Article:
Ahmad, A. orcid.org/0009-0003-3528-8008, Jagdhane, N., Ademmer, K. et al. (1 more author) (2024) Carl Wernicke of the Wernicke area: a historical review. World Neurosurgery, 185. pp. 225-233. ISSN: 1878-8750

https://doi.org/10.1016/j.wneu.2024.02.103

Carl Wernicke of the Wernicke Area: A Historical Review

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Key words
- Aphasia
- Carl Wernicke
- Hydrocephalus
- Sensory aphasia
- Speech area of brain
- Superior temporal gyrus
- Wernicke area

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Citation: World Neurosurg. (2024) 185:225-233.
https://doi.org/10.1016/j.wneu.2024.02.103

Journal homepage: www.journals.elsevier.com/world-neurosurgery

Available online: www.sciencedirect.com

The Wernicke area, also known as Brodmann area 22, is located in the posterior segment of the superior temporal gyrus in the dominant hemisphere. Carl Wernicke, a German neurologist, described this area in 1874. The life story of Carl Wernicke, a 19th-century medical genius, remains an inspiration for all neuroscientists even a hundred years later. We outline Wernicke's life story and academic achievements in neurosurgery, neurology, and psychiatry. We explore his remarkable ability to turn his many setbacks into steps forward, his controversial foray into psychiatry, and his wide-ranging set of contributions, including his work on external ventricular drainage for hydrocephalus and encephalopathy; his description of the eponymous Wernicke area; and his field-defining work on aphasia. This historical review attempts to bring to life a seminal figure in the neurosciences, providing an insight into his visionary thought process.

INTRODUCTION

Carl Wernicke (1848–1905), a neurologist, neurosurgeon, and psychiatrist, is renowned for his field-defining work on aphasia with his first publication in 1874, *Der Aphasische Symptomencomplex: eine psychologische Studie auf anatomischer Basis* ("The Aphasia Symptom-Complex: A Psychological Study on an Anatomic Basis") as seen in Figure 1.[1] He was just 26 years old then, but his work gained him instant fame in the field. However, his contributions to modern medicine go beyond his work on aphasia. These contributions are often not adequately recognized and we attempt to highlight them in this article. In the 19th century, Wernicke played a key role in the development of anatomy, neurology, neurosurgery, and psychiatry as we understand them today. His data-driven approach using the latest neuroanatomy and neurophysiology to derive novel insights into the human body has made him a revolutionary figure in the neurosciences. In subsequent sections, we summarize his life story to provide a brief account of his inspiring journey and achievements in the medical field.

THE LIFE HISTORY OF CARL WERNICKE

Carl Wernicke was born on May 15, 1848, in Tarnowitz, a village in the historical region of Silesia, which belonged to Prussia and then the German Empire during his lifetime, but in the modern day is part of Poland.[2] From a family of modest means, he was well supported by his mother, who strongly believed in education, resulting in his schooling at the academies of Oppeln and Breslau, the major cities of the region. After Wernicke's father died, his mother encouraged him to study at the University of Breslau, which was at the time, the capital of the region and its largest city (now Wrocław in Poland). She too passed away after her son's state examinations for medical school. However, she ensured that she had secured the funds needed to support him during his time at university.

Completing medical school in 1870, Wernicke is noted to have enjoyed his studies and had garnered a reputation for being a good fellow among the faculty and colleagues (Figure 2). As is not uncommon, he was unsure of which specialty to choose after graduation. Having great respect for the work and character of Dr Foerster, the resident ophthalmologist, he undertook a 6-month assistantship with him. This association guaranteed him Foerster's friendship, which would serve him well in future endeavors. The subsequent Franco-Prussian War of 1870 provided Wernicke with exposure to surgery and made him consider becoming a surgeon, as well. After the war, he took part in an assistantship at the Psychiatric Institute of the Allerheiligen Hospital under Heinrich Neumann (1814–1888). During this tenure, he also had an opportunity to work for 6 months in Vienna under Theodor Meynert (1833–1892), who was then considered the founder of comparative anatomy of the nervous system.[3]

This period exposed Wernicke to many luminaries of the day, many of whom he would call friends, and provided him with experiences that greatly affected his career. In particular, his experience in Vienna in 1874 seemed to have resonated with Wernicke. He would later often state how Meynert had affected his career and credited Meynert for his initial discoveries in aphasia.[4] Through this leading figure in neuroanatomy, Wernicke developed his love for the field and was exposed to the conundrum of aphasia. In the same year,

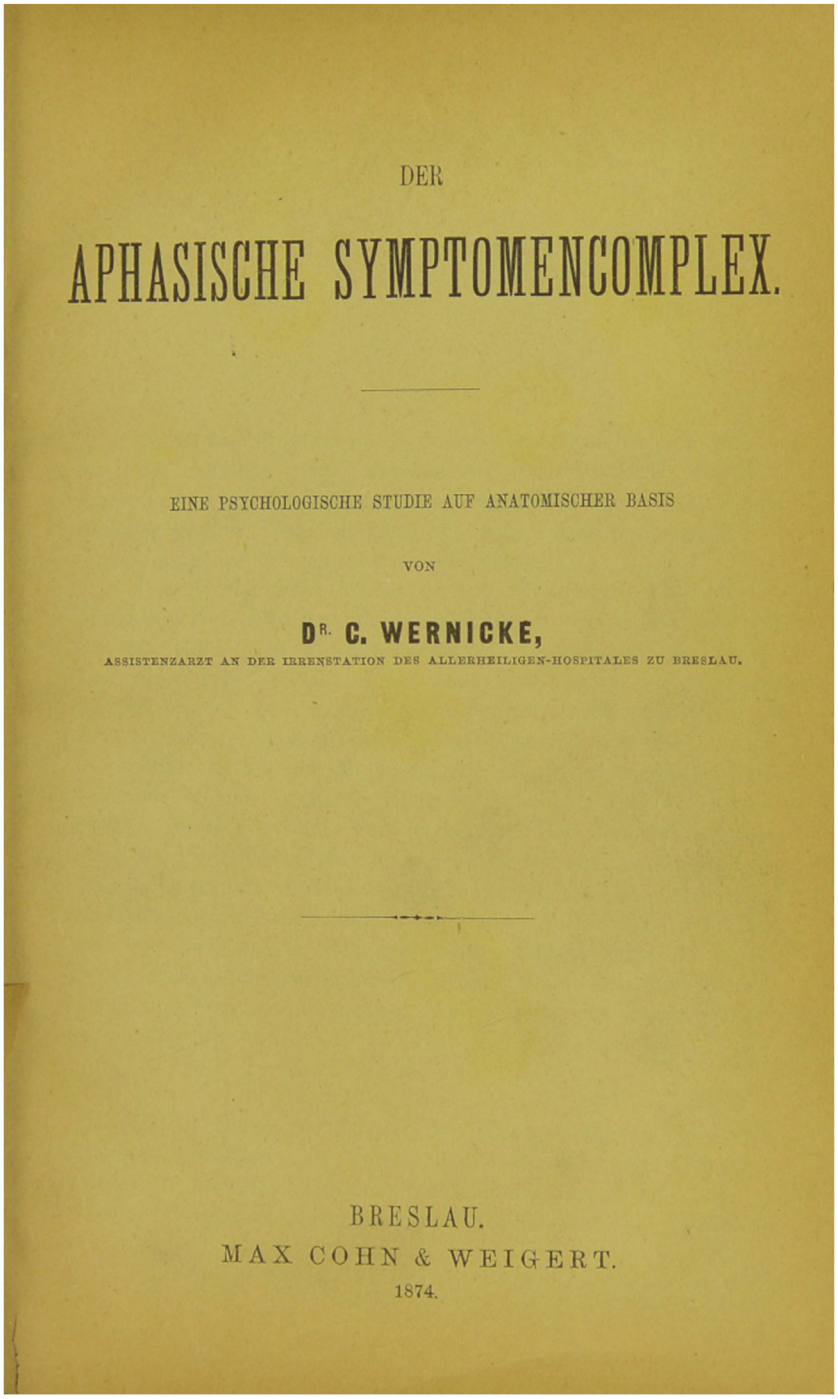


Figure 1. Book cover of *Der Aphasische Symptomencomplex: eine psychologische Studie auf anatomischer Basis* ("The Aphasia Symptom-Complex: A Psychological Study on an Anatomic Basis") by Carl Wernicke in 1874. Reproduced under the Public Domain Mark licence from the King's College London, Foyle Special Collections Library.

he penned his field-changing first publication on aphasia, at the age of 26 years. This publication gained him a reputation that helped him secure an assistantship with Carl Westphal (1833–1890), a leading psychiatrist at the Berlin Charité Hospital, a premier institute for health care in Germany in 1875 and up to the modern day.

Dispute with Medical Administration in Berlin

Wernicke's time in Berlin had started well but a dispute with the local management almost ended his career. By 1876, he had completed his "Habilitation," granting him junior membership of the medical faculty and permission to charge lecture fees. He was hailed as a rising star and had great expectations; however, an event occurred that almost cost him his career. Although details are scarce, an argument with the hospital administration in March 1878 regarding personal matters escalated to the extent that not only was his assistantship terminated but Althoff, the ministerial director during his time, who held powers of veto in the medical faculty, ensured that Wernicke would never return to Berlin again for work. Considering Berlin's leading position for research in Germany, it seemed that Wernicke's career was coming to an early end. However, arguably, this incident had the opposite effect. In response to this devastating turn of affairs, Wernicke instead took advantage of the free time he now had to socialize with friends and pursue his passion for scientific writing. Publications during this time cemented his position as an authority in neurology and equally his interest in psychiatry.

Resurrection of Career at Breslau

In 1885, Wernicke returned to a formal academic life at the University of Breslau with the support of his old friend, the ophthalmologist Foerster. In 5 years, he became chairman of the Department of Neurology and Psychiatry after the death of his first mentor, Neumann. Wernicke's tenure saw him switch to a more psychiatric focus, using his data-driven approach derived from neurohistology and neurosurgery to test his own hypotheses on psychiatric disorders. It provided him with the first opportunity in many years to have the resources required to carry out studies of psychiatric and focal neurologic symptoms, along with many students and assistants who now rank as key contributors to the medical field. Some of the noted names

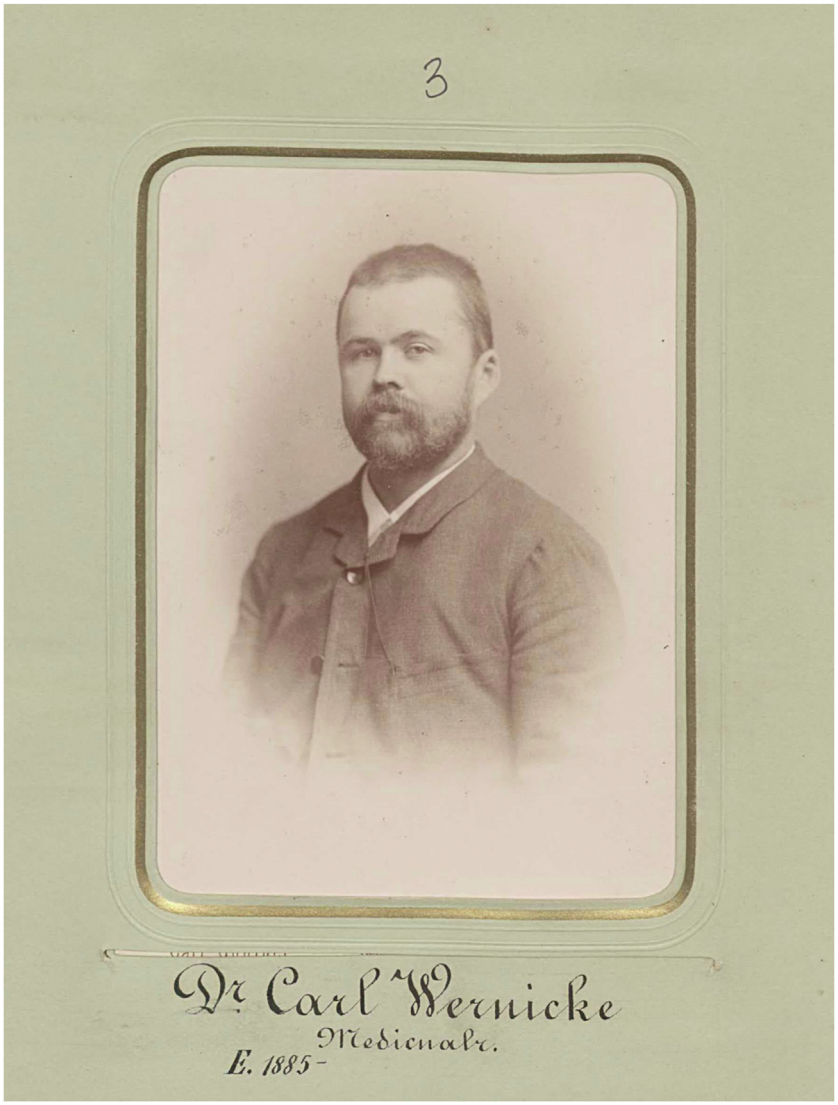


Figure 2. A portrait of Carl Wernicke. Reproduced under the Public Domain Mark licence from the University of Wrocław, Wrocław University Museum Special Collections Library.

include Heinrich Lissauer (1861–1891) for his work on agnosia and Carl Kleist (1879–1960) for his work on psychopathology, having created the terms unipolar depression (now major depressive disorder) and bipolar disorder.[5] In addition to his academic excellence, Wernicke was also accomplished in his personal life, with his biography stating that "after the day's work he could often be seen going out into the countryside with a child on each hand," with 3 children (2 daughters and a son) and a loving wife.[2]

Rise, Fall, and Rise Again

When asked about his goals in life, Wernicke is reported to have said to his student Kleist during a hiking trip in the Glatzer mountains, "There is only one proper motive in work and that is…"*Seek ye first the kingdom of God and all the rest shall follow.*'"[2] After almost 20 years, the funding for Wernicke's department was curtailed. This development encouraged him to pursue his research ambitions at a larger university. He applied to 3 locations (Vienna, Berlin, and Munich) without success. Vienna failed because of false rumors of his refusal being circulated in the media; Berlin was stopped by his adversary Althoff; and his other adversary, Emil Kraepelin (1856–1926), received the position in Munich instead of him. This situation resulted in Wernicke's having no university affiliation again for 1 year, with the returned fear of his career ending abruptly. Once again, Wernicke turned a misfortune into an opportunity by using this time to work on his most famous psychiatric publication, *Grundriss der Psychiatrie* ("Foundations of Psychiatry"). Although his affiliation was restored after a year, his dissatisfaction with the institution led him to accept an offer from the University of Halle to lead their Clinic of Psychiatry and Neurology.

Wernicke in Halle

Wernicke's brief 1-year tenure at Halle began in 1904 and held great promise on both an academic and personal level. At the age of 57 years, he was noted as being '"more mellow"' and happier with the opportunities on offer at Halle by his assistant Kleist.[2] Wernicke's continued skill at managing work–life balance meant that at this stage in his career, he not only was held in high esteem by the academic world, with exciting new research planned, but had also cultivated a close circle of friends, a loving family, and a set of active hobbies ranging from gymnastics and mountain climbing to cycling. Cycling is especially pertinent because he experienced a fatal accident while on a cycling trip in Thuringer forest. A cart ran over him, leaving him with injuries; although nowadays such injuries are manageable, at the time, they meant 2 days of severe pain, ending with his death on June 15, 1905. From the numerous obituaries, it was clear that a man who was both loved and respected had passed from the research community and that his work would be recognized as withstanding the test of time.[6]

> To us, his last assistants, remains the memory of renowned yet modest man, a model who entrusted us with far-reaching confidence and independence, a teacher who discovered in each a certain talent… To have been his students

Figure 3. A woodcut of Albert Magnus' conceptualization of ventricles titled *De anima* made in 1506. From left to right, each ventricle corresponds to a specific brain function: I, common sensory input and imagination; II, rational thought, evaluation, and creativity; and III, memory and motion.[7,8] Reproduced under the Public Domain Mark licence from the Wellcome Collection, *Philosophia Naturalis* by Albertus Magnus.

shall remain our pride as long as we live— Kleist's eulogy[2]

APHASIA BEFORE CARL WERNICKE

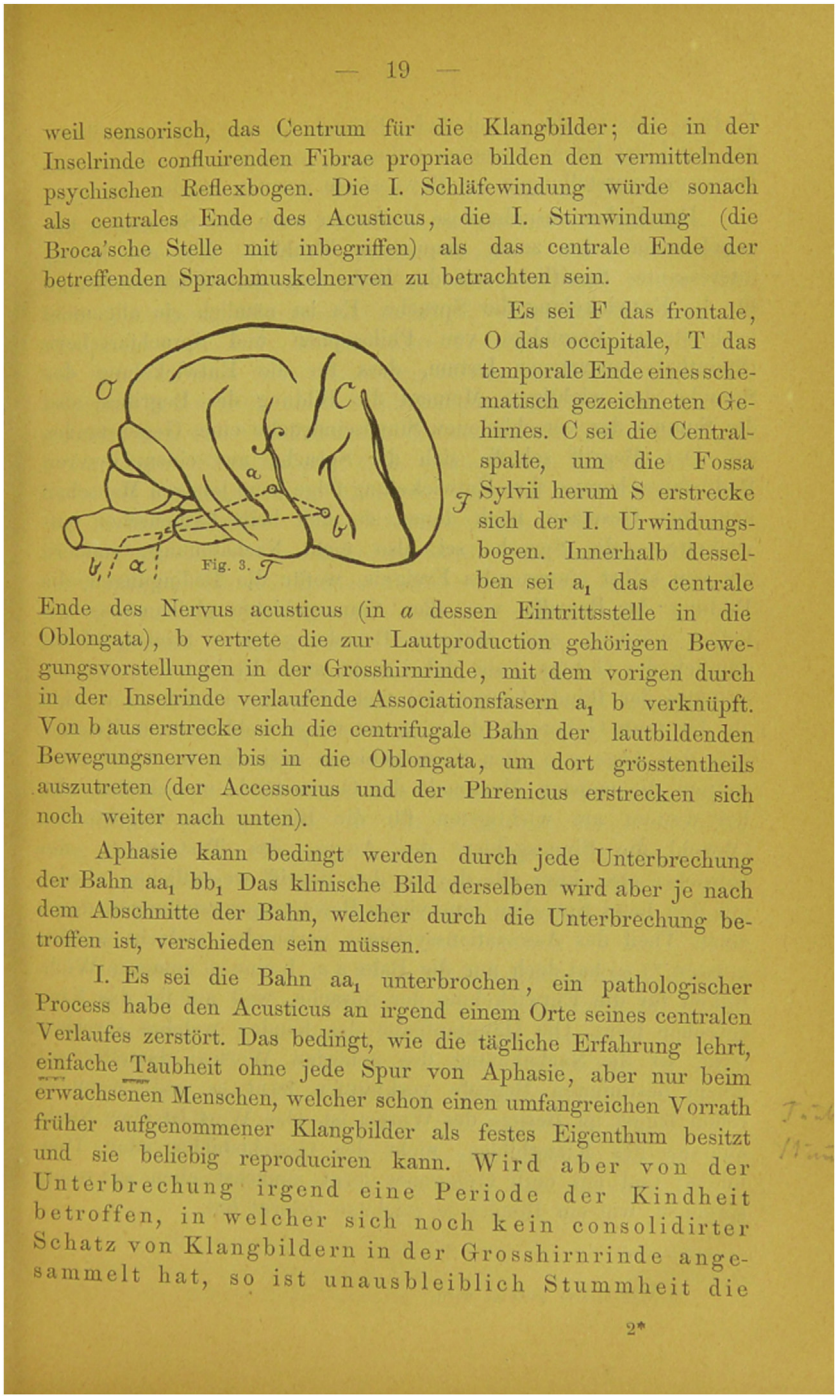
Aphasia, defined as a language impairment with a clear and distinctive set of descriptive clinical features, was first clearly described in the 17th century by Schmidt and Rommel, although appreciation of this condition has been present at least since the ancient Greeks.[7] Respected writers such as Samuel Johnson and Johann Wolfgang von Goethe describe it in their writings, showing its recognition among the public in the 18th and 19th centuries. From the etiologic perspective, early understanding of language impairment revolved around either a "paralysis of the tongue" or the predominant theory of brain function localization in the ventricles.[8] The most popular conceptualization was that of Albert Magnus (1200—1280) as seen in Figure 3, in which each of the 3 ventricles broadly corresponds to perception, reason, and memory[9] (Figure 3).

Progress on understanding the cause behind aphasia was arguably slowed at an intellectual level by René Descartes (1596—1650) and his theory of mind—body dualism, because it popularized a separation between the organic body (the brain) and the inorganic mind, which in this context meant language.[10] Called holism as opposed to localization, this approach was the undisputed status quo until Franz Joseph Gall (1758—1828) defended his work on phrenology in public debate, breaking the taboo that had developed around discussing the possibility of a connection between the brain and the mind. Jean-Baptiste Bouillaud (1796—1881), Gall's student, carried on his work in localization and taught Paul Broca (1824—1880), who became a recognized figure in the field and after whom the Broca area is named. Broca helped promote the theory of localization and famously debated with Trousseau in 1864 in the Académie de Médicine, Paris, when Trousseau disproved Broca's conceptualization of a sole language center by comparing patient autopsies and verifying if lesions would be found in the relevant section. This debate advanced the term "aphasia" as a general word for language disturbances but showed that the conceptualization of the Broca area as the sole area responsible for speech was incorrect.

The localization of language function in the brain was the key debate of the century into which Carl Wernicke was born and he played a significant role in shaping it. He later credited the work of Broca as having played a key role in helping develop his thoughts on the field.

WERNICKE AND HIS WORK ON APHASIA

Carl Wernicke applied the neuroanatomic approach developed in his time with Meynert with the conceptualization of localizations championed by Broca and Eduard Hitzig (1838—1907) to lay out a field-defining approach to aphasia.[10] At


— 19 —

weil sensorisch, das Centrum für die Klangbilder; die in der Inselrinde confluirenden Fibrae propriae bilden den vermittelnden psychischen Reflexbogen. Die I. Schläfewindung würde sonach als centrales Ende des Acusticus, die I. Stirnwindung (die Broca'sche Stelle mit inbegriffen) als das centrale Ende der betreffenden Sprachmuskelnerven zu betrachten sein.

Fig. 3. T

Es sei F das frontale, O das occipitale, T das temporale Ende eines schematisch gezeichneten Gehirnes. C sei die Centralspalte, um die Fossa Sylvii herum S erstrecke sich der I. Urwindungsbogen. Innerhalb desselben sei a_1 das centrale Ende des Nervus acusticus (in *a* dessen Eintrittsstelle in die Oblongata), b vertrete die zur Lautproduction gehörigen Bewegungsvorstellungen in der Grosshirnrinde, mit dem vorigen durch in der Inselrinde verlaufende Associationsfasern a_1 b verknüpft. Von b aus erstrecke sich die centrifugale Bahn der lautbildenden Bewegungsnerven bis in die Oblongata, um dort grösstentheils auszutreten (der Accessorius und der Phrenicus erstrecken sich noch weiter nach unten).

Aphasie kann bedingt werden durch jede Unterbrechung der Bahn aa_1 bb_1 Das klinische Bild derselben wird aber je nach dem Abschnitte der Bahn, welcher durch die Unterbrechung betroffen ist, verschieden sein müssen.

I. Es sei die Bahn aa_1 unterbrochen, ein pathologischer Process habe den Acusticus an irgend einem Orte seines centralen Verlaufes zerstört. Das bedingt, wie die tägliche Erfahrung lehrt, einfache Taubheit ohne jede Spur von Aphasie, aber nur beim erwachsenen Menschen, welcher schon einen umfangreichen Vorrath früher aufgenommener Klangbilder als festes Eigenthum besitzt und sie beliebig reproduciren kann. Wird aber von der Unterbrechung irgend eine Periode der Kindheit betroffen, in welcher sich noch kein consolidirter Schatz von Klangbildern in der Grosshirnrinde angesammelt hat, so ist unausbleiblich Stummheit die

2*

Figure 4. The Wernicke arc taken from *Der Aphasische Symptomencomplex: eine psychologische Studie auf anatomischer Basis* ("The Aphasia Symptom-Complex: A Psychological Study on an Anatomic Basis") by Carl Wernicke in 1874. C, central sulcus; F, frontal lobe; O, occipital lobe; S, sylvian fissure; T, temporal lobe. Wernicke mentions a "gyral convolution" around the fissure and *a* is the terminus of the acoustic nerve. This area is known as the Wernicke area, whereas *b* is known as the Broca area. The 2-point Wernicke arc connects *a* to *b* using associative fibers. This model is used in subsequent sections to explain aphasia. Reproduced under the Public Domain Mark licence from the King's College London, Foyle Special Collections Library.

the age of 26 years in 1874, after his assistantship in Vienna, Carl Wernicke published his first and career-defining book titled *Der Aphasische Symptomencomplex: eine psychologische Studie auf anatomischer Basis* ("The Aphasia Symptom-Complex: A Psychological Study on an Anatomic Basis"). Precise neuroanatomic description of his aphasia model and the theory of memory imagery is outside the scope of this section; however, the book is recognized as a classic in aphasiology. The study laid out the first description of a novel sensory speech center, sensory aphasia, and a schema to understand aphasia.[2] Over the next 2 years, Wernicke further elaborated points of his schema, cementing his position, such as in his 1875 study *Das Urwindungsystem des menschelichen Gehirns* ("The Primordial Gyral-System of the Human Brain"), an in-depth comparative neuroanatomic study building on descriptions laid out in his first work, detailing the sensory speech center, which he called the "first primordial gyrus," a unit in the parietal region in the superior temporal gyrus involved in speech, which is known as the Wernicke area. Subsequently, Wernicke went on to update and develop this model throughout his life with the monograph *Recent Works on Aphasia* in 1885 and the posthumously published *Deutsche-Klinik—Aphasia Symptom Complex* in 1906 finalizing his contributions to the field.[2]

Wernicke's Contributions to Defining Types of Aphasia

The schema involved a 2-point diagram known as the Wernicke arc, as shown in **Figure 4**.[11] This schema formed the basis of predicting speech and language disorders using precise anatomic locations, with the 2 points being an auditory center known as the Wernicke area and a motor area for speech formation known as the Broca area. Wernicke had not only discovered the brain area named after him but also developed an understanding of the Broca area.[10] This arc was relevant in predicting the impact of lesions. If the lesion was present at the Wernicke area, it caused sensory aphasia (the loss of sound images), resulting in loss of speech comprehension from others and

the self. If the lesion was in the Broca area, it led to motor aphasia (loss of articulated speech). If the lesion was between the 2 centers, in the associative fiber pathway as described by Meynert (1867), it led to conduction aphasia, in which comprehension was present but inappropriate use of words was also present.[3] If the lesion was present at both the Broca and Wernicke areas, total aphasia would be present.[1] Wernicke himself described it as a psychic reflex arc and used it as a model for psychiatric conditions, as discussed elsewhere.[3]

Wernicke based his theory of language on 3 main points: the cerebral cortex being the organ of consciousness, specific parts of the brain holding particular significance such as the Broca and Wernicke areas, and associative fibers connecting and coactivating all layers.[10] On analysis, Wernicke's approach was balanced with elements of holism through his abstraction of the higher parts of the psychophysiologic process required for communication in the cortex along with localization and provided the basis for the connectionist approach that would become popular in the late 20th century.[2]

Conceptualization of speech and language disease using the Wernicke arc still dominates the field. Wernicke had helped mainstream the theory of localization to explain aphasia and had made it broadly acceptable, although it still had its detractors. His approach to aphasia is referred to as the Breslau-Halle school.[12] This approach was recognized and adopted by the international community during his lifetime, showing the decisive impact of his work on aphasia in the field and cementing Germany as the leading country for aphasia work.[2]

WERNICKE AND FREUD ON APHASIA

Of the many critiques generated by Wernicke's work on aphasia, arguably the most impactful on the medical field was the 1891 *Zur Auffassung der Aphasien: Eine kritische Studie* ("On the Understanding of Aphasia: A Critical Study") by the neurologist and father of psychoanalytic psychology, Sigmund Freud (1856–1939). This was Freud's first book as a sole author and is recognized as a turning point in his career.[13] He attacked Wernicke's conceptualization of aphasia as an organic disease by calling him a "diagram maker," asserting that Wernicke's approach did not have a factual basis.[14] Freud recognized only asymbolic, verbal, and agnostic aphasia and proposed an alternative theory using mental associations between words and memory images of objects. Freud's works revolved around a psychological cause of aphasia as opposed to the biological memory images being localized in an observable neuroanatomic framework as promoted by Wernicke.[15]

The impact of this critique was significant, not only because of its focus on aphasia but also because of its opposition to the broader movement of biological psychiatry. It led Freud to switch from neuroanatomy to pursue studies that resulted in him founding psychoanalytic psychology, which was also used to interpret language disorders.[15,16]

WERNICKE AND HIS OTHER CONTRIBUTIONS TO NEUROLOGY AND NEUROSURGERY

Carl Wernicke was prolific in his writing in neurology; **Table 1** lists his eponyms.[17] We have highlighted some of his important contributions in subsequent sections.

Wernicke Encephalopathy

In 1881–1882, Carl Wernicke published the *Lehrbuch der Gehirnkrankheiten* ("Textbook of Brain Disease"), for which he became most well known in his time because it remained the leading textbook in the field until Von Monakow's work in the 1890s. Across 3 volumes, it authoritatively laid out brain pathophysiology and disease classification using a localization approach. This approach was crucial for the field because the latest research such as that by Meynert was noted as being too "brief" and "obscure" for most researchers to benefit from.[2] It outlined what is now known as Wernicke encephalopathy. A follow-up to this work was arguably his *Atlas des Gehirns* ("Atlas of the Brain") from 1897–1903, which was the first photographic review of the human brain, mainly organized by his assistants.

Wernicke Hemiplegia, Wernicke Pupillary Reactions, and Cortical Deafness

In 1883, Carl Wernicke published a translation of the then recently deceased French neurologist Guillaume-Benjamin-Amand Duchenne's research on movement physiology, which is noted to have been a possible inspiration for Wernicke's later work on residual hemiplegia.[2] With the support of Friedlander, Wernicke also published the first detailed study of cortical deafness.

In 1893, one of his final works was the *Gesammelte Aufsätze und kritische Referate zur Pathologie die Nervensystems* ("Collected Essays and Critical Reviews in Neuropathology"). It contained a variety of studies, from reprints and new essays in neuroanatomy to critiques of contemporary research. The most important of these studies was a description of Wernicke encephalopathy and Wernicke-Mann hemiplegia, the tracing of the pyramidal

Table 1. List of Eponyms Associated with Carl Wernicke[17]

Eponym	Description
Wernicke area	An area of the brain involved in speech
Wernicke aphasia	A term used for classic receptive aphasia
Wernicke encephalopathy	The appearance of ocular, cerebellar, neurologic, and memory loss as a result of thiamine deficiency
Wernicke pupillary reaction	The absence of pupillary reflex to light in the blind portion of the retina
Wernicke-Korsakoff syndrome	The combined presence of Wernicke encephalopathy and Korsakoff syndrome
Wernicke-Mann hemiplegia	A type of partial hemiplegia of the extremities
Wernicke cramp	A psychogenic muscle cramp caused by anxiety or fear
Wernicke dementia	A historic term for dementia

tract to the spinal cord, and a study of what is now known as the Wernicke pupillary reactions.[18]

Wernicke's Contributions to the Treatment of Hydrocephalus

In neurosurgery, Carl Wernicke mainly contributed to the treatment of hydrocephalus.[19] In 1881, he carried out the first documented ventricular puncture using aseptic techniques in an operation involving puncturing the trigone with a trocar using a lateral approach. In addition, he also was the first to popularize external ventricular drainage by leaving a left ventricular cannula in place.

WERNICKE AND HIS CONTRIBUTIONS TO AND CONTROVERSIES IN PSYCHIATRY

Carl Wernicke was exposed to psychiatry early in his career and went on to become a key figure in the biological psychiatry movement by pioneering a novel nosology centered around a systematic neurobiological basis for mental disorders.[20] This nosology followed in the tradition of previous aphasiologists such as Gall (1758–1828) and Broca, who promoted the concept of the cerebral cortex being the site of mental processes and motor aphasia, respectively.[3] Because aphasia was generally considered to be at the intersection of the mind and body, Gall and Broca also went on to become key contributors to the biological psychiatry movement. As recognized by Wernicke's contemporary Heilbronner (1905), the monograph of his titular work on aphasia held the subtitle of "a psychological study on an anatomic basis." This subtitle was a clear indication of Wernicke's conceptualization of aphasia as a psychological disorder with an anatomic basis, with its mechanism forming the basis for his later works.[3]

Wernicke's biological approach made him an adversary of Emil Kraepelin (1856–1926), whose methodology inspired the contemporary International Classification of Diseases and Diagnostic Statistics Manual approach to psychiatric nosology.[5,21,22] Wernicke was also critiqued by contemporaries such as the prominent psychopathologist Karl Jasper (1883–1969), who called him a "brain mythologiser," claiming that he was inappropriately extrapolating his aphasia model to the entire field of psychiatry.[3,16] Jaspers likened Wernicke to Freud, claiming that both individuals used few facts to produce sweeping generalizations and abstract models.

Forays into Psychiatric Nosology—The Theory of Elementary Symptoms and Sejunction

No known works have survived that explicate how Carl Wernicke formulated his psychiatric approach beyond writings on consciousness in 1879 and on the relationship of aphasia to mental illness in 1890. However, conference proceedings show that he had developed his beliefs in 2 stages: the theory of an "elementary symptom" and then his "sejunction" theory, which became infamous and was the subject of criticism.[23]

His first conceptualization was of the "elementary symptom," in which every psychiatric disorder had a key underlying symptom that "forms the basis of all other symptoms" and could be targeted. In practice, he used anxiety as the elementary symptom for most disorders and had never produced a repeatable methodology of how to investigate and decide on the elementary symptom of a presentation, making its usefulness etiologically limited. The key difficulty in understanding this approach is his lack of formal writings on this theory beyond clinical vignettes.[23] However, that situation may be a result of his decision to pursue the formal realization of his approach to aphasia onto other psychiatric disorders instead of further developing this approach. The "elementary symptom" theory may have been inspired by his initial experience in psychiatry under Neumann as his teacher, who was a leading proponent of the concept of "'unitary psychosis," the assumption that all forms of psychosis were different stages of 1 disease with a single underlying cause: *Wahnsinn* (madness).[24]

Wernicke's second conceptualization was centered around the concept of sejunction. In 1899–1900, he wrote the *Krankenvorstellungen aus der psychiatrischen Klinik in Breslau* ("Clinical Studies from the Breslau Psychiatric Clinic"), a 3-volume case review compilation. This material provided the clinical foundation for his key text on psychiatry, the *Grundriss der Psychiatry* ("Foundations of Psychiatry"), which was published in 1900.[2] The book and its novel theory of sejunction was controversial, with notable contemporary Theodor Ziehen (1862–1950) critically stating that "His Foundations of Psychiatry is written almost as if a science of psychiatry did not yet exist."[3] Using his characteristic biologically driven approach to the brain, Wernicke described psychiatric illness as a sejunction, a disruption in the connective pathways of the brain caused by a lesion.[20] It clinically presented itself in 3 ways: a loss of function, hyperfunction, or a parafunction. This framework was used to classify a range of different disorders. For example, in psychomotility, patients presented with akinesia, hyperkinesias, and parakinesia (which ranged from chorea to mannerisms).[20]

The foundations for this theory were both the localization approach that Wernicke had developed as an early researcher and a more developed theory of memory images, which he had first described in his titular work on aphasia in 1874. Originally, the term memory image was proposed to describe how sensory information was processed and stored by the human mind.[16] It was a psychological construct; however, Wernicke used it to describe both psychological and sensory information processed by neural connective pathways. An example of how this term was conceptualized is that nervous excitation for sensory information manifested as hallucinations, whereas motor information manifested as psychomotor agitation. Wernicke's key contributions to psychiatry from this body of work are theoretic to a field that has recently seen a revival: self-disorders, a term used to describe features of the schizophrenia spectrum.[5] His work helped develop and anticipate various areas of the field from the interoception–exteroception dichotomy and abnormal interoception to selfhood, consciousness, and the modern-day understanding of self-disorder itself.[16,20] Wernicke's creation of the term

"perplexity" to define "the state of mind in which most mentally ill people remain while they are still curable" is a term still in use, although he understood it in a manner best shown by the following quote when discussing his nosology:

> If we imagine that it were possible to rob a healthy person unnoticed of a large part of the memory images in which the outside world is reflected in him, or to change their content, we would fully understand all sorts of wrongs that he committed in his perplexity.[16]

Wernicke's work on psychiatry was a natural evolution of his work on neurology. He helped found what is referred to as the Wernicke-Kleist-Leonhard school of psychiatry, which had abandoned his theory of sejunction but kept his neuroanatomic approach to psychiatry.[20] Some of Wernicke's described conditions such as "anxiety-psychosis," "motility psychosis," and "expansive autopsychosis" were reworked by students Kleist and then by Karl Leonhard (1904–1988) into cycloid psychosis, which has entered into Kraepelin's diagnostic classification and remains to this day.[25] Wernicke's sejunction theory describes a connectionist view of the psyche, arguably anticipating modern neural networking approaches.

Despite his "Elementary symptom" theory not being developed further and having severe flaws, the concept of a key symptom is still relevant. Although not considered a part of nosology, it persists in psychopharmacology in the form of target symptoms (e.g., the use of anxiolytics in patients with acute psychosis).[23] Continuing developments in target symptoms are in keeping with Wernicke's earlier tradition.

WERNICKE IN THE 21ST CENTURY

Carl Wernicke is aptly remembered as a pivotal figure in the neurosciences in the modern day because of his contributions to aphasia. At the beginning of the 20th century, toward the end of Wernicke's life and after his death, neurology and psychiatry split into 2 specialties. Although the localization approach has persisted in neurology, with behavioral neurologists and clinical neuropsychologists carrying on Wernicke's work, biological psychiatry has given way to modern psychiatry's Kraepelinian symptoms-based classification.[16] Wernicke's theory of connectionism has been vindicated by contemporary research through the resurgence of neural networks, which share similarities. His work inspired Norman Geschwind (1926–1984) to play an important role in the development of behavior neurology and neurolinguistics, especially in aphasia.[15]

With the resurgence of neuropsychiatry and interest in neural networks, Wernicke's work, although not so well known, is more relevant than ever before. With the recent creation of the research domain of criteria indicating a trend toward biological psychiatry, the systematic neuroanatomic and connectionist approach pioneered by the Wernicke-Kleist-Leonhard school of psychiatry and its body of work may be worthy of reappraisal.[26]

Wernicke was a man described as "*Der Forscher*, the explorer—theorist in quest of a theory of psychic life."[2] His remarkable capacity to balance professional and personal life and maintain remarkable physical health is a timely reminder that it is possible to maintain a high standard of well-being while producing field-changing work. Despite his interest in biologically explicating the human mind, he believed that a person was greater than the sum of their parts. We would like to close this homage with a quote from Wernicke taken from his biography that is even more pertinent with the advances in computing:

> If man would not be a mere counting-machine or registrar, he remains exposed to error. But should he, therefore, hold the counting-machine as his ideal? May that thought hold as little sway in my riper years, as it has in the past. (Carl Wernicke in Breslau, 1892)[2]

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Abdullah Ahmad: Writing — original draft, Investigation. **Nitin Jagdhane:** Writing — review & editing. **Karin Ademmer:** Writing — review & editing. **Kishor Choudhari:** Writing — review & editing, Supervision, Conceptualization.

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Conflict of interest statement: The authors declare that the article content was composed in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Received 12 December 2023; accepted 19 February 2024

Citation: World Neurosurg. (2024) 185:225-233.
https://doi.org/10.1016/j.wneu.2024.02.103

Journal homepage: ***www.journals.elsevier.com/world-neurosurgery***

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