Cécile Vogt-Mugnier (1875–1962): Pioneering Neuroscience and Feminism on Her Sesquicentennial Birth Anniversary

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SUMMARY

This article marks the 150th birth anniversary of Cécile Vogt-Mugnier (1875–1962), a pioneering neuroscientist whose groundbreaking research significantly advanced our understanding of brain structure and function. Her work in cerebral cortex mapping, the mind-body debate, and brain-targeted medical interventions laid the foundation for modern neuroanatomy and neuropsychiatry. Vogt-Mugnier's studies on thalamic myeloarchitecture, corpus striatum pathology, and cortical cytoarchitecture, along with her co-development of the "pathoclisis" theory linking molecular genetics to neuroanatomy, were instrumental in shaping the field. Her exploration of cytoarchitecture and electrical stimulation was pivotal in the development of functional brain mapping.

In addition to her scientific achievements, Vogt-Mugnier was a strong advocate for gender equity in STEM (Science, Technology, Engineering, and Mathematics), seamlessly integrating feminist principles into her research. Her humanistic ideals, alongside her commitment to advancing women in science, played a crucial role in shaping her enduring legacy. Despite facing gender biases and enduring the "Matilda Effect," which led to the underappreciation of her contributions, her collaboration with Oskar Vogt remains a cornerstone of neuroscience, with a lasting influence on the field.

Key words: Neuroscience, Neuroanatomy, Basal ganglia, Gender Equity

RESUMO

Este artigo comemora o 150º aniversário de nascimento de Cécile Vogt-Mugnier (1875–1962), uma pioneira da neurociência, cujas pesquisas avançaram significativamente a compreensão da estrutura e função do cérebro. Seu trabalho no mapeamento do córtex cerebral, no debate mente-corpo e nas intervenções médicas direcionadas ao cérebro lançou as bases para a neuroanatomia moderna e a neuropsiquiatria. Os estudos de Vogt-Mugnier sobre mieloarquitetura talâmica, patologia do corpo estriado e citoarquitetura cortical, juntamente com o desenvolvimento conjunto da teoria da "pathoclisis", que vincula a genética molecular à neuroanatomia, foram fundamentais para a formação do campo. Sua pesquisa sobre citoarquitetura e estimulação elétrica foi crucial para o desenvolvimento do mapeamento funcional do cérebro.

Além de suas realizações científicas, Vogt-Mugnier foi uma defensora ativa da equidade de gênero em CTEM (Ciência, Tecnologia, Engenharia e Matemática), integrando princípios feministas em suas pesquisas. Seus ideais humanistas, juntamente com seu compromisso em promover as mulheres na ciência, desempenharam um papel fundamental na construção de seu legado duradouro. Apesar de enfrentar preconceitos de gênero e sofrer os efeitos do "Efeito Matilda", que levou à subvalorização de suas contribuições, sua colaboração com Oskar Vogt permanece como um marco na neurociência, com uma influência duradoura no campo.

Palavras-chave: Neurociência, Neuroanatomia, Gânglios basais, Equidade de Gênero

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INTRODUCTION

Cécile Vogt-Mugnier (fig 1) stands as one of the most influential figures in neuroscience, particularly renowned for her work on the cytoarchitecture of the cerebral cortex and on basal ganglia, which transformed the understanding of brain structure and its function[1-13]. Despite enduring systemic biases that often relegated her contributions behind those of her male colleagues, Vogt-Mugnier's rigorous research made significant contributions to understanding the layered structure of the cerebral cortex, cerebral fiber pathways, and the anatomical and physiological features of the extrapyramidal system. In addition to her scientific accomplishments, Vogt-Mugnier was an ardent advocate for gender equity, championing increased representation of women in research[1,4,5,9]. This article honors her enduring impact on neuroscience and the ongoing struggle for greater gender inclusivity in the scientific community.

Figure 1. Portrait of Vogt-Maugnier Vogt-Mugnier (1875–1962): Pioneer in Neuroscience and Feminist Resilience in Science.

Early Life and Education

Cécile Vogt-Mugnier was born on March 27, 1875, in Annecy, France, into an intellectually progressive environment of unmarried parents, that encouraged independence and critical thinking. Her father's early death when she was two, along with her mother's nonconformist values, which distanced the family from the church, deeply influenced Vogt-Mugnier's future path as a pioneering scientist and advocate for gender equality. Her medical education commenced in Paris in 1893, culminating in her graduation in 1900 under the tutelage of prominent neurologists such as Pierre Marie at the Bicêtre Hospital. This academic foundation marked the onset of her extraordinary career in neuroscience [1,4,10,11].

In 1899, Vogt-Mugnier married fellow neurologist Oskar Vogt, who worked alongside Joseph Jules Dejerine and Augusta Marie Dejerine-Klumpke]. In 1897, at the age of 22, Cécile Mugnier became pregnant while studying for her medical degree. She gave birth the following year as an unmarried mother, and four years later, Oskar adopted her child. Their marriage was characterized by both personal and professional collaboration; however, Vogt-Mugnier's contributions were frequently overshadowed by the male-dominant institutional narrative [Oehler R]. Despite this, she achieved considerable advancements in neuroanatomy, particularly through their joint research on the basal ganglia, co-founding the Neurologische Zentralstation in Berlin, a pivotal center for innovative brain research. Vogt-Mugnier's early life experiences and progressive values molded her leftist ideologies and her dual endeavors in science and social advocacy, particularly for women in the scientific domain.

Founding and Impact of Brain Research Institutes: The Vogts' Contributions

In 1898/99, Cécile and Oskar Vogt launched their brain research program, *Neurologische Zentralstation*, in their Berlin apartment. The program included a psychotherapy practice, a psychological laboratory, and a neuroanatomy department, with income primarily generated from psychotherapy. By 1902, their research received financial support from Friedrich Wilhelm University in Berlin, leading to the establishment of the *Neurobiologisches Laboratorium* (Neurobiological Laboratory). Over the following years, their work made significant contributions to brain research, setting the stage for future advancements in the field[3,9,11].

In 1911, the Kaiser - Wilhelm - Gesellschaft - KWG (Kaiser Wilhelm Society) was established to promote scientific research across various disciplines. The Vogts' work helped establish the Institute for Brain Research in 1914, housed in the Neurobiological Laboratory near Charité Medical School, within the KWG. This institute later became the Kaiser-Wilhelm-Institut für Hirnforschung (KWI), where Oskar Vogt served as director. Despite facing gender biases that limited Cécile Vogt-Mugnier's recognition, she played a crucial role in their groundbreaking work alongside her husband. Their contributions were further supported by an international network of collaborators, many of whom fled Nazi Germany.

From 1901 to 1910, under Oskar Vogt's mentorship, Korbinian Brodmann published his influential 1909 cytoarchitectonic classification of cortical areas, a key development in neuroanatomy. In 1928, Oskar Vogt's study of Lenin's brain led to the founding of the Moscow Brain

Institute, where he controversially claimed that Lenin's brain demonstrated superior associative thinking[14].

In 1931, the KWI moved to a state-of-the-art facility in Berlin-Buch. However, the Vogts' opposition to National Socialism led to their forced early retirement in 1937. In response, they established a private research institute in the Black Forest and, in 1936, founded the *Institut für Hirnforschung und allgemeine Biologie* in Neustadt. Despite rising political pressures, they continued their groundbreaking work. Oskar Vogt also provided refuge to Jewish colleagues and openly criticized the Nazi regime, demonstrating moral courage in the face of adversity[15].

In 1937, Hugo Spatz succeeded Oskar Vogt as director of the KWI, and Julius Hallervorden became the head of neuropathology. Both were later implicated in unethical research involving victims of Nazi euthanasia, casting a shadow over the institute's legacy.

After World War II, the KWI was reorganized under the Max Planck Society and renamed the Max Planck Institute for Brain Research in 1948. A new facility was opened in Frankfurt-Niederrad in 1962, marking a new phase in the institute's development.

The Vogts' legacy endures through the institutions they founded and their pivotal contributions to neuroanatomy and brain research. Despite the interruption caused by National Socialism, which forced their departure from Berlin due to their opposition to Nazi racial policies, they continued their research and protected Jewish colleagues. Their resilience in the face of adversity and their commitment to advancing neuroscience remain defining features of their work[15]. While some of their research, such as brain enhancement, ventured into ethically controversial areas, their contributions to the field of brain research are undeniably profound.

Anatomical and Clinical Studies

Cécile Vogt - Mugnier's groundbreaking neuroscience work began under the mentorship of Pierre Marie at the Bicêtre Hospital in Paris, where she completed her doctoral thesis, Étude sur la Myélinisation des Hémisphères Cérébraux (Study on the Myelination of the Cerebral Hemispheres). This pivotal research explored the development and distribution of myelin across different mammalian species, laying the groundwork for her later investigations into the cytoarchitecture and myeloarchitecture of the central nervous system[9]. In collaboration with her husband, Oskar Vogt, she employed innovative techniques such as cortical electrostimulation in monkeys to map the cortex and thalamus, significantly advancing the understanding of neural pathways and specific brain regions. Their work integrated neuroanatomy with functional neuroscience, providing invaluable insights into the central nervous system.

The Vogts' pioneering cytoarchitectonic studies led them to describe nearly 200 distinct areas within the human cerebral cortex, each with unique neuronal arrangements. Some of these areas were linked to specific functional responses through electrical stimulation, providing the foundation for modern brain mapping[2]. Together, their research on the basal ganglia laid the foundation for understanding motor control and its implications for neuropsychiatric disorders, ensuring the Vogts' lasting legacy in neuroscience. Their work also contributed to the study of movement disorders such as Huntington's chorea, in which they identified pathological changes within the basal ganglia. This research culminated in the identification of "Vogt's syndrome," a condition that bridged neuroanatomy and clinical psychiatry[9].

Vogt - Mugnier's work spanned neurology, psychiatry, anatomy, and psychology, offering a physiological lens through which to view mental illness. She critiqued Freud's psychoanalysis, proposing that unresolved emotional experiences, rather than unconscious repression, were the root cause of neuroses. She coined the term "dysamnesia" to describe this condition, promoting a biopsychosocial approach that emphasized the role of somatic factors in psychiatric disorders[9]. Her investigations into hysteria and other psychiatric conditions highlighted the physiological contributions to mental illness, contributing to a paradigm shift in psychiatry that prioritized biological over psychological explanations.

As detailed in Satzinger's paper[9], both Cécile and Oskar Vogt localized brain functions and explored the cellular mechanisms underlying consciousness and psychiatric disorders. Their work linked psychiatric conditions, including psychoses, with structural brain changes, while also addressing socially significant issues like criminality. Although they initially employed psychotherapeutic methods, by the 1920s their focus shifted to somatic and pharmacological therapies, in line with a broader shift in psychiatry towards biological explanations.

In 1909, Cécile Vogt-Mugnier published La Myelocytoarchitecture du Thalamus du Cercopithèque, a study that explored the thalamic structures in Old World monkeys and their interconnected roles within the basal ganglia. Her 1911 study on the "status marmoratus" of the corpus striatum revealed its association with movement disorders marked by slow, writhing movements, advancing the understanding of basal ganglia pathology. In collaboration with Hermann Oppenheim, she studied hereditary palsy and double athetosis, emphasizing the mottled appearance of the striatum as a key pathological feature.

In a quick search on Pubmed, it seems that between 1946 and 1962, Vogt-Mugnier published a series of influential papers on psychiatric disorders and neuroanatomy, covering topics such as the classification of schizophrenia, the anatomical basis of psychiatric conditions, and the aging process of neural structures. Her work on aging revealed that neuronal aging is genomically regulated and varies across different brain regions. She found that inactivity accelerates neuronal aging, while activity helps delay it. Notable publications, *including Etiological Classification of Schizophrenia and Other Functional Psychoses* (1953) and *Nature and Orthological Significance of Pathological Phenomena* (1947), highlighted her ability to integrate neuroanatomy with psychiatry. Her research also delved into systemic conditions such as aging and arteriosclerosis, with studies like *Thalamusstudien I* (1941) providing critical insights into how structural brain abnormalities lead to clinical pathologies. However, her radical theories on human behavior linked to an assumed innate brain structure, particularly her post-1945 efforts to find a clear anatomical substrate for schizophrenia, are now considered an overly simplistic approach to understanding brain structure and function[10].

The Vogts focused on the intricate relationships between brain structure and behavior, introducing the concept of "pathoclitic architecture." In this theory, Vogt-Mugnier proposed that environmental changes could induce genomic mutations contributing to variability in the human cerebral cortex. She defined pathoclisis as a genomic predisposition leading to excessive variability and pathological changes in the brain, connecting cytoarchitectonic differences to molecular genetic variability —a concept that is now central to neuroscience[2]. Her research also explored sublethal brain injuries, such as cerebral ischemia, examining genomic responses that influence cell survival or death. Her work highlighted the role of selective vulnerability in specific brain regions, which is now essential for designing targeted therapeutic strategies[2]. The pathoclitic architecture framework, examined in Stahnisch's analysis, emerged from the Vogts' research at the Kaiser Wilhelm Institute, where they studied the histological basis of neuropsychiatric diseases. Their investigations linked microscopic brain changes with pathology, physiology, and genetics. While their work was influenced by eugenic ideas, it ultimately paved the way for later research paradigms, even as its prominence waned with the rise of functional neuroscience post-World War II. By the 1960s, the morphological methods pioneered by the Vogts were replaced by integrative, functional approaches, marking a shift in neuroscience while underscoring the ethical complexities of early research.

Parent[6] and Percheron [7] extensively reviewed the history of basal ganglia research. According to Percheron, the contributions of Vogt-Maugnier, both independently and with her husband Oskar Vogt, were foundational in advancing neuroanatomy and neurology, especially concerning the basal ganglia. In 1909, Vogt-Maugnier published *La myelocytoarchitecture du thalamus du cercopitheque in Journal für Psychologie und Neurologie*, which examined the myelocytic architecture of the thalamus in cercopithecus monkeys. Two years later, in 1911, she introduced the concept of corpus striatum syndrome in *Quelques considérations générales à propos du syndrome du corps strié.*

The Vogts' collaboration in 1919, *Zur Kenntnis der pathologischen Veränderungen des striatum und des pallidum und zur Pathophysiologie des dabei auftretenden Krankheitserscheinungen*, focused on pathological changes in the striatum and pallidum, as well as the pathophysiology of related disorders. Their 1920 *work, Zur Lehre der Erkrankungen des striären Systems*, offered a comprehensive theoretical framework for diseases of the striated system, and in 1941, they published *Thalamusstudien I*, a study of the thalamus. Together, these works were instrumental in advancing the understanding of brain anatomy, especially the basal ganglia and thalamus.

The Vogts' research, particularly Cécile and Oskar Vogt's 1920 study *Zur Lehre der Erkrankungen des Striären Systems*, underscored the critical role of the basal ganglia in both motor and non-motor functions. Their work significantly shaped later studies on disorders such as corpus striatum syndrome. They also redefined the basal ganglia by grouping the caudate nucleus, putamen, and nucleus accumbens under the unified term "striatum," challenging earlier theories that regarded these structures as separate entities [6,12]. In 1911, Vogt-Maugnier introduced the concept of corpus striatum syndrome, with her seminal research gaining wide recognition in the *Journal für Psychologie und Neurologie*. In this study, she examined the relationship between brain lesion localization and neurological symptoms, arguing that precise identification of lesions was crucial for accurate diagnosis and treatment. Vogt-Maugnier distinguished between primary symptoms, directly caused by lesions, and secondary symptoms, which resulted from disrupted brain mechanisms or a loss of inhibitory control. Through clinical examples, she demonstrated that similar lesions could produce diverse symptoms, highlighting the complexity of brain function. She proposed a distinct striatal syndrome marked by spasms and athetoid movements, without significant paralysis or cognitive impairment. Her findings, supported by both clinical and anatomical evidence, contested previous studies that attributed these symptoms to cortical lesions instead of striatal damage. While acknowledging the challenges of precise lesion localization, Vogt-Maugnier emphasized the need for ongoing research to better understand brain functions and neurological disorders[12].

Historical, Humanistic, and Gender Context

Vogt-Mugnier's groundbreaking contributions to neuroscience stand as a testament to her exceptional intellect and determination, especially in the face of the significant societal barriers that women in science encountered during her era. Her pioneering work in neuroanatomy and psychiatry not only advanced these fields but also played an instrumental role in the broader struggle for gender equality in scientific research[1,2,4,5,9,13].

A passionate advocate for social justice and intellectual freedom, Vogt - Mugnier vocally opposed the

Nazi regime, championing the autonomy of researchers to pursue independent inquiry. Despite the intense persecution of the Nazi era, she and her husband, Oskar Vogt, adhered to their scientific and ethical principles. They saved Jewish colleagues from harm and preserved the integrity of their research, demonstrating remarkable resilience and unwavering commitment to their values. Beyond her professional pursuits, Vogt-Mugnier embodied a liberal philosophy of life[15].

Igor Klatzo, one of her contemporaries, referred to her as a "teacher in the art of living," underscoring her ability to combine intellectual rigor with cultural refinement. Whether enjoying fine wines or sharing everyday wisdom, she approached life with humility and sophistication, qualities that earned her widespread admiration and respect[2,13].

Despite her profound intellectual contributions, Vogt-Mugnier's work was often overshadowed by the more prominent figure of her husband, Oskar Vogt. However, many of her contemporaries, including Klatzo, considered her intellect and insights to be more advanced. Klatzo acknowledged her central role in shaping the foundational concepts within their shared research, even as she remained in the background, steadfastly supporting Oskar's career and their family's endeavors.

As a feminist trailblazer, Vogt-Mugnier shattered numerous barriers in the male-dominated field of neuroscience. Navigating the challenges of academia as a single mother, she persistently advocated for the inclusion of women in science. She created opportunities for female researchers and employed women in technical positions, defying societal norms and laying the groundwork for greater gender equity in STEM. Her dedication to this cause earned her numerous accolades, including honorary doctorates and even a nomination for the Nobel Prize. However, these recognitions often fell short of fully acknowledging the full extent of her impact.

Vogt - Mugnier's feminist commitment also influenced her daughters: Claire (1898–1978), who pioneered child neuropsychiatry in Paris; Marthe (1903–2003), who advanced neuropharmacology in the UK and became a Fellow of the Royal Society; and Marguerite (1913–2007), a leading cancer biologist and virologist at Caltech in the U.S. Their achievements reflect the enduring legacy of their mother's mentorship and her steadfast commitment to intellectual growth and scientific inquiry.

The "Matilda Effect" highlights the systematic undervaluation of women's contributions in science, technology, engineering, and mathematics (STEM), where their achievements were often dismissed or wrongly attributed to men. This phenomenon serves as a stark reminder of the challenges Vogt-Mugnier faced throughout her career. Despite these obstacles, her perseverance and advocacy for equity continue to inspire future generations working to dismantle the barriers that persist in STEM fields.

CONCLUSION

Vogt - Mugnier played a vital role in the Vogts' marital and scientific consortium, making significant contributions that advanced neuroscience while breaking barriers for women in science. Her groundbreaking research on the corpus striatum syndrome shed light on the anatomical basis of cognitive and motor dysfunctions, forming a cornerstone for modern neuroanatomy and neuropsychiatry.

As part of the Vogts' partnership, Vogt-Mugnier not only co-led monumental cytoarchitectonic studies, mapping distinct brain regions and correlating them with specific functions, but also contributed to their influential theory of pathoclisis, which linked selective cellular vulnerability to genomic variations. Her influence extended beyond science, as she actively championed gender equity, becoming a symbol of feminist resilience in STEM.

Together, the Vogts' visionary work anticipated critical advancements in molecular genetics, brain mapping, and the selective vulnerability of brain regions, all while navigating the socio-political upheavals of their time. Their marital partnership, defined by mutual respect, intellectual collaboration, and shared goals, underscores the enduring power of teamwork in achieving scientific excellence.

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