences: A Reader*. Malden, MA: Blackwell.

Bergson, H. (1896). *Matière et memoire: Essai sur la relation du corps à l'esprit*. Paris: Félix Alcan.

Bergson, H. (1934). *La pensée et le mouvant: Essais et conférences*. Paris: Félix Alcan.

Bernard, C. (1878). *Leçons sur les phénomènes de la vie communs aux animaux et aux végétaux, tome premier* (pp. 113–114). Paris: J.-B. Baillière et fils.

Bernard, C. (1974). *Lectures on the phenomena common to animals and plants* [1878] (translated by H. E. Hoff, R. Guillemin, L. Guillemin). Springfield, IL: Charles C. Thomas.

Besada, C. H. (2010). Dr. Christofredo Jakob: Historia de la escuela neurobiológica Germano-argentina. *Revista Argentina de Radiología, 74*, 132–139.

Bickle, J. (2009). *The Oxford handbook of philosophy and neuroscience*. Oxford: Oxford University Press.

Bickle, J., Mandik, P., & Landreth, A. (2010). The philosophy of neuroscience. In E.

N. Zalta (Ed.) *The Stanford encyclopedia of philosophy*. http://plato.stanford.edu/archives/sum2010/entries/neuroscience. Retrieved in June 24, 2011.

Blackmore, S. J. (2005). *Consciousness: A very short introduction*. Oxford: Oxford University Press.

Blumen, S. C., & Blumen, N. (2002). From the philosophy auditorium to the neurophysiology laboratory and back: From Bergson to Damasio. *The Israel Medical Association Journal, 4*, 163–165.

Breedlove, S. M., Rosenzweig, M. R., Watson, N. V., & Rosenzweig, M. R. (2004). *Biological psychology: An introduction to behavioral, cognitive, and clinical neuroscience*. Sunderland, Mass: Sinauer Associates.

Broca, P. (1861). Perte de la parole, ramollissement chronique et destruction partielle du lobe antérieur gauche du cerveau. *Bulletin de la Société d'Anthropologie (Paris), 2*, 235–238.

Brodmann, K. (1909). *Vergleichende lokalisationslehre der grosshirnrinde in ihren prinzipien dargestellt auf grund des zellenbaues*. Leipzig: Barth.

Brodmann, K. (1913). Neue Forschungsergebnisse der grosshirnrindenanatomie mit besonderer berücksichtigung anthropologischer Fragen. *Verhandlungen der Gesellschaft Deutscher Naturforscher und Ärzte, 85*, 200–240.

Brook, A., & Mandik P. (2007). The philosophy and neuroscience movement. *Analyse Kritik*, *26*, 382–397.

Broome, M. R. (2005). Suffering and eternal recurrence of the same: The neuroscience, psychopathology, and philosophy of time. *Philosophy, Psychiatry & Psychology, 12*, 187–194.

Burrow, T. (1943). The neurodynamics of behavior. A phylobiological foreword.

Philosophy of Science, 10, 271–288.

Campbell, A. W. (1905). *Histological studies on the localisation of cerebral function*. Cambridge: University Press.

Cannon, W. B. (1927). The James–Lange theory of emotions: A critical examination and an alternative theory. *American Journal of Psychology, 39*, 106–124.

Cannon, W. B. (1931). Against the James–Lange and the thalamic theories of emotions. *Psychological Review, 38*, 281–295.

Cappe, C., Rouiller, E. M., & Barone, P. (2009). Multisensory anatomical pathways. *Hearing Research, 258*, 28–36.

Capizzano, A. (2006). Actualidad del pensamiento de Cristofredo Jakob. *Revista del Hospital Italiano de Buenos Aires, 26*, 71–73.

Catani, M., Dell'Acqua, F., Vergani, F., Malik, F., Hodge, H., Roy, P., Valabregue, R., & de Schotten, M. T. (2012). Short frontal lobe connections of the human brain. *Cortex,* doi:10.1016/j.cortex.2011.12.001

Catani, M., & ffytche, D. H. (2005). The rises and falls of disconnection syndromes. *Brain*, *128*, 2224–2239.

Catani, M., & Stuss, D. T. (2012). At the forefront of clinical neuroscience. *Cortex, 48*, 1–6.

Chalmers, D. J. (1995). The puzzle of conscious experience. *Scientific American, 273*, 80–86.

Chow, T. W., & Cummings, J. L. (1999). Frontal subcortical circuits. In B. L. Miller & J. L. Cummings (Eds.), *The human frontal lobes: Functions and disorders* (pp. 25–43). New York: Guilford Press.

Churchland, P. (2008). The impact of neuroscience on philosophy. *Neuron, 60*, 409–411.

Churchland, P. S. (1986). *Neurophilosophy: Toward a unified science of the mind-brain*. Cambridge, MA: MIT Press.

Cockburn, J. (2008). Stroke. In B. Woods & L. Clare (Eds.), *Handbook of the clinical psychology of ageing* (pp. 201–218). West Sussex: John Wiley and Sons Ltd.

Crick, F., & Koch C. (1990). Towards a neurobiological theory of consciousness. *Seminars in Neuroscience, 2,* 263–275.

Dalgleish, T. (2004). The emotional brain. *Nature Reviews Neuroscience, 5,* 582–589.

Damasio, A. R. (1994). Descarte's error: emotion, reason, and the human brain. New York: Grosset/Putman.

Damasio, A. R. (1996). The somatic marker hypothesis and the possible functions of the prefrontal cortex. *Philosophical transactions of the Royal Society of London, 351*, 1413–1420.

Damasio, A. R. (1999). *The feeling of what happens: Body and emotion in the making of consciousness*. New York: Harcourt Brace.

Damasio, A. R. (2010). *Self comes to mind: Constructing the conscious brain*. New York: Pantheon Books.

Darwin, C. (1872). The expression of the emotions in man and animals [1965]. Chicago: Chicago Univiversity Press.

Dawson, K. A. (2004). Temporal organization of the brain: Neurocognitive mechanisms and clinical implications. *Brain and Cognition, 54*, 75–94.

de Duve, C. (2002). *Life evolving: Molecules, mind, and meaning*. New York: Oxford University Press.

Dehaene, S., & Brannon, E. M. (2010). Space, time, and number: A Kantian research program. *Trends in Cognitive Science, 14*, 517–519.

Dehaene, S., & Naccache, L. (2001). Towards a cognitive neuroscience of consciousness: Basic evidence and a workspace framework. *Cognition, 79*, 1–37.

Dehaene, S., Kerszberg, M., & Changeux, J. P. (1998). A neuronal model of a global workspace in effortful cognitive tasks. *Proceedings of the National Academy of Sciences of USA*, *95*, 14529–14534.

Dennett, D. C. (1978). Why you can't make a computer that feels pain. *Synthese, 38,* 415–449.

Dennett, D. C. (1991). *Consciousness explained*. Boston: Little, Brown and Co.

Dennett, D. C., & Kinsbourne, M. (1992). Time and the observer: The where and when of consciousness in the brain. *Behavioral and Brain Sciences, 15*, 183–247.

Devinsky, O., & D'Esposito, M. (2004). *Neurology of cognitive and behavioral disorders.* New York: Oxford University Press.

Duncan, J., & Miller, E. K. (2002). Cognitive focus through adaptive neural coding in the primate prefrontal cortex. In D. T. Stuss & R .T. Knight (Eds.), *Principles of frontal lobe function* (pp. 278–291). Oxford: Oxford University Press.

Duncan, J., & Owen, A. M. (2000). Common regions of the human frontal lobe recruited by diverse cognitive demands. *Trends in Neurosciences, 23*, 475–483.

Eckardt-Klein, B. von (1975). Some consequences of knowing everything (essential) there is to know about one's mental states. *Review of Metaphysics*, *29*, 3–18.

Economo, C. von, & Koskinas, G. N. (1925). *Die Cytoarchitektonik der Hirnrinde des erwachsenen Menschen. Textband und Atlas*. Wien: Springer.

Edelman, G. M. (1989). *The remembered present: A biological theory of consciousness.* New York: Basic Books.

Edelman, G. M. (1992). *Bright air, brilliant fire: On the matter of the mind*. New York: Basic Books.

Edelman, G. M., & Tononi, G. (2000). *A universe of consciousness: How matter becomes imagination.* New York: Basic Books.

Elston, G. N., & Garey, L. (2004). *New research findings on the anatomy of the cerebral cortex of special relevance to anthropological questions*. Australia: University of Queensland Press.

Etcharry-Bouyx, F., & Ceccaldi, M. (2007). Gestural apraxia. In O. Godefroy & J. Bogousslavsky (Eds.), *The behavioral and cognitive neurology of stroke* (pp. 36–52). Cambridge: Cambridge University Press.

Evers, C. W., & Lakomski, G. (2000). *Doing educational administration: A theory of administrative practice*. Amsterdam: Pergamon.

Eysenck, M. W. (2004). *Psychology: An international perspective*. Hove, UK: Psychology Press.

Fawcett, A. J., & Nicolson, R. I. (2007). Dyslexia, learning, and pedagogical neuroscience. *Developmental Medicine and Child Neurology*, *49*, 306–311.

ffytche, D. H., & Catani, M. (2005). Beyond localization: From hodology to function. *Philosophical Transactions of the Royal Society of London (Biology), 360*, 767–779.

Fingelkurts, A. A., Fingelkurts, A. A., & Kähkönen, S. (2005). Functional connectivity in the brain-is it an elusive concept? *Neuroscience and Biobehavioral Reviews, 28,* 827–36.

Finger, S. (1994). *Origins of neuroscience: A history of explorations into brain function*. New York: Oxford University Press.

Finger, S. (2000). *Minds behind the brain: A history of the pioneers and their* *discoveries*. Oxford: Oxford University Press.

Fischer, K. W., Daniel, D. B., Immordino-Yang, M. H., Stern, E., Battro, A., Koizumi, H. (2007). Why mind, brain, and education? Why now? *Mind, Brain, and Education, 1*, 1–2.

Flechsig, P. (1927). *Meine myelogenetische Hirnlehre mit biographischer Einleitung*. Berlin: Julius Springer.

Fogassi, L., Gallese, V., Fadiga, L., Luppino, G., Matelli, M., & Rizzolatti, G. (1996). Coding of peripersonal space in inferior premotor cortex (area F4). *Journal of Neurophysiology, 76*, 141–157.

Fontana, H., Belziti, H., & Requejo, F. (2002). El espacio perforado anterior y zonas aledañas. Consideraciones funcionales. Parte I. *Revista Argentina de Neurocirugía*, *16*, 1–11.

François, C. (1999). Systemics and cybernetics in a historical perspective. *Systems Research and Behavioral Science, 16*, 203–219.

Freud, S. (1891). *Zur auffassung der aphasien, eine kritische studie.* Leipzig: Deuticke.

Freud, S. (1920). The psychogenesis of a case of homosexuality in a woman. *Standard Edition, 18*, 145–172.

Fritsch, G. T., & Hitzig, E. (1960). On the electrical excitability of the cerebrum [1870]. In G. Von Bonin (Ed.), *Some papers on the cerebral cortex* (pp. 73–96). Springfield, IL: Charles C. Thomas.

Fujii, T., Tanabe, H. C., Kochiyama, T., & Sadato, N. (2009). An investigation of cross-modal plasticity of effective connectivity in the blind by dynamic causal modeling of functional MRI data. *Neuroscience Research, 65*, 175–186.

Fuster, J. (2006). The cognit: A network model of cortical representation.

International Journal of Psychophysiology, 60, 125–132.

Fuster, J. M, Bodner, M., & Kroger, J. K. (2000). Cross-modal and cross-temporal association in neurons of frontal cortex. *Nature, 405*, 347–351.

Gardner, H. (1985). *The mind's new science: A history of the cognitive revolution*. New York: Basic Books.

Garey, L. J. (2006). *Brodmann's localisation in the cerebral cortex*. New York: Springer.

Geschwind, N. (1965). Disconnexion syndromes in animals and man. Part I. *Brain, 88*, 237–294.

Geschwind, N. (1965). Disconnexion syndromes in animals and man. Part II. *Brain, 88*, 585–644.

Ghazanfar, A. A., & Schroeder, C. E. (2006). Is neocortex essentially multisensory? *Trends in Cognitive Sciences, 10*, 278–285.

Gibson, J. J. (1986). *The ecological approach to visual perception*. Hillsdale, NJ: Lawrence Erlbaum.

Giedd, J. N. (2004). Structural magnetic resonance imaging of the adolescent brain. *Annals of the New York Academy of Sciences, 1021*, 77–85.

Godefroy, O., Cabaret, M., Petit-Chenal, V., Pruvo, J. P., & Rousseaux, M. (1999). Control functions of the frontal lobes. Modularity of the central-supervisory system? *Cortex, 35*, 1–20.

Goldar, J. C. (1975). *Cerebro límbico y psiquiatría*. Buenos Aires: Editorial Salerno.

Goldberg, E. (2005). *The wisdom paradox*. New York: Gotham Books.

Goldmann-Gross, R. G., & Grossman, M. (2008). Update on apraxia. *Current Neurology and Neuroscience Reports, 8*, 490–496.

Goldman-Rakic, P. (2000). Localization of function all over again. *NeuroImage, 11*, 451–457.

Goldman-Rakic, P. S., & Porrino, L. J. (1985). The primate mediodorsal (md) nucleus and its projection to the frontal lobe. *Journal of Comparative Neurology, 242*, 535–560.

Goswami, U. (2004). Neuroscience, education and special education. *British Journal of Special Education*, *31*, 175–183.

Grafman, J. (2000). Evidence for forms of neuroplasticity. *Journal of Communication Disorders*, *33*, 345–356.

Grasset, J. (1912). *Tratado de fisiopatología clínica. III. Neurobiología, ontogenía y filogenia, herencia*. Barcelona: Salvat y Compañía.

Graziano, M. S. A., Reiss, L. A., & Gross, C. G. (1999). A neuronal representation of the location of nearby sounds. *Nature*, *397*, 428–430.

Graziano, M. S. A., Yap, G. S., & Gross, C. G. (1994). Coding of visual space by premotor neurons. *Science*, *266*, 1054–1057.

Greene, J. D. W. (2005). Apraxia, agnosias, and higher visual function abnormalities. *Journal of Neurology, Neurosurgery and Psychiatry*, *76*, 25–34.

Greenspan, R. J., & Baars, B. J. (2005). Consciousness eclipsed: Jacques Loeb, Ivan P. Pavlov, and the rise of reductionistic biology after 1900. *Consciousness and Cognition*, *14*, 219–230.

Gross, C. G. (1998). Claude Bernard and the constancy of the internal environment. *Neuroscientist*, *4*, 380–385.

Gross, R. G., & Grossman, M. (2008). Update on apraxia. *Current Neurology and Neuroscience Reports*, *8*, 490–496.

Hallett, M. (2007). Volitional control of movement: The physiology of free will. *Clinical Neurophysiology*, *118*, 1179–1192.

Hurley, S. (2001). Perception and action: alternative views. *Synthese, 129*, 3–40.

Husserl, E. (1928). *Vorlesungen zur phänomenologie des inneren zeitbewusstseins* [1893–1917] (herausgegeben von Martin Heidegger). Halle: Max Niemeyer.

Ibañez, A., & Cosmelli, D. (2008). Moving beyond computational cognitivism: Understanding intentionality, intersubjectivity and ecology of mind. *Integrative Psychological & Behavioral Science, 42*, 129–136.

Ito, M. (2004). 'Nurturing the brain' as an emerging research field involving child neurology. *Brain and Development, 26*, 429–433.

Jacobsen, C. F, Elder, J. H., & Haslerud G. M. (1936). Studies of cerebral function in primates. *Comparative Psychology Monographs, 13*, 1–60.

Jakob, C. (1895). *Atlas des gesunden und kranken nervensystems nebst grundriss der anatomie, pathologie und therapie desselben*. München: J. F. Lehmann.

Jakob, C. (1896). *An Atlas of the normal and pathological nervous systems. Together with a sketch of the anatomy, pathology, and therapy of the same* (transl. by J. Collins). New York: William Wood & Co.

Jakob, C. (1897). Atlas der klinischen Untersuchungsmethoden nebst Grundriss der klinischen Diagnostik und der speziellen Pathologie und Therapie der inneren Krankheiten. München: Verlag von J. F. Lehmann.

Jakob, C. (1899). *Atlas des gesunden und kranken nervensystems nebst grundriss der anatomie, pathologie und therapie desselben* (2nd Ed.). München: J. F. Lehmann.

Jakob, C. (1901). *Atlas of the nervous system including an epitome of the anatomy, pathology, and treatment* (2nd Ed.) (transl. by E. D. Fisher). Philadelphia-London: W. B. Saunders & Co.

Jakob, C. (1906a). Consideraciones anátomo-biológicas sobre los centros del lenguaje. *La Semana Médica (Buenos Aires), 13*, 733–737.

Jakob, C. (1906b). Estudio anátomo-topográfico acerca de las relaciones entre los hemisferios cerebrales y el cráneo. *Revista de la Sociedad Médica Argentina (B. Aires), 14*, 353–378.

Jakob, C. (1906c). Estudios biológicos sobre los lóbulos frontales cerebrales. *La Semana Médica, 13*, 1375–1381.

Jakob, C. (1906d). Existe ó no un centro de Broca? *La Semana Médica (Buenos Aires), 13*, 677–678.

Jakob, C. (1906e). La leyenda de los lóbulos frontales cerebrales como centros supremos psíquicos del hombre. *Arquivos de Psiquiatría, Criminología y Ciencias Afines, 5*, 679–699.

Jakob, C. (1906f). Nueva contribución á la fisio-patología de los lóbulos frontales. *La Semana Médica, 13*, 1325–1329.

Jakob, C. (1906g). Existe ó no un centro de Broca? *La Semana Médica (Buenos Aires), 13*, 677–678.

Jakob, C. (1907–1908). Localización del alma y de la inteligencia, pt. I–IX. *El Libro (B. Aires), 1*, 151–159, 281–291, 433–445, 553–567; *2*, 3–16, 171–186, 293–308, 537–552, 695–710.

Jakob, C. (1907a). La légende des lobes frontaux en tant que centres supérieurs du psychisme de l'homme (abstracted by F. Deleni). *Revue Neurologique, 15*, 595.

Jakob, C. (1907c). Sobre apraxia. *La Semana Médica, 14*, 1344.

Jakob, C. (1907c). Sobre la sintomatología de las afecciones del lóbulo frontal. *La Semana Médica, 14*, 1285.

Jakob, C. (1909a). Curso sobre enfermedades del sistema nervioso en relación con su anatomía patológica dictado en la clínica del Dr. Ramos Mejía (Recog. por P.M. Barlaro). La Ciencia Médica, Buenos Aires.

Jakob, C. (1909b). Estudios anátomoclínicos sobre los lóbulos frontales del cerebro humano (Comunicación presentada al IV Congreso Médico Latinoamericano, Rio de Janeiro, 1–8 de agosto de 1909). *Argentina Médica, 7*, 463–472.

Jakob, C. (1910). La célula cortical en la locura. (Estudios histopatológicos sobre las células piramidales en las enfermedades mentales). Anales de la Administración Sanitaria y Asistencia Pública (pp. 263–267). Ediciones de La Semana Médica – Buenos Aires: Imprenta de E. Spinelli.

Jakob, C. (1911). *Das Menschenhirn: Eine Studie über den Aufbau und die Bedeutung seiner grauen Kerne und Rinde*. München: J. F. Lehmann.

Jakob, C. (1912a). Über die Ubiquität der senso-motorischen Doppelfunktion der Hirnrinde als Grundlage einer neuen, biologischen Auffassung des corticalen Seelenorgans. *Journal für Psychologie und Neurologie (Leipzig), 19*, 379–382.

Jakob, C. (1912b) Ueber die Ubiquität der senso-motorischen Doppelfunktion der Hirnrinde als Grundlage einer neuen biologischen Auffassung des kortikalen Seelenorgans. *Münchener Medizinische Wochenschrift, 59*, 466–468.

Jakob, C. (1913a). La psicología orgánica y su relación con la biología cortical. *Archivos de Psiquiatría, Criminología y Ciencias Afines (Buenos Aires), 12*, 680–698.

Jakob, C. (1913b). *La biología en el sistema de las ciencias filosóficas y naturales.* Buenos Aires: Universidad Nacional de Buenos Aires-Imprenta de Coni Hnos.

Jakob, C. (1913c). La psicopatogenia de los niños retardados: Psicogenesis degenerativa y su tratamiento biológico. *Revista de la Asociación Medica Argentina, 21*, 1003–1016.

Jakob, C. (1914). Los problemas biogenéticos en sus relaciones con la filosofía moderna. *Revista del Círculo Médico Argentino y Centro Estudiantes de Medicina (Buenos Aires), 14*, 87–98.

Jakob, C. (1916a). Encuesta sobre en plan de estudios de medicina y la formación del profesorado universitario. *Revista del Círculo Médico Argentino y Centro de Estudiantes de Medicina, 16*, 1–2.

Jakob, C. (1916b). Sobre la existencia simultánea de una doble función sensomotriz de la corteza cerebral come base de una nueva concepción biológica del órgano psíquico cortical. *Prensa Médica Argentina, 2*, 305–307.

Jakob, C. (1918). Del mecanismo al dinamismo del pensamiento: Estudio histórico-crítico de psicología orgánica. *Anales de la Facultad de Derecho y Ciencias Sociales de la Universidad de Buenos Aires, 18*, 195–238.

Jakob, C. (1919). La teoría actual de las gnosias y praxias como factores fundamentales en el dinamismo cortical. *Revista del Círculo Médico Argentino y Centro Estudiantes de Medicina (Buenos Aires), 19*, 1266–1275.

Jakob, C. (1920). Filosofía de la naturaleza: Un curso de conferencias dictadas en la Facultad de Filosofía y Letras en 1920, Cátedra de Biología. *Revista del Jardín Zoologico de Buenos Aires [Época II], 16*, 28–55.

Jakob, C. (1921). La teoría actual de las gnosias y praxias como factores fundamentales en el dinamismo de la corteza cerebral. *La Crónica Médica, 38*, 17–24.

Jakob, C. (1922). Del tropismo a la teoría general de la relatividad. *Revista de Humanidades (La Plata), 3*, 45–58.

Jakob, C. (1923). *Elementos de neurobiología*. La Plata: Biblioteca Humanidades.

Jakob, C. (1926). El espíritu de la música en la filosofía pre y postkantiana. *Revista de*

Humanidades (La Plata) 13, 119–132.

Jakob, C. (1935a). La filogenia de las kinesias: Sobre su organización y dinamismo evolutivo. *Anales del Instituto de Psicología de la Facultad de Filosofía y Letras de la Universidad de Buenos Aires, 1*, 109–127.

Jakob, C. (1935b). Sobre las bases orgánicas de la memoria. *Revista de Criminología, Psiquiatría y Medicina Legal, 127*, 84–114.

Jakob, C. (1937a). Descartes en la biología. In: L. J. Gerrero (Ed.), *Descartes – Homenaje en el Tercer Centenario del "Discurso del Método", tomo I* (pp. 57–66). Buenos Aires: Instituto de Filosofía de la Facultad de Filosofía y Letras.

Jakob, C. (1937b). *La enseñanza universitaria de la anatomía cerebral. Revista de la Asociación Médica Argentina, 51*, 799–803.

Jakob, C. (1938). La psicología de Descartes a través de tres siglos. *Anales del Instituto de Psicologia (Buenos Aires), 2*, 297–327.

Jakob, C. (1939). *El neoencéfalo: Su organización y dinamismo*. Buenos Aires: Universidad Nacional de La Plata, Facultad de Humanidades y Ciencias de la Educación–Imprenta López.

Jakob, C. (1941a). La función psicogenética de la corteza cerebral y su posible localización (Aspectos de la ontopsicogénesis humana). *Anales del Instituto de Psicología de la Facultad de Filosofía y Letras de la Universidad de Buenos Aires, 3*, 63–80.

Jakob, C. (1941b). *Neurobiología General (Folia Neurobiologica Argentina, Tomo I).* Buenos Aires: Aniceto López.

Jakob, C. (1943a). Clinica. Laboratorio. *Revista de Asociación Bioquímica Argentina. Septiembre – Octubre*, 42–45.

Jakob, C. (1943b). *Folia Neurobiológica Argentina, Tomo II. El Pichiciego (Chlamydophorus Truncatus): Estudios Neurobiológicos de un Mamífero Misterioso de la Argentina*. Buenos Aires: Aniceto López.

Jakob, C. (1943c). *Folia neurobiológica Argentina, tomo III. El lóbulo frontal: Estudio monográfico anatomoclínico sobre base neurobiológica.* Buenos Aires: Aniceto López-López y Etchegoyen.

Jakob, C. (1945a). El cerebro humano: Su significación filosófica. Ensayo de un programa psico-bio-metafísico, después de 50 años de dedicación neurobiológica. *Revista Neurológica de Buenos Aires, 10*, 89–110.

Jakob, C. (1945b). Sobre el origen de la conciencia: investigaciones neurobiológicas sobre la dinámica cortical en relación con su sectorización conmemorativa. In E. Mouchet (Ed.), *Temas actuales de psicología normal y patológica, publicados bajo el patrocinio de la Sociedad de Psicología de Buenos Aires* (pp. 345–381). Buenos Aires: Editorial Médico-Quirúrgica/Talleres 'The Standard'.

Jakob, C. (1946a). *Folia neurobiológica Argentina, tomo V. Documenta biofilosófica: Folleto I: Biología y filosofía A. Aspectos de sus divergencias y concomitancias; B. Ensayo de psicogenia orgánica*. Buenos Aires: López & Etchegoyen.

Jakob, C. (1946b). La demencia progresiva: Un analisis neurobiologico de la enfermedad de Pick. *Revista Neurologica de Buenos Aires, 1*, 81–94.

Jakob, C. (1948). La psicointegración introyento-ambiental orgánica y sus problemas para la neuropsiquiatría y psicología, primera parte: Su filogenía constructiva. *Revista Neurológica de Buenos Aires, 13*, 115–141.

Jakob, C., & Onelli, C. (1913). Atlas del cerebro de los mamíferos de la Republica

Argentina: Estudios anatómicos, histológicos, y biológicos comparados sobre la evolución de los hemisferios y de la corteza cerebral. Buenos Aires: G. Kraf.

Jakob, C., & Copello, A. R. (1948). La psicointegración introyento-ambiental orgánica y sus problemas para la neuropsiquiatría y psicología. *Revista Neurologica de Buenos Aires, 13*, 63–79.

Jakob, C., & Copello, A. R. (1949). La cuantificación neuronal de la región limbica en su relación con la esfera introyental afectiva. *Archivos de Neurocirugía, 6*, 475–481.

Jakob, C., & Pedace, E. A. (1949). La misión del lóbulo frontal frente a una cuantificación sintética de sus elementos productores. Archivos de Neurocirugía, 6, 467–474.

James, W. (1884). What is an emotion? *Mind, 9*, 188–205.

James, W. (1952). *The Principles of Psychology* [1890]. Chicago: University of Chicago – Encyclopaedia Britannica.

Jung, C. G. (1960). *The psychogenesis of mental disease*. New York: Pantheon Books.

Kant, I. (1781). *Critik der reiner vernunft*. Riga: Johann Friedrich Hartknoch.

Kant, I., Guyer, P., & Wood, A. W. (1998). *Critique of pure reason*. Cambridge: Cambridge University Press.

Kleist, K. (1934). *Gehirnpathologie.* Leipzig: Johann Ambrosius Barth.

Koechlin, E., Ody, C., & Kouneiher, F. (2003). The architecture of cognitive control in the human prefrontal cortex. *Science, 302*, 1181–1185.

Koizumi, H. (2004). The concept of ‘developing the brain’: A new natural science for learning and education. *Brain and Development, 26*, 434–441.

Kouider S. (2009). Neurobiological theories of consciousness. In Banks, W. (Ed.), *Encyclopedia of Consciousness,* (pp. 87–100), vol. 2. Amsterdam: Elsevier.

Lautin, A. (2001). The limbic brain. New York: Kluwer Academic/Plenum Publishers.

Leiguarda, R. C., & Marsden, C. D. (2000). Limb apraxias: Higher-order disorders of sensorimotor integration. *Brain, 123,* 860–879.

Liepmann, H., Lange, J., Pötzl, O., & Brown, J. W. (1988). *Agnosia and apraxia: Selected papers of Liepmann, Lange, and Pötzl*. Hillsdale, NJ: L. Erlbaum Associates.

Lissauer, H. (1890). Ein Fall von Seelenblindheit nebst einem Beitrage zur Theorie derselben. *Archiv für Psychiatrie und Nervenkrankheiten, 21*, 222–270.

Lissauer, H., & Jackson, M. (1988). A case of visual agnosia with a contribution to theory. *Cognitive Neuropsychology, 5*, 157–192.

López Pasquali, L. (1965). *Christfried Jakob. Su obra neurológica, su pensamiento psicológico y filosófico.* Buenos Aires: López.

Lorch, M. P. (2008). The merest logomachy: The 1868 Norwich discussion of aphasia by Hughlings Jackson and Broca. *Brain, 131,* 1658–1670.

Lores Arnaiz, M. R., Borrego Maturana, F., & Azzara, S. (2002). Las ideas de Christofredo Jakob sobre mapa cortical y functiones superiores. *Revista de la Historia de la Psicologia, 23,* 9–36.

MacLean, P. D. (1949). Psychosomatic disease and the ‘‘visceral brain’’: Recent developments bearing on the Papez theory of emotion. *Psychosomatic Medicine, 11*, 338–353.

MacLean, P. D. (1955). The limbic system (‘‘visceral brain’’) and emotional behavior. *Archives of Neurology and Psychiatry, 73*, 130–134.

Macmillan, M. (2004). ‘I could see, and yet, mon, I could na’ see’: William

MacEwen, the agnosias, and brain surgery. *Brain and Cognition, 56*, 63–76.

Mashour, G. A. (2007). The cognitive binding problem: From Kant to quantum neurodynamics. *NeuroQuantology, 2*, 29–38.

Maturana, H. R., & Varela, F. J. (1980). *Autopoiesis and cognition*. *The realization of the living.* Dordrecht: Reidel.

Maturana, H. R., & Varela, F. J. (1987). *The tree of knowledge: The biological roots of human understanding*. Boston, MA: New Science Library – Shambhala Publications.

Meyer, A. (1974).The frontal lobe syndrome, the aphasias and related conditions: A contribution to the history of cortical localization. *Brain*, 97, 565–600.

Meyer, L. (1981). Cristofredo Jakob: A veinticinco años de su muerte. *Acta Psiquiátrica y Psicologica América Latina, 27*, 13–14.

Mitchell, B. D., & Cauller, L. J. (2001). Corticocortical and thalamocortical projections to layer I of the frontal neocortex in rats. *Brain Research, 921*, 68–77.

Monakow, C. von (1904). Über den gegenwärtigen Stand der Frage nach der Lokalisation im Grosshirn. *Ergebnisse der Physiologie, 3*, 100–122.

Monakow, C. von (1910). Neue Gesichtspunkte in der Frage nach der Lokalisation im Grosshirn. *Zeitschrift für Physiologie der Sinnesorgane, 54*, 161–182.

Moyano, B. A. (1957). Christfried Jakob, 25/12/1866–6/5/1956. *Acta Neuropsiquiátrica Argentina, 3*, 109–123.

Nagel, T. (1971). Brain bisection and the unity of consciousness. *Synthese, 22*, 396–413.

Nagy, Z., Westerberg, H., & Torkel, K. (2004). Maturation of white matter is associated with the development of cognitive functions during childhood.

Journal of Cognitive Neuroscience, 16, 1227–1233.

Northoff, G. (2004). What is neurophilosophy? A methodological account. *Journal for General Philosophy of Science, 35*, 91–127.

Ochs, S. (2004). *A history of nerve functions: From animal spirits to molecular mechanisms*. Cambridge: Cambridge University Press.

Olmsted, J. M. D., & Olmsted, E. H. (1952). *Claude Bernard and the experimental method in medicine*. New York: Henry Schuman.

Orlando, J. C. (1966). *Christofredo Jakob: Su vida y obra*. Buenos Aires: Editorial Mundi.

Outes, D. L. (2006). A medio siglo de la muerte de Christofredo Jakob, 1956–2006: Fuentes de la concepción biológica de la doble corteza. *Electroneurobiología (Buenos Aires), 14*, 3–28

Outes, D. L., & Benítez, I. (1976). Sobre el origen de la concepción biológica de la doble corteza: A veinte años de la muerte de Christofredo Jakob, 1956–1976. *Revista Neurológica Argentina, 1*, 220–228.

Owen, R. (1866–1868). *On the anatomy of vertebrates, vol. I–III.* London: Longmans, Green, and Co.

Panksepp, J. (1998). *Affective neuroscience: The foundations of human and animal emotions*. New York: Oxford University Press.

Papez, J. W. (1937a). A proposed mechanism of emotion. *Archives of Neurology and Psychiatry 38*, 725–743.

Pedace, E. A. (1949). Contribución de la escuela neurobiológica Argentina del Prof. Chr. Jakob en el estudio del lobulo frontal. *Archivos de Neurocirugía, 6*, 464–466.

Petitto, L. A., & Dunbar, K. (2004). *New findings from educational neuroscience on* *bilingual brains, scientific brains, and the educated mind.* Paper presented at the conference on Building Usable Knowledge in Mind, Brain, and Education. Cambridge, MA: Harvard Graduate School of Education.

Petrides M. (2005). Lateral prefrontal cortex: Architectonic and functional organization. *Philosophical Transactions of the Royal Society of London (Biology), 360*, 781–795.

Piaget, J. (1952). *The origins of intelligence* (2nd Ed.). New York: International Universities Press.

Piaget, J. (1954). *The construction of reality in the child*. New York: Basic Books.

Piaget, J. (1967). *Biologie et connaissance: essai sur les relations entre les régulations organiques et les processus cognitifs*. Paris: Gallimard.

Piaget, J. (1972). *The principles of genetic epistemolology.* London: Routledge and Kegan Paul.

Piaget, J. (1976). *Le comportement, moteur de l'évolution*. Paris: Gallimard.

Pujol, J., Soriano-Mas, C., Ortiz, H., Sebastian-Galles, N., Losilla, J. M., & Deus J. (2006). Myelination of language-related areas in the developing brain. *Neurology, 66*, 339–343.

Quine, W. (1960). *Word and object*. Cambridge, MA: MIT Press.

Raichle, M. E. (2002). Foreword. In D. T. Stuss & R. T. Knight (Eds.), *Principles of frontal lobe function* (pp. vii-ix). Oxford: Oxford University Press.

Ribary, U., Llinás, R., & Joliot, M. (1994). Human oscillatory brain activity near 40Hz coexists with cognitive temporal binding. *Proceedings of the National Academy of Sciences of USA, 91*, 11748–11751.

Risberg, J. (2006). Evolutionary aspects on the frontal lobes. In J. Risberg & J. Grafman (Eds), *The frontal lobes: Development, function, and pathology* (pp.

1–20). Cambridge: Cambridge University Press.

Rudrauf, D., Lutz, A., Cosmelli, D., Lachaux, J. P., & Le Van Quyen, M. (2003). From autopoiesis to neurophenomenology: Francisco Varela's exploration of the biophysics of being. *Biological Research, 36*, 27–66.

Sadato, N. (2005). How the blind 'see' Braille: lessons from functional magnetic resonance imaging. *The Neuroscientist, 11*, 577–582.

Semendeferi, K., Lu, A., Schenker, N., & Damasio, H. (2002). Humans and great apes share a large frontal cortex. *Nature Neuroscience, 5*, 272–276.

Shallice, T. (2002). Fractionation of the supervisory system. In: D. T. Stuss & R. T. Knight (Eds.), *Principles of frontal lobe function* (pp. 261–277). Oxford: Oxford University Press.

Shallice, T., & Burgess, P. (1996). The domain of supervisory processes and temporal organization of behaviour [and discussion]. *Philosophical Transactions: Biological Sciences, 351*, 1405–1412.

Shallice, T., & Jackson, M. (1988). Lissauer on agnosia. *Cognitive Neuropsychology, 5*, 153–156.

Sowell, E. R., Thompson, P. M., Holmes, C. J., Jernigan, T. L., & Toga, A. W. (1999). In vivo evidence for postadolescent brain maturation in frontal and striatal regions. *Nature Neuroscience, 2,* 859–860.

Stuss, D. T. (2006). Frontal lobes and attention: Processes and networks, fractionation and integration. *Journal of the International Neuropsychological Society, 12*, 261–271.

Stuss, D. T., Alexander, M. P., Floden, D., Binns, M. A., Levine, M., McIntosh, A. R., Rajah, N., & Hevenor, S. J. (2002). Fractionation and localization of distinct frontal lobe processes: Evidence from focal lesions in humans. In: D.

T. Stuss & R. T. Knight (Eds.), *Principles of frontal lobe function* (pp. 392–407). Oxford: Oxford University Press.

Szirko, M., 1999. Constructivism is not pantopoiesis. *Karl Jaspers Forum.* http://www.kjf.ca/15-C32SZ.htm. Retrieved November 8, 2011.

Szũcs. D., & Goswami, U. (2007). Educational neuroscience: Defining a new discipline for the study of mental representations. *Mind, Brain, and Education, 1*, 114–127.

Teuber, H. L. (2009). The riddle of frontal lobe function in man. *Neuropsychology Review, 19*, 25–46.

Théodoridou, Z. D., & Triarhou L. C. (2009). Fin-de-siècle advances in neuroeducation: Henry Herbert Donaldson and Reuben Post Halleck. *Mind Brain and Education, 3,* 117–127.

Théodoridou, Z. D., Triarhou L. C. (2011a). Challenging the supremacy of the frontal lobe: Early views (1906–1909) of Christfried Jakob on the human cerebral cortex. *Cortex.* doi:10.1016/j.cortex.2011.01.001.

Théodoridou, Z. D., & Triarhou L. C. (2011b). Christfried Jakob's late views on cortical development, localization and neurophilosophy. *Neuroscience Letters, 500 (Suppl.)*, e43–e44.

Théodoridou, Z. D., & Triarhou, L. C. (2011c). Christfried Jakob's 1921 theory of the gnoses and praxes as fundamental factors in cerebral cortical dynamics. *Integrative Psychological and Behavioral Science, 45*, 247–262.

Théodoridou, Z. D., & Triarhou, L. C. (2012a). Christfried Jakob's late views (1930–1949) on the psychogenetic function of the cerebral cortex and its localization: Culmination of the neurophilosophical thought of a keen brain observer. *Brain and Cognition* (in press).

Theodoridou, Z. D., & Triarhou, L. C. (2012b). Evolution of Christfried Jakob's views on the frontal lobe, 1899–1949. In A. E. Cavanna (Ed.), *Frontal lobe: Anatomy, Function and Injury*. Hauppauge, NY: Nova Science Publishers (in press).

Thompson, E., & Varela, F. J. (2001). Radical embodiment: Neural dynamics and consciousness. *Trends in Cognitive Science, 5*, 418–425.

Tononi, G., & Edelman, G. M. (1998). Consciousness and complexity. *Science, 282*, 1846–1851.

Triarhou, L. C. (2008). Centenary of Christfried Jakob's discovery of the visceral brain: An unheeded precedence in affective neuroscience. *Neuroscience and Biobehavioral Reviews, 32*, 984–1000.

Triarhou, L. C. (2009). Tripartite concepts of mind and brain, with special emphasis on the neuroevolutionary postulates of Christfried Jakob and Paul MacLean. In S. P. Weingarten & H. O. Penat (Eds.), Cognitive Psychology Research Developments (pp. 183–208). Hauppauge, New York: Nova Science Publishers.

Triarhou, L. C. (2010a). Final publications of Christfried Jakob: On the frontal lobe and the limbic region. In: C. E. Flynn & B. R. Callaghan, (Eds.), *Neuroanatomy Research Advances* (pp. 165–169). Hauppauge, New York: Nova Science Publishers.

Triarhou, L. C. (2010b). Revisiting Christfried Jakob's concept of the dual onto-phylogenetic origin and ubiquitous function of the cerebral cortex: A century of progress. *Brain Structure and Function, 214*, 319–338.

Triarhou, L. C., & del Cerro, M. (2006a). Semicentennial tribute to the ingenious neurobiologist Christfried Jakob (1866–1956). 1. Works from Germany and the first Argentina period, 1891–1913. *European Neurology, 56*, 176–188.

Triarhou, L. C., & del Cerro, M. (2006b). Semicentennial tribute to the ingenious neurobiologist Christfried Jakob (1866–1956). 2. Publications from the second Argentina period, 1913–1949. *European Neurology, 56,* 189–198.

Triarhou, L. C., & del Cerro, M. (2007). Pioneers in Neurology: Christfried Jakob (1866–1956). *Journal of Neurology, 254*, 124–125.

Tsapkini, K., Vivas, A. B., & Triarhou, L. C. (2008). 'Does Broca's area exist?' Christofredo Jakob's 1906 response to Pierre Marie's holistic stance. *Brain and Language, 105*, 211–219.

Uexküll, J. von (1957). A stroll through the worlds of animals and men [1934]. In C. Schiller (Ed.), *Instinctive behavior* (pp. 5–80). New York: International Universities Press.

Varela, F. (1996). Neurophenomenology: A methodological remedy to the hard problem. *Journal of Consciousness Studies, 3,* 330–350.

Véganzonès, M. A., & Winograd, C. (1997). *Argentina in the 20th Century: An account of long-awaited growth*. Paris: Development Centre of the Organisation for Economic Co-operation and Development.

Vivas, A. B., Tsapkini, K., & Triarhou, L.C. (2007). Anatomo-biological considerations on the centers of language: An Argentinian contribution to the 1906 Paris debate on aphasia. *Brain and Development, 29,* 455–461.

Wallace, M. T., Meredith, M. A., & Stein, B. E. (1992). Integration of multiple sensory modalities in cat cortex. *Experimental Brain Research, 91*, 484–488.

Weizsäcker, V. von (1950). *Der Gestaltkreis.* Stuttgart: Thieme.

Wiener, N. (1948). *Cybernetics or control and communication in the animal and the machine.* Paris: Hermann.

Yakovlev. P. I., & Lecours, A. R. (1967). The myelogenetic cycles of regional maturation of the brain. In A. Minkowski (Ed.), *Regional Development of the Brain in Early Life* (pp. 3–70). London: Blackwell.

York, G. K. (2009). Localization of language function in the twentieth century. *Journal of the History of the Neurosciences*, *18*, 283–290.

Zeman, A. (2001). Consciousness, *Brain*, *124*, 1263–1289.

Zülch, K. J. (1975). Pyramidal and parapyramidal motor systems in man. In K. J. Zülch, O. Creutzfeldt, & G. C. Galbraith (Eds.), *Cerebral localization: An Otfrid Foerster symposium* (pp. 32–47). Berlin-Heidelberg: Springer.

LIST OF PUBLICATIONS

PAPERS

Théodoridou, Z. D., & Triarhou L. C. (2009). Telencephalic specialization and hemispheric plasticity in functional language compensation: Clues from Neuropathology [article in Greek]. *Annals of Psychology of the University of Crete, 4,* 133–152.

Théodoridou, Z. D., & Triarhou L. C. (2009). Fin-de-siècle advances in neuroeducation: Henry Herbert Donaldson and Reuben Post Halleck. *Mind Brain and Education, 3,* 117–127.

Théodoridou, Z. D., & Triarhou L. C. (2011). Challenging the supremacy of the frontal lobe: Early views (1906–1909) of Christfried Jakob on the human cerebral cortex. *Cortex, 48,* 15–25.

Théodoridou, Z. D., & Triarhou, L. C. (2011). Christfried Jakob's 1921 theory of the gnoses and praxes as fundamental factors in cerebral cortical dynamics. *Integrative Psychological and Behavioral Science, 45*, 247–262.

Théodoridou, Z. D., & Triarhou, L. C. (2012). Christfried Jakob's late views (1930–1949) on the psychogenetic function of the cerebral cortex and its localization: Culmination of the neurophilosophical thought of a keen brain observer. *Brain and Cognition* (in press).

ABSTRACTS

Theodoridou, Z. D., & Triarhou, L. C. (2010). *Early views of Christfried Jakob on the cerebral cortex: Challenging the supremacy of the frontal lobe.* Abstract presented at the 15th Annual Meeting of the International Society for the

History of the Neurosciences, Paris, France. Journal of the History of the Neurosciences, 19, 409–410.

Théodoridou, Z. D., & Triarhou L. C. (2011). *Christfried Jakob's late views on cortical development, localization and neurophilosophy.* Abstract presented at the 3rd Biennial Meeting of the Society of Applied Neuroscience, Thessaloniki, Greece. Neuroscience Letters, 500 (Suppl.), e43–e44.

CHAPTERS

Theodoridou, Z. D., & Triarhou, L. C. (2012). Evolution of Christfried Jakob’s views on the frontal lobe, 1899–1949. In A. E. Cavanna (Ed.), *Frontal lobe: Anatomy, Function and Injury*. Hauppauge, NY: Nova Science Publishers (in press).