J Neurol (2015) 262:2399–2400
DOI 10.1007/s00415-015-7801-9

PIONEERS IN NEUROLOGY

Tatsuji Inouye (1881–1976)

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Received: 26 May 2015 / Accepted: 26 May 2015 / Published online: 6 June 2015

Tatsuji Inouye (1881–1976) was the first person to delineate accurately the cortical representation of visual space in humans. Inouye's father, who was descended from a long line of Japanese physicians, founded the Inouye Eye Hospital in Tokyo in 1884 which continues to bear the family name. Tatsuji was head of this hospital from 1909 to 1963 when he was succeeded by his son and, more recently, his grandson.

Inouye studied medicine at Tokyo University (MD 1904) and joined the staff of the Ophthalmology department under Jujiro Komoto, then a leading ophthalmologist in Japan [2]. The following year Inouye was ordered to serve as a medical officer in the Russo-Japanese War (1904–1905). His assignment was to evaluate visual loss in wounded soldiers to determine the value of their pensions. The Russians were using a new rifle (the Moisin Nagent) that fired a small calibre, relatively high-velocity bullet. Some Japanese soldiers survived being hit by these projectiles in the back of their head. Inouye used this opportunity to map out the location of the visual field by carefully examining 29 cases (including some soldiers similarly wounded in the Boxer Rebellion of 1900).

Inouye measured all the soldiers' visual fields himself using dynamic perimetry performed with four differently coloured targets. Most of the patients had entry and exit wounds, and he made the reasonable assumption that the projectile had passed between the two in a straight line, but how could these coordinates in scalp space be translated into brain space? To do this Inouye had to create a standardized model of the surface of the head and the average relations of this to the brain below. He did this using a stereotactic instrument of his own making, the cranio-coordinometer. First, he created an average head model by taking measurements 10 mm apart all over the scalps of 26 Japanese controls. Using 12 cadavers he then made direct measurements of the distance between points on the scalp and key brain landmarks such as the calcarine fissure, parieto-occipital fissure, tentorium cerebelli and the posterior horn of the lateral ventricle. From these two sets of measures he was able to transform the triangulated path of the bullet from each patient into standard brain space.

Although others had produced craniometers for human use, including Victor Horsley (1857–1916), and other brain maps existed, this is the first example I can find of the production of a brain mapping coordinate system in standard (average) space: "This brain model is a hypothetical one which does not exist in reality. Rather we represent it for our own purpose by a set of figures which are none other than the cut surfaces of the hypothetical brain model" ([6], p.2).

Inouye's contribution came only 25 years after the occipital lobe had been identified as the site of visual cortex. Francesco Gennari (1750–?) was the first to describe the striate cortex. He dubbed it the "lineola albidiar" but it soon came to be known eponymously. He had no idea what its function was; at that time the prevailing view was that the cerebral cortex was equipotent with no one-to-one structure–function mapping. The evidence to challenge this view, that some brain functions can be localized, started to accrue in the nineteenth century. In a now famous series of experiments, David Ferrier (1843–1928) demonstrated both the strengths and weaknesses of cortical ablation

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methodology as a way of pursuing localization. He removed cortex from the parietal lobes of monkeys and rendered them profoundly visually impaired, leading him to conclude that the primary visual area was located in the angular gyrus [1]. Ferrier had inadvertently rendered the experimental animals profoundly visuo-spatially impaired rather than blind, an error not lost on Hermann Munk (1839–1912), a physiologist working at the Berlin Veterinary School. Munk went on to show that the occipital lobe houses visual cortex with the left visual field represented in the right lobe and vice versa [9]. The Swedish neuropathologist Salomon Henschen (1847–1930) confirmed that damage to the striate cortex is responsible for producing a contralateral hemianopia in humans [3]. He also correctly ascertained that the lower visual field is represented on the upper bank of the calcarine cortex, and vice versa, but he falsely located the representation of foveal vision at the anterior part of calcarine cortex, rather than towards the occipital pole. This error was perpetuated [8] until Inouye's studies were carried out.

Inouye's meticulous measurements of the bullet trajectories and subsequent Euclidian transformations of these led him to produce what he called a "true-area representation" of the visual field in striate cortex. This map correctly identifies three important features relating to the cortical representation of vision. First, it confirms the location of the horizontal and vertical meridians, with the lower visual field represented on the upper bank of the calcarine cortex and vice versa. Second, it identifies the occipital pole as the site of foveal vision, with progressively more eccentric portions of the hemifield being represented in an orderly fashion anteriorly along the cortex abutting the calcarine fissure. Finally, and perhaps most importantly in terms of visual neuroscience, it notes that central vision has an expanded cortical representation, although, like others after him, Inouye underestimated the size of this effect.

Inouye's work was replicated by two British neurologists who received much of the credit even though they used very similar techniques: Gordon Holmes with his observations on soldiers who participated in World War I [4], and John Spalding with soldiers injured in World War II [10]. To his credit, Holmes did reference Inouye's work calling it an "excellent monograph" ([4], p.37) but perhaps because Inouye first published in German [5] most subsequent sources quote Holmes' paper instead.

After producing his ground-breaking work, Inouye moved on to more clinical pursuits. He devised a chart that more accurately measured visual acuity in Japanese readers; he also ran a successful intervention programme to counteract "school myopia". When the Japanese Ophthalmic Society honoured him, the citation included these latter achievements only and not his seminal work on the representation of vision in striate cortex [7]. Like many before them and some since, the learned Society failed to notice Inouye's great contribution to visual science.

Conflicts of interest The author states that there is no conflict of interest.

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