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CLASSICS IN PEDIATRIC NEUROSURGERY

Tatsuji Inouye: the mind's eye

R. Shane Tubbs · Donny Kakati · Joshua J. Chern · Marios Loukas · Mohammadali Shoja · Martin M. Mortazavi · Aaron A. Cohen-Gadol

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Abstract
Introduction The name Tatsuji Inouye is relatively unknown in the West. This prominent Japanese scientist was one of the first to thoroughly study the visual cortex and to map its gyri. Inouye was also a caring physician who wanted only the best for his patients.
Conclusions In the present review, we discuss the life of Tatsuji Inouye and his significant contributions to our current understanding of the visual cortex.

Keywords Anatomy · Occipital cortex · Japan · History · Visual cortex · Vision

Much of the historical credit for the mapping of the visual cortex has gone to Gordon Holmes for the studies he performed during World War I. Several years prior to this, however, a young Japanese ophthalmologist performed similar studies during the Russo–Japanese War for which he is not often credited. In his study, *Die Sehstoerungen der kortlichen Sehsphaere* (Fig. 1), Tatsuji Inouye (Fig. 2) studied the way the visual fields were affected in gunshot victims who suffered direct damage to the visual cortex [1]. His work was only recently translated by Glickstein and Fahle [2] as *Eye Disturbances after Gunshot Injuries to the Cortical Visual Pathways.*

Tatsuji Inouye produced the first topographical representation of the visual cortex during the Russo–Japanese War in 1904–1905. Inouye, only a year after his graduation from medical school, was hired by the Japanese government to determine the visual losses suffered by Japanese soldiers in order that their pensions would justly fit the amount of damage they had endured [3]. Inouye used this as an opportunity to explore the way the visual field is represented on the visual cortex.

An important factor that affected the ability of Inouye to perform his research was the Mosin-Nagant Model 91, a new type of weaponry, which had a muzzle velocity of 620 m/s and a bullet diameter of 7.6 mm [4]. This new model allowed for easy penetration of the skull, but the bullet did not travel fast enough to cause significant brain injury from resulting shockwaves created by the bullet entry, as the weapons of previous wars had [5]. This newer weaponry used by Russian soldiers resulted in exit and entry wounds in a direct path without significant damage to surrounding brain tissue, which allowed Inouye to directly analyze the effects of the wounds on the visual cortex and resulting visual fields [6].

Using his invention, the cranio-coordinometer, Inouye was able to decipher which parts of the visual cortex correlated to which parts of the visual fields by studying the relationships between cortical fissures and the overlying skull from the path left by bullets [5]. Inouye demonstrated that the trajectory of the bullets did indeed maintain straight lines, proving the validity of his work by using simple case studies that showed for example, entry, exit, and shoulder wounds from the same

R. S. Tubbs (✉) · D. Kakati · J. J. Chern · M. M. Mortazavi
Department of Pediatric Neurosurgery, Children's Hospital,
1600 7th Avenue South ACC 400,
Birmingham, AL 35233, USA
e-mail: shane.tubbs@chsys.org

M. Loukas
Department of Anatomical Sciences, St. George's University,
Grenada, Trinidad and Tobago

M. Shoja · A. A. Cohen-Gadol
Department of Neurosurgery,
Goodman Campbell Brain and Spine and Indiana University,
Bloomington, IN, USA

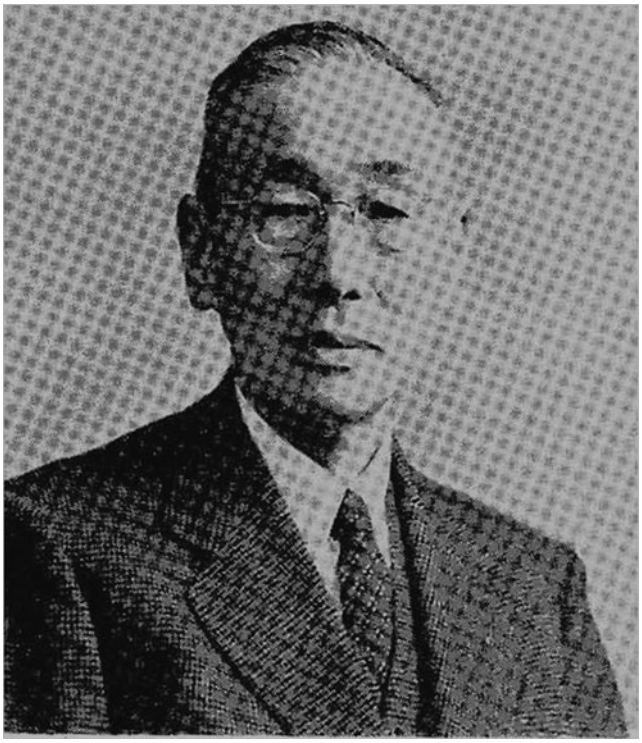


Fig. 1 Tatsuji Inouye

bullet all lay in a straight line [2]. His findings included the representation of the macula on the visual cortex and the explanation for macular sparing, as well as correct representation of the poles of the visual fields and visual cortex [2]. Later, studies by Gordon Holmes confirmed much of the prior research published by Inouye, but disagreed in that Holmes showed that the dual circulation of the striate cortex also contributed to macular sparing [7]. Studies by Hoy and Horton showed that actually, 75% of the striate cortex represented central vision as opposed to 25% as Inouye and Holmes had agreed upon [8]. While Holmes is given most of the credit for the original mapping of the visual cortex, Holmes did give credit to Inouye in his own piece by calling Inouye's work an "excellent monograph" [6].

While his contributions to the mapping of the visual cortex are tremendous, Inouye is known better for his other contributions and his family life in today's literature. Tatsuji was born in 1881 as the second son of Tatsuya Inouye. Tatsuya hailed from a renowned family that has practiced medicine for almost 400 years [5]. Tatsuya trained under Dr. Bauduin in both ophthalmology and surgery, before founding the Inouye Eye Hospital in Tokyo in 1884, which continues to bear his family name to this day.

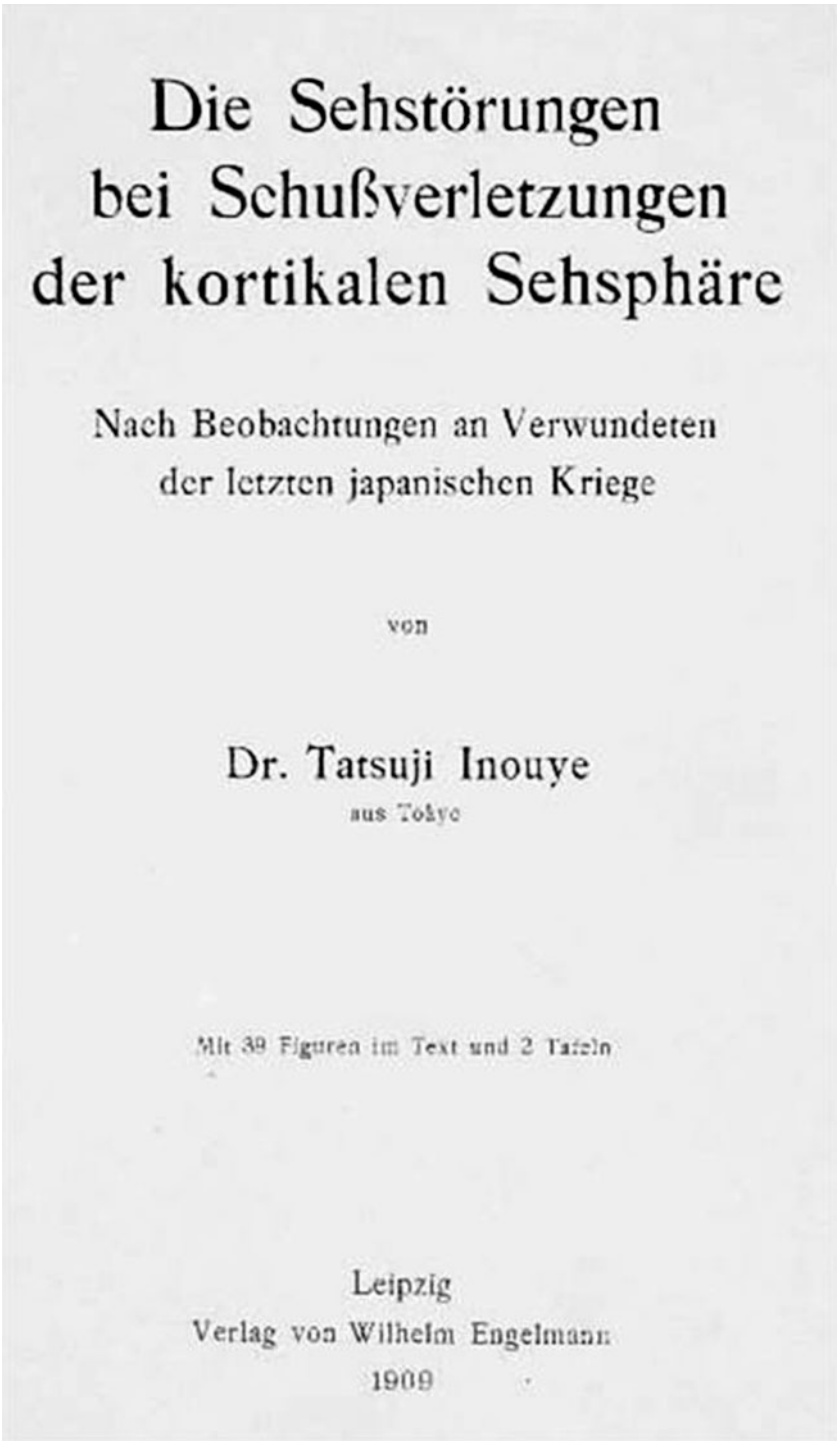
Tatsuji graduated from medical school at Tokyo University in 1904 where he joined the staff under Jujiro Komoto [5]. A year later, Inouye was ordered by the Japanese government to serve in the army as a physician to decipher how much pension wounded soldiers should be granted [3]. Tatsuji worked at the Tokyo-Toyama Military Hospital where he compiled his studies to map the visual cortex and its relation to visual field deficits after studying 29 soldiers with cranial bullet wounds [5].

After returning from the war, Inouye traveled to Leipzig where he published his studies from the war. He then studied abroad in Berlin, London, and Paris before returning to lead the Inouye Eye Hospital in 1909, holding the leadership position until 1963 [5]. After returning home, Inouye left science to pursue more medicinal endeavors [3]. In 1916, Inouye went about developing new visual acuity charts. He first developed the Itohiki, an instrument which allowed one letter to be viewed at a time during vision testing by using a slit projector. He also believed that the current lettering system used in acuity charts, which used curved letters as compared to ordinary Japanese script, often made it difficult for Japanese citizens to decipher, and this resulted in less reliable results from the visual acuity screen. Inouye developed a newer chart where the letters where straighter and arranged more horizontally, and this new chart was quickly recognized as being a more reliable examination of actual visual acuity than the previously used Landolt charts. The newly developed visual acuity chart developed by Inouye was adapted for use in children [4].

In the late 1930s, the government requested help from Inouye to curb the increasing prevalence of myopia in school children. After studying the causes and contributory factors leading to this "school myopia," Inouye invented a hand glove, which controlled the distance between the eyes and the writing hand to reduce overstraining [4].

Inouye served the Japanese people for more than 60 years until he was finally succeeded by his son Masazumi Inouye at the Inouye Eye Hospital. During his time, Tatsuji Inouye saw patients in his home after the eye hospital was destroyed in 1923 in the Tokyo earthquake. He also helped serve American soldiers in World War II and soldiers wounded during the Korean conflict [4]. Inouye's greatest achievement lies in the work for which he is given the least credit, the mapping of the visual cortex. But through all of his great contributions to mankind, the true humanity of the man can be seen in the words of his foreword in his first publication:

> "The hardship and ferocity of the last war led me to publish these observations. The awfulness and horror of the experience, of which those who did not take part


Die Sehstörungen
bei Schußverletzungen
der kortikalen Sehsphäre

Nach Beobachtungen an Verwundeten
der letzten japanischen Kriege

von

Dr. Tatsuji Inouye
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Fig. 2 Title page from Inouye's historic work on the visual cortex

cannot have the slightest appreciation, at the same time raised the hope in me and in all other physicians that in the future, war may, if possible, be prevented. If this is not to be, then it should be carried out with all possible care, reducing as much as possible the terrible sorrow and hardships for its participants. If my work could have even the slightest influence in this direction, then it would fill me with the greatest contentment."

Tatsuji Inouye died at the age of 96 in 1975 after living a full life as a practitioner of Zen philosophy. He wholeheartedly believed in and lived by the adage: Mizaru,

Iwazaru, Kikazaru—if the mind is at peace, the brain is at peace [4].

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