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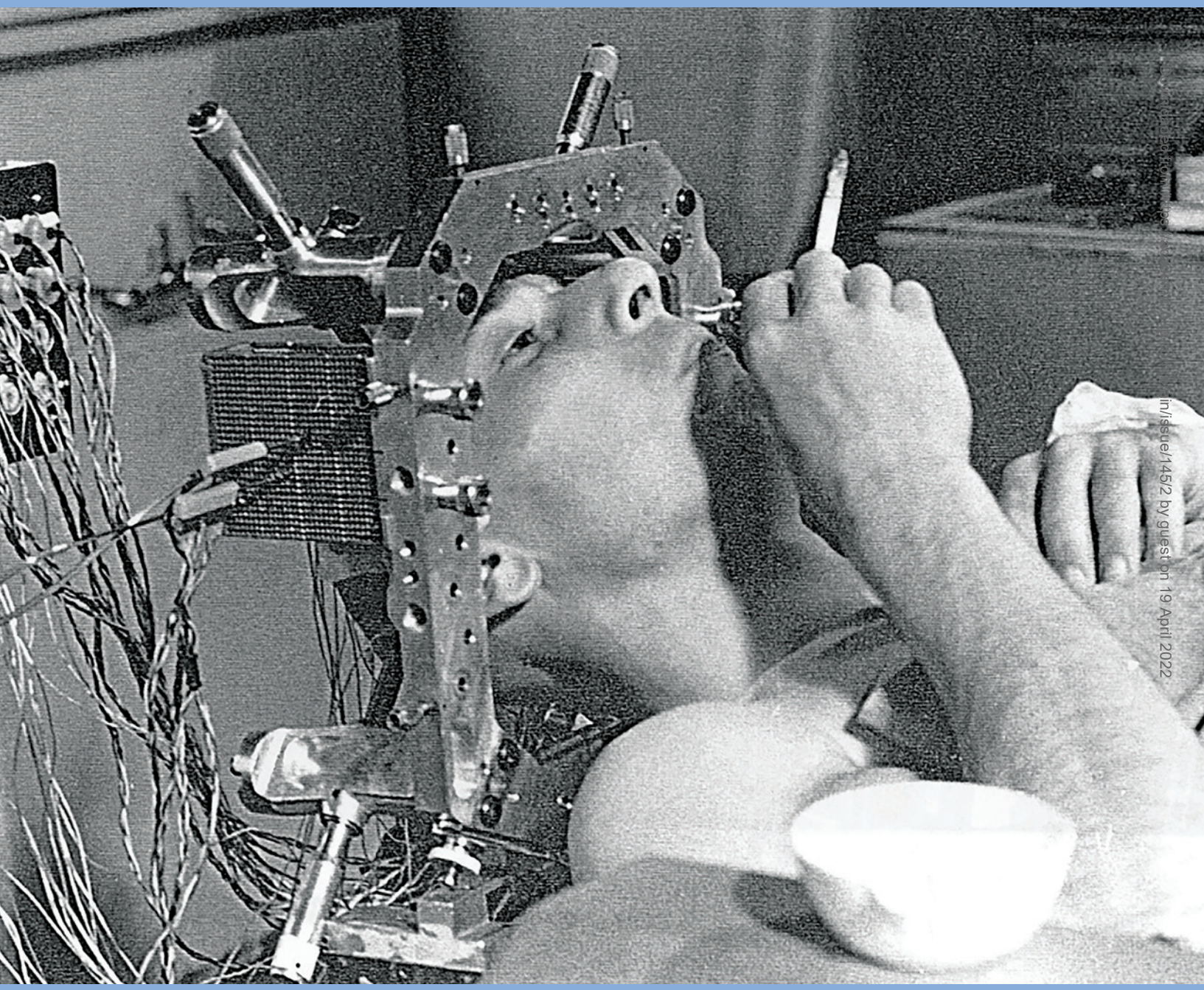

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ESSAY

Jean Talairach: the man behind the cerebral stereotactic space

The Sainte-Anne Hospital, founded in 1867, is a leading psychiatric hospital in France. A neurosurgery Department was founded there in 1941 where Jean Talairach developed modern stereotactic neurosurgery. Despite making major contributions to the field, very little is generally known about him. Here, we present some glimpses of a remarkable career which combined psychiatry with brain surgery.

Talairach was born on 15 January 1911. He was not a straight-A student and called himself 'a dreamer'.[1] After his medical studies in Montpellier, he pursued a residency in Paris in 1937.[1] Henri Ey, his cousin, urged him to become a psychiatrist and suggested Talairach should be trained at the Sainte-Anne Hospital—'the only place where you can be trained to psychiatry'. He passed the residency exam from the psychiatric Hospitals of the Seine in 1938. On 15 April 1938 Talairach started his military service, first discovering neurosurgery with the treatment of craniocerebral trauma occurring in the battlefield. After being demobilized in 1940, Talairach was asked to stay at the Sainte-Anne Hospital where he became chief resident in the psychiatry Department (CMME) of Jean Delay in 1944. In parallel with his medical studies, however, he was recruited by the French Resistance.

From 1940 to 1944, he spent his time drawing up a detailed map of the Parisian quarries with his friend René Suttel, another resident in psychiatry. This map, displaying kilometres of quarries and tunnels beneath the surface of the city, was handed over to the Resistance for their operations in the city. During the subsequent Liberation of Paris, a battle that took place from 19–25 August 1944, Talairach played an active role as a doctor.[2] Then, after he became aware that André Curtillet, a neurosurgeon in the First French Army, and his team were killed on 12 April 1945, Talairach decided to form a medical unit with doctors and nurses from the Sainte-Anne Hospital and to join the battlefront with the First French Army (Fig. 1A).[3] He stayed in this military medical unit until the invasion of Germany by the Allies. For his military service, Talairach was awarded two military crosses and the National Order of the Legion of Honour.

In April 1942, Talairach had been introduced to Marcel David, one of the first French neurosurgeons.[1] Eight days after their first encounter, David offered him a position on his team, not as a psychiatrist, but as a resident in neurosurgery.[1] Talairach, already knowledgeable about basic skills learned during the War, trained in neurosurgery in parallel with his residency in psychiatry. He remembered this period as follows: 'morning psychiatry, afternoon neurosurgery and night quarries'.[1] David and Talairach quickly started a fruitful collaboration: David trained him and offered him financial and moral support during his expensive and demanding studies, while Talairach made great efforts to develop an original stereotactic methodology and the tools that went with it. They promoted their collaborative works at the crossroads of neurosurgery and psychiatry through articles and presentations.

From the outset, Talairach designed a surgical head frame that could be replaced in the exact starting position for the surgical procedure itself, after the initial exploratory step.[4] He built his first stereotactic frame with a double grid system in 1947 at Paul Brousse Hospital.[1,5] The Talairach stereotactic frame kept being improved until 1965 with a fifth-generation frame allowing for multidirectional trajectories. This last version was rewarded in May 1965 with the Nessim Habif Mundial Prize from the University of Geneva. It is worth noting that none of Talairach's frames was patented for ethical reasons and that Marcel David funded these expensive devices with the help of the Sainte-Anne Hospital.[4]

The most remarkable feature of the radiological exams performed by Talairach was the intra-operative tele-angiographic X-rays to limit as much as possible any cranial enlargement or distortion on the radiographs. Such intraoperative control was mandatory for him. Due to the spatial constraints of such intraoperative imaging tools, the full exploitation of the stereotactic system required a dedicated surgical room. In September 1958, Marcel David offered Jean Talairach the first stereotactic operating room in France, dedicated to stereotactic neurosurgery and to neurophysiological explorations of the brain. The 4.75 m length of the two X-ray tubes on two orthogonal planes limited any image enlargement and the dome shape of the roof explained why this room was respectfully named 'the Chapel' by its users and visitors.[1,5]

Anatomical studies were undoubtedly the most important of Talairach's contributions. As early as 1952, Talairach, Henri Hecaen, and Julian de Ajuriaguerra were awarded with the Forque-Baumetz prize from the French Academy of Surgery for their anatomical studies on the relative position of basal nuclei and third ventricle.

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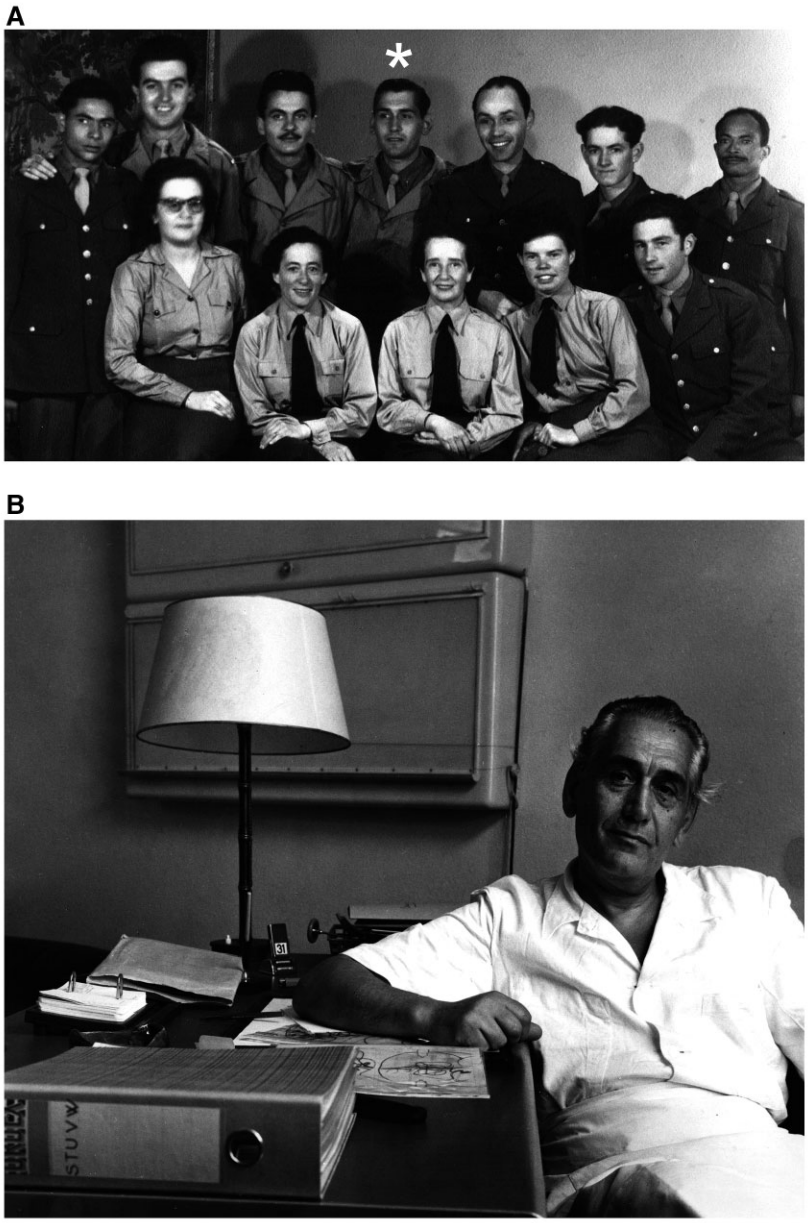

Figure 1 Jean Talairach. (**A**) The Neurosurgical team (nicknamed the Sainte-Anne Hospital team) of the First French Army on 17 July 1945 at Karlsruhe (Germany) with, from *left* to *right* and *top* to *bottom*, Mr Delmi, Mr Guidoni, Mr Marty, Mr Talairach (white star), Mr Sauguet, Mr Jacques, Mr Alidjerada, Mrs Marchand, Mrs Linet, Mrs Mo, Mrs Sulloz, and Mr Perzo. (**B**) Jean Talairach in his office, working on a cerebral stereotactic implantation using drawings based on intraoperative X-rays and stereo-EEG data. These pictures were reproduced with the permission the Sainte-Anne Hospital Museum.

Talairach performed his first stereotactic operation on 7 December 1948 at Paul Brousse Hospital on a 72-year-old male patient who presented a severe intractable trigeminal neuralgia. Instead of proposing the old-fashioned thalamotomy, Jean Talairach performed an electrocoagulation of both ventromedian and centromedian nuclei of the thalamus with a specifically designed stereotactic apparatus, leading to favourable outcomes. After Spiegel and Wycis in the USA, Jean Talairach became one of the world pioneers of human stereotaxis (Fig. 1B). But when he presented this intervention at the French Language Society of Neurology a few months later,[4] he faced a barrage of criticism. Both psychiatrists and neurologists expressed fears concerning the possible uncontrollable expansion of the indications, in particular concerning psychosurgery.

From 1947 to 1957, while facing the criticisms that followed his first stereotactic neurosurgery intervention, Talairach pursued his anatomical studies with assiduously. Patrick J. Kelly wrote:

> 'I was impressed by what one dedicated individual can accomplish in spite of many obstacles. For years, Talairach had worked in a vacuum and few had appreciated his genius. When he proposed his method for stereotaxis in 1949, his colleagues pronounced that it was "blind, antisurgical and unnecessarily complicated".'[5]

Talairach, David and Pierre Tournoux conducted at night, in the stereotactic operating room, experiments on more than 100 cadaver brains. After metallic rods were set up, heads were placed

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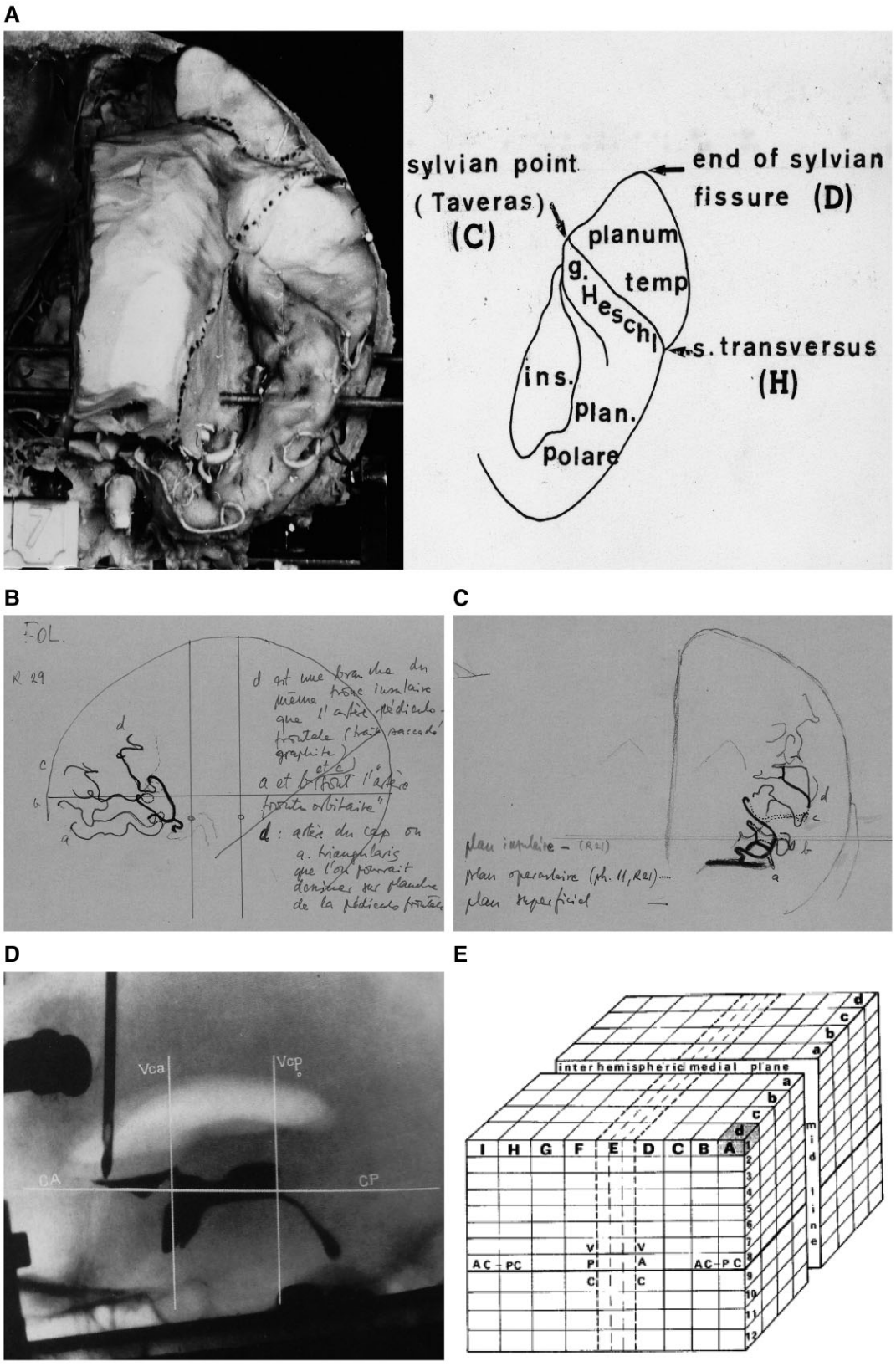

Figure 2 Stereotactic pioneer works. (**A**) One of the anatomical brain specimens used by Jean Talairach and his team to develop the first stereotactic atlas with metallic punches in place and corresponding drawings of the neuroanatomical locations. (**B** and **C**) Drawings by Jean Talairach originating from his anatomical studies on cortical anatomy and vascularization. (**D**) The first description of the AC-PC line from the 1952 seminal publication ('*Etudes stéréotaxiques des structures encéphaliques profondes chez l'homme*' by Talairach *et al.*[6]). (**E**) Proportional Talairach grid system presented in the 1988 atlas. These pictures were reproduced with the permission of the Sainte-Anne Hospital Museum, Elsevier Masson and Thieme Publishing Group.

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in the stereotactic frame in the operating room and multiple X-rays allowed them to precisely locate the rods in the brain (Fig. 2). Talairach described the now well-known reference AC-PC line in 1952: the line passing through the posterior superior edge of the anterior commissure (AC) and the anterior inferior edge of the posterior commissure (PC) could serve as a universal landmark for structure identification in space.[4,6]

In 1952, the neurologist Jean Bancaud joined the neurosurgery Department of the Sainte-Anne Hospital. He suggested Talairach apply his stereotactic methods to investigate patients suffering from drug-resistant epilepsy. The anatomical studies and stereotactic equipment of Talairach on the one hand and the neurophysiological knowledge and EEG recordings of Bancaud on the other were a perfect combination to overcome the limitations of electrocorticography. Their partnership was probably the main factor explaining the important advances concerning epilepsy surgery that were made at the Sainte-Anne's, with the first intraoperative electrophysiological recordings being performed in 1952, and the first intracerebral implantation of deep brain electrodes to monitor the electrical activity during epileptic seizure performed on May 1957. Stereo-EEG, which combines the exploration of stereotactically identified intracerebral structures using depth electrodes and extra-operative EEG recordings, was born.

Stereo-EEG provides data on seizure origin as well as propagation, and based on clinical, imaging, and neurophysiological correlations, allows identification of the epileptogenic zone to guide tailored resection of the cortex or brain lesions responsible for seizure onset, also known as 'cortectomy'. Based on this method, epilepsy surgery began at Sainte-Anne's in 1957 with stereotactic implantations of radioactive seeds of yttrium-90 into the amygdala nuclei and the hippocampal formation.

Brain resection began a little later, in 1960.[7] Epilepsy surgery was Talairach's 'clinical masterpiece' but it was not received well. In 1962, during a congress of neurology, Bancaud was confronted with several criticisms, the major one being the pointlessness of such complex investigation. These first reactions following national airing of the television show 'Consciousness and personality' also did not go down well. Journalists went to film a stereo-EEG in order to demystify epilepsy and epilepsy surgery but public reaction was largely negative due to the shock of witnessing the apparent violence of drug-resistant epilepsy on a prime-time television. Nevertheless, after the initial reaction, stereo-EEG and the daily work of the Sainte-Anne's team began to be considered as a new opportunity for patients who would have been considered incurable shortly before.[4]

The invention of stereo-EEG was only the tip of the iceberg however.[8] Talairach and Bancaud's contributions included a new epilepsy classification with a precise description of complex syndromes. The results reported in 1973 favourably compared with other surgical series and underlined the effectiveness of stereo-EEEG which remains, to date, the gold standard to investigate patients suffering from drug-resistant epilepsy.

If epilepsy surgery was his major clinical contribution, Talairach's 'scientific masterpiece' was his contribution to human brain anatomy. In 1957, Talairach published his first stereotactic atlas, entitled *Stereotactic Anatomic Atlas*[9] and was awarded with the Mounier de Saridakis prize in 1958. He added the extreme points of the brain in the three dimensions to the AC-PC line and published a second atlas in 1967 on the stereotactic anatomy of the telencephalon. Despite his retirement in 1980, Talairach pursued his anatomical studies with gusto and published two new atlases in 1988 and in 1993, both translated in English.[10] The brain was divided into six areas by hemisphere and a rigid transformation translated the patient brain to the template space. This proportional system allowed for a spatial statistical identification of a structure and its function valid for every brain, by reference to a stereotactic atlas. This atlas, although based on the sagittal segmentation of a 60-year-old female's brain represents the first example of brain normalization, which is now a standard technique in neuroimaging studies. In 1989, Talairach was awarded with the grand prize of chemical and natural sciences for his 1988 atlas. The 1993 atlas, incorporating MRI data, quickly became a classic of neurosurgical literature,[10] while the Talairach Daemon was one of the first normalization software applications to be created.

Jean Talairach died on 15 March 2007 in a room of the Neurosurgery Department of the Sainte-Anne Hospital that once was his office. His professional career encapsulates the evolution of neurosurgery during the 20th century. Talairach started his career by surgically treating craniocerebral trauma during World War II and ended it by building an MRI-based stereotactic brain atlas. In between, he developed stereotactic atlases and innovative stereotactic methods to treat patients previously considered incurable, including drug-resistant epilepsy. He remains the most cited of French neurosurgeons.

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Competing interests

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