Editorial

We Must Invest in Applied Knowledge of Computational Neurosciences and Neuroinformatics as an Important Future in Malaysia: The Malaysian Brain Mapping Project

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Abstract

The Academy of Sciences Malaysia and the Malaysian Industry-Government group for High Technology has been working hard to project the future of big data and neurotechnology usage up to the year 2050. On the 19 September 2016, the International Brain Initiative was announced by US Under Secretary of State Thomas Shannon at a meeting that accompanied the United Nations' General Assembly in New York City. This initiative was seen as an important effort but deemed costly for developing countries. At a concurrent meeting hosted by the US National Science Foundation at Rockefeller University, numerous countries discussed this massive project, which would require genuine collaboration between investigators in the realms of neuroethics. Malaysia's readiness to embark on using big data in the field of brain, mind and neurosciences is to prepare for the 4th Industrial Revolution which is an important investment for the country's future. The development of new strategies has also been encouraged by the involvement of the Society of Brain Mapping and Therapeutics, USA and the International Neuroinformatics Coordinating Facility.

Keywords: *big data, computational neurosciences, neuroinformatics, neurotechnology, Malaysia, industrial revolution, brain mapping*

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To prepare for the 4th Industrial Revolution (4IR) (1), Malaysian neuroscientists must concentrate on engaging in analytics of big data collected on the human neuron system using computational neurosciences and neuroinformatics. Computational neurosciences previously defined as the study of brain functions concerning the information-processing properties of the structures that make up the nervous system must link with the diverse fields of neurosciences, cognitive sciences and psychology with electrical engineering, chemistry, mathematics and physics. Moreover, it is different from machine learning and depends on data derived from resting and active biological neurons and other cells, namely astrocytes for their temporal-spatial electrophysiology, as well as their chemical "characteristics". These data are collected using advanced neurotechnology equipment, such as high-density-array electroencephalography, functional magnetic resonance imaging, near infrared spectroscopy, magnetoencephalography and other devices that both stimulate and record the response of neural tissues.

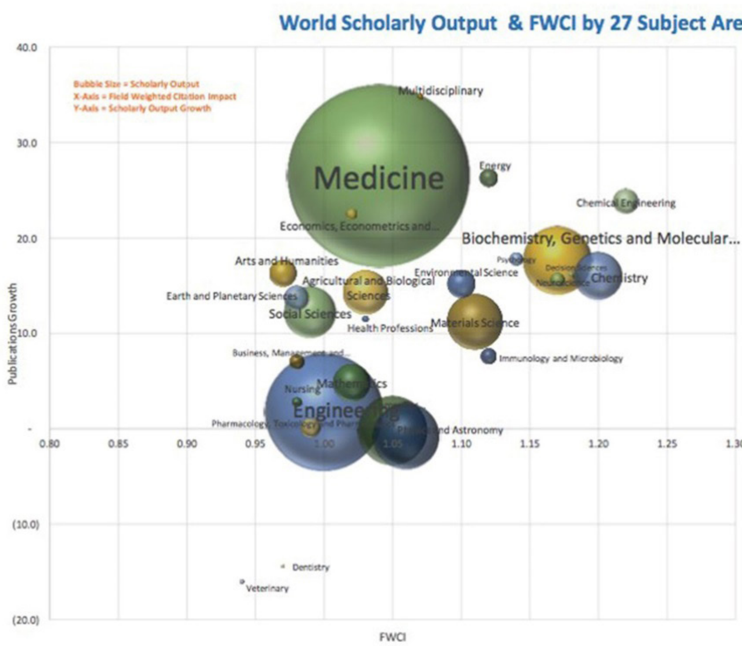
The Academy of Sciences Malaysia (ASM) and the Malaysian Industry-Government group for High Technology (MIGHT) has worked over the past 2 years to project the future of big data and neurotechnology usage up to the year 2050 (2, 3). The International Brain Initiative was announced by US Under Secretary of State Thomas Shannon at a meeting that accompanied the United Nations' General Assembly in New York City on the 19 September 2016. This initiative was seen as an important effort but deemed costly for developing countries. At a concurrent meeting hosted by the US National Science Foundation at Rockefeller University, numerous countries discussed this massive project, which would require genuine collaboration between investigators in the realms of neuroethics (4). Looking at these ongoing global perspectives, it is about time that ASM and MIGHT unite Malaysian neuroscientist so as to achieve these knowledge skills and technology to join the 4IR.

Computational neuroscience and neuroinformatics represent growing fields in Malaysia which are important for the growth of Brain Mapping as highlighted by the Society for Brain Mapping and Therapeutics and the International Neuroinformatics Coordinating Facility (INCF) (5). Both focuses on understanding the human brain, the most complex computer system in existence. Computational neuroscience and neuroinformatics are two distinct (with some overlapping) areas, and yet they complement each other. Computational neuroscience is a research field concerned with theoretical methods of investigating the function and mechanism of the nervous system. It aims to give a quantitative description of functionality and biologically realistic neuron networks and to capture them in realistic models that can be used to develop new hypotheses to be experimentally tested. This field is also often loosely referred to as computational modelling. To continue deepening our understanding of the brain, it is necessary for many and various sub-disciplines to share data and findings in a meaningful way. In contrast, neuroinformatics is a research field concerned with the organisation of neuroscience data via the application of databases and analytical tools. Such areas of research are important for the integration, sharing, management and analysis of increasingly large-volume, high-dimensional, and fine-grain experimental data. This field provides computational tools, mathematical models and interoperable databases for research scientists.

Scientific endeavours in the computational neuroscience and neuroinformatics fields have been ongoing for centuries. Today, the advance of technology has led to the point where we can understand brain function perhaps down to the molecular level; however, Malaysia still has a long way to go to fulfil the goal of understanding basic brain function. The future of computational neuroscience and neuroinformatics are wide open in Malaysia, and the directions that remain to be explored in the development of methods, techniques and algorithms are described below (6).

Data archiving is used to efficiently collect, store, query and share neuroimaging data. Some of these data are large in scale (big data), geographically distributed and already have a large dataset and a well-established user community. To engage in data archiving, it is also necessary to apply a new infrastructure, such as cloud technology, that provides a globally integrated view of the data. Another approach is data visualisation, which facilitates viewing and understanding the context of brain data (7). Three-dimensional (3D) visualisation and virtualisation for the human brain is the best approach to meeting domain-specific needs. As important equipment, high-performance machines with heterogeneous environments are required to rapidly carry out large-scale parallel data-processing tasks. This is necessary for the efficient processing of high-volume datasets, especially when a popular bottom-up explorative data analysis (8) approach is used. Furthermore, data mining is an approach used to efficiently extract meaningful information from the data; this represents the most challenging part of computational neuroscience and neuroinformatics advancement. Machine learning and statistical software are crucial requirements for the success of data mining. Data modelling is also necessary, as it provides a link between the data we collect and our theories about the way the brain works. This approach provides a scaffold for collecting data of interest and acts as a proving ground for theories. Software package tools facilitate the analysis of heterogeneous datasets for a better understanding the structure and function of the brain. Such tools enhance data collection, sharing, storage, manipulation, analysis, integration, interpretation, modelling and collaboration. Tools can be used to run large-scale simulations and helping scientists to carry out difficult and time consuming tasks. Brain-computer interface (BCI) prototype development is necessary to generate intelligent technical devices with brain-inspired sensors that carry out a complex task in a safe, reliable way. Finally, strategic collaboration between many parties, such as clinicians and researchers, should be fostered to understand the brain. The US BRAIN Initiative (9) and BLUE Brain project (10) are some examples of collaboration. The future is heavily dependent on a new spirit of working together as a global community.

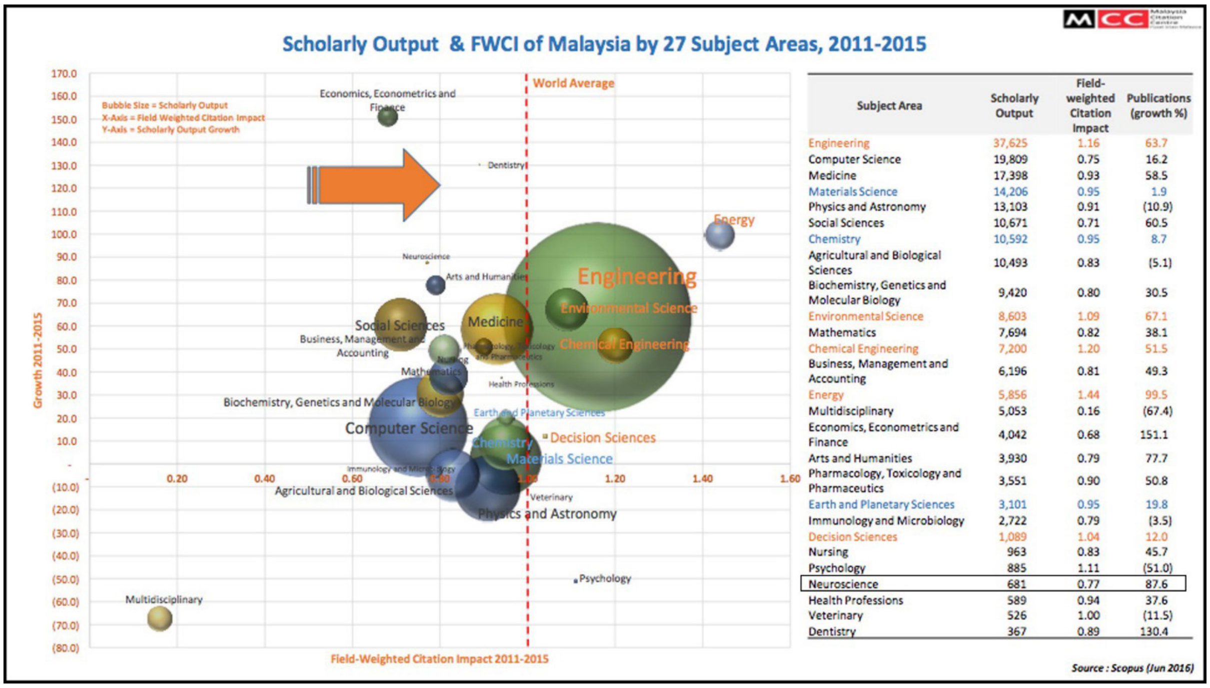
The growth of neurosciences in Malaysia, audited using Scopus data (Figure 1–6), indicates that the investment of neurosciences in research universities in Malaysia are focused mainly on general neurosciences and that neuroscientists are mostly working in silos. This needs to change if we are to join the Global Brain Project.



Subject Area	Scholarly Output	Field-weighted Citation Impact	Publications (growth %)
Medicine	4,123,779	1.04	26.5
Engineering	2,675,704	1.00	1.7
Biochemistry, Genetics and Molecular Biology	1,561,421	1.17	17.6
Computer Science	1,556,780	1.05	(0.2)
Physics and Astronomy	1,501,296	1.06	(0.8)
Materials Science	1,271,109	1.11	11.2
Social Sciences	1,173,094	0.99	12.2
Chemistry	1,095,811	1.20	16.0
Agricultural and Biological Sciences	1,018,862	1.03	14.3
Mathematics	850,495	1.02	4.8
Environmental Science	643,531	1.10	15.2
Arts and Humanities	626,021	0.97	16.3
Chemical Engineering	565,129	1.22	23.8
Earth and Planetary Sciences	563,081	0.98	13.7
Pharmacology, Toxicology and Pharmaceutics	443,692	0.99	0.1
Energy	416,800	1.12	26.3
Immunology and Microbiology	366,548	1.12	7.6
Business, Management and Accounting	343,011	0.98	7.0
Neuroscience	323,710	1.17	15.6
Psychology	309,708	1.14	17.8
Economics, Econometrics and Finance	253,481	1.02	22.5
Nursing	225,169	0.98	2.8
Health Professions	158,111	1.03	11.5
Multidisciplinary	139,683	1.07	34.8
Decision Sciences	124,315	1.18	16.2
Veterinary	113,906	0.94	(16.0)
Dentistry	80,414	0.97	(14.4)

Source : Scopus (Jun 2016)

Figure 1. The field-weighted citation impact (FWCI) of neuroscience (worldwide) is 1.17, which is very good compared to other subjects (black square). The FWCI world average is 1.0. The publication growth rate for neuroscience is 115.6% (5 years)



Subject Area	Scholarly Output	Field-weighted Citation Impact	Publications (growth %)
Engineering	37,625	1.16	63.7
Computer Science	19,809	0.75	16.2
Medicine	17,398	0.93	58.5
Materials Science	14,206	0.95	1.9
Physics and Astronomy	13,103	0.91	(10.9)
Social Sciences	10,671	0.71	60.5
Chemistry	10,592	0.95	8.7
Agricultural and Biological Sciences	10,493	0.83	(5.1)
Biochemistry, Genetics and Molecular Biology	9,420	0.80	30.5
Environmental Science	8,603	1.09	67.1
Mathematics	7,694	0.82	38.1
Chemical Engineering	7,200	1.20	51.5
Business, Management and Accounting	6,196	0.81	49.3
Energy	5,856	1.44	99.5
Multidisciplinary	5,053	0.16	(67.4)
Economics, Econometrics and Finance	4,042	0.68	151.1
Arts and Humanities	3,930	0.79	77.7
Pharmacology, Toxicology and Pharmaceutics	3,551	0.90	50.8
Earth and Planetary Sciences	3,101	0.95	19.8
Immunology and Microbiology	2,722	0.79	(3.5)
Decision Sciences	1,089	1.04	12.0
Nursing	963	0.83	45.7
Psychology	885	1.11	(51.0)
Neuroscience	681	0.77	87.6
Health Professions	589	0.94	37.6
Veterinary	526	1.00	(11.5)
Dentistry	367	0.89	130.4

Figure 2. The field-weighted citation impact (FWCI) of neuroscience in Malaysia is < 0.8 (black square). The FWCI world average is 1.0. The percentage growth of Malaysian neuroscience (< 90%) is below the world average (100%). However, the result is good compared to other subject areas in Malaysia

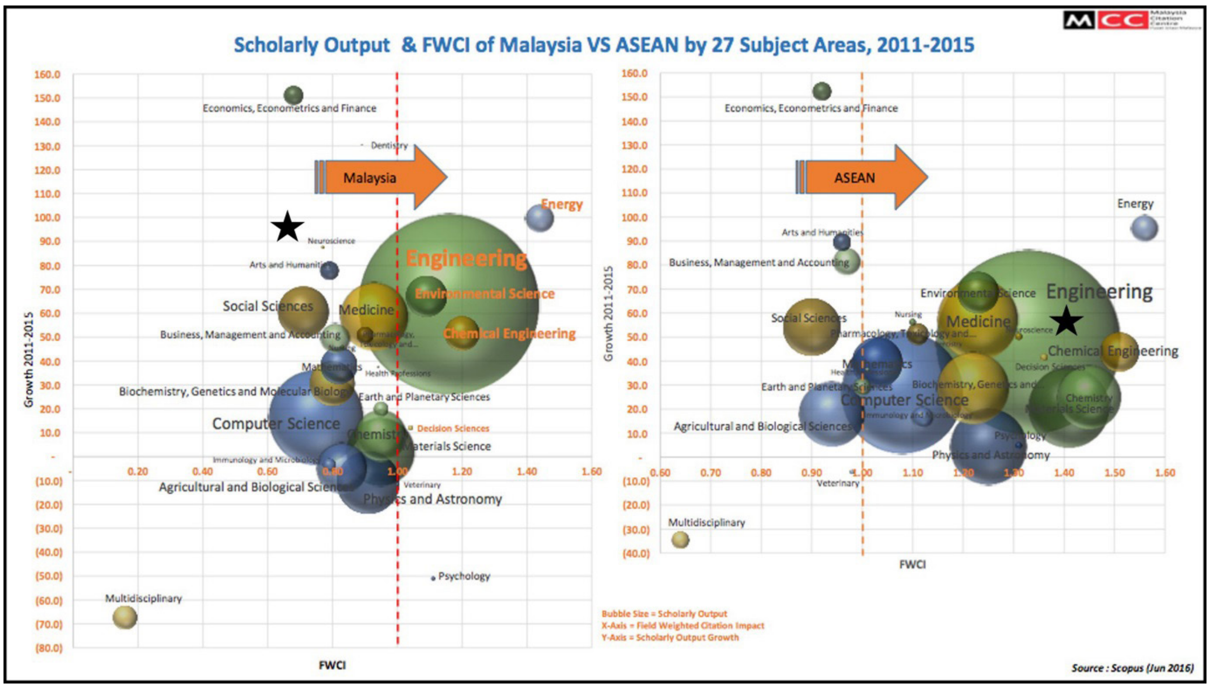


Figure 3. Neuroscience in Malaysia is below the world's average in terms of growth and FWCI (black star). Neuroscience in ASEAN is above the world's average in terms of FWCI but exhibits much slower growth (black star)

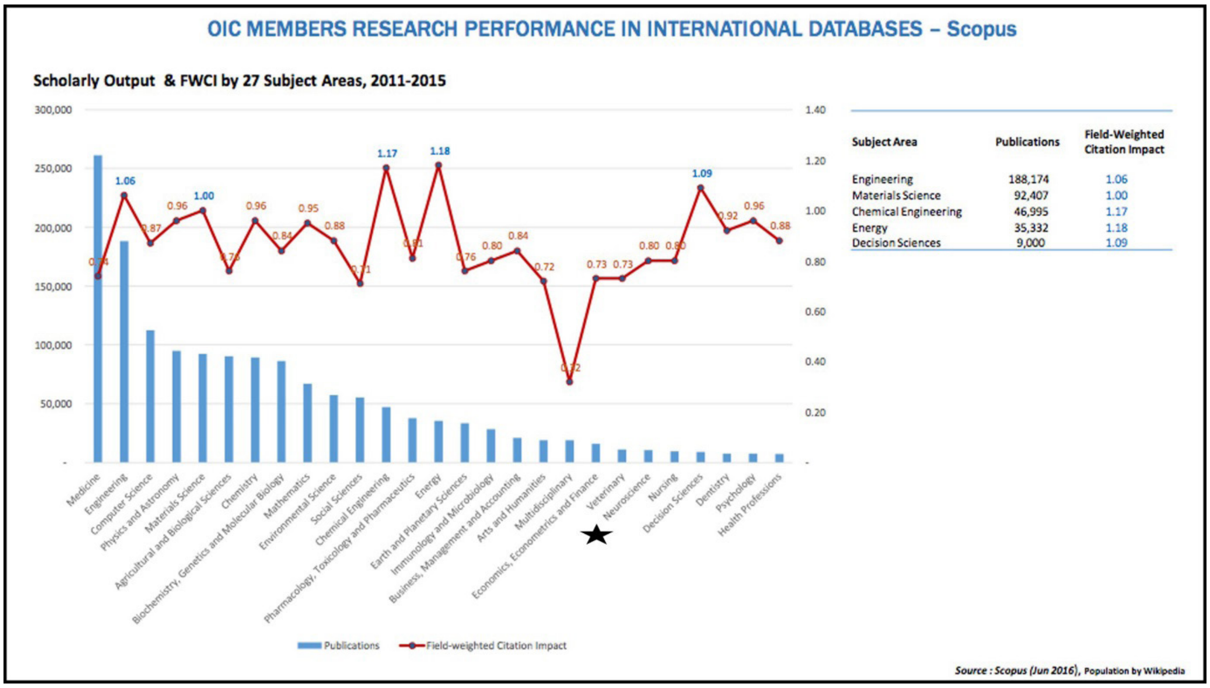


Figure 4. Performance of neuroscience in OIC member countries (0.8) is below the world's average (1.0) in terms of FWCI (black star)

RU's Publications by Subject Area Ranked by FWCI, 2011-2015

	Subject Area	Publications	Publications (growth %)	Citations	Authors	Authors (growth %)	Citations per Publication	Field-weighted Citation Impact
1	Energy	3,477	91.6	34,599	4,125	120.0	10.0	1.77
2	Decision Sciences	547	32.7	2,435	844	38.6	4.5	1.45
3	Chemical Engineering	5,376	37.9	41,825	6,238	54.5	7.8	1.23
4	Engineering	21,028	51.8	68,824	18,177	72.2	3.3	1.20
5	Environmental Science	5,844	49.9	35,285	7,483	69.8	6.0	1.18
6	Dentistry	235	54.3	888	345	68.1	3.8	1.18
7	Psychology	564	-61.9	1,681	1,042	-64.4	3.0	1.08
8	Earth and Planetary Sciences	1,926	25.6	7,317	2,234	23.3	3.8	1.06
9	Health Professions	401	19.7	1,506	688	47.3	3.8	1.06
10	Materials Science	10,291	-16.0	52,787	8,025	35.3	5.1	0.97
11	Chemistry	8,407	-7.3	54,973	7,036	56.3	6.5	0.93
12	Physics and Astronomy	9,881	-19.4	39,945	7,621	16.2	4.0	0.92
13	Mathematics	4,696	22.5	12,001	4,879	42.4	2.6	0.91
14	Pharmacology, Toxicology and Pharmaceutics	2,371	20.1	12,386	3,452	35.2	5.2	0.91
15	Business, Management and Accounting	3,088	59.3	6,317	3,700	81.8	2.0	0.90
16	Medicine	12,847	60.8	54,336	15,183	70.5	4.2	0.89
17	Veterinary	448	-5.2	1,247	796	26.2	2.8	0.89
18	Computer Science	10,174	15.1	24,871	9,733	21.5	2.4	0.87
19	Agricultural and Biological Sciences	7,598	-10.3	30,556	9,564	12.5	4.0	0.82
20	Arts and Humanities	2,542	112.4	2,603	3,231	117.7	1.0	0.82
21	Neuroscience	487	85.3	2441	864	108.6	5.0	0.82
22	Biochemistry, Genetics and Molecular Biology	7,214	21.8	38,275	10,234	34.4	5.3	0.79
23	Nursing	681	52.0	2,327	1341	56.8	3.4	0.79
24	Immunology and Microbiology	2,145	-5.1	10,431	3,605	6.8	4.9	0.76
25	Social Sciences	6,391	61.8	8,519	7,352	62.6	1.3	0.75
26	Economics, Econometrics and Finance	2,418	164.6	3,122	2,862	185.6	1.3	0.67
27	Multidisciplinary	3,502	-63.1	7,120	5,954	-45.0	2.0	0.15

Source : Scopus (Julai 2016)

Figure 5. Neuroscience is ranked 21 amongst 27 subject areas in Malaysia (red square)

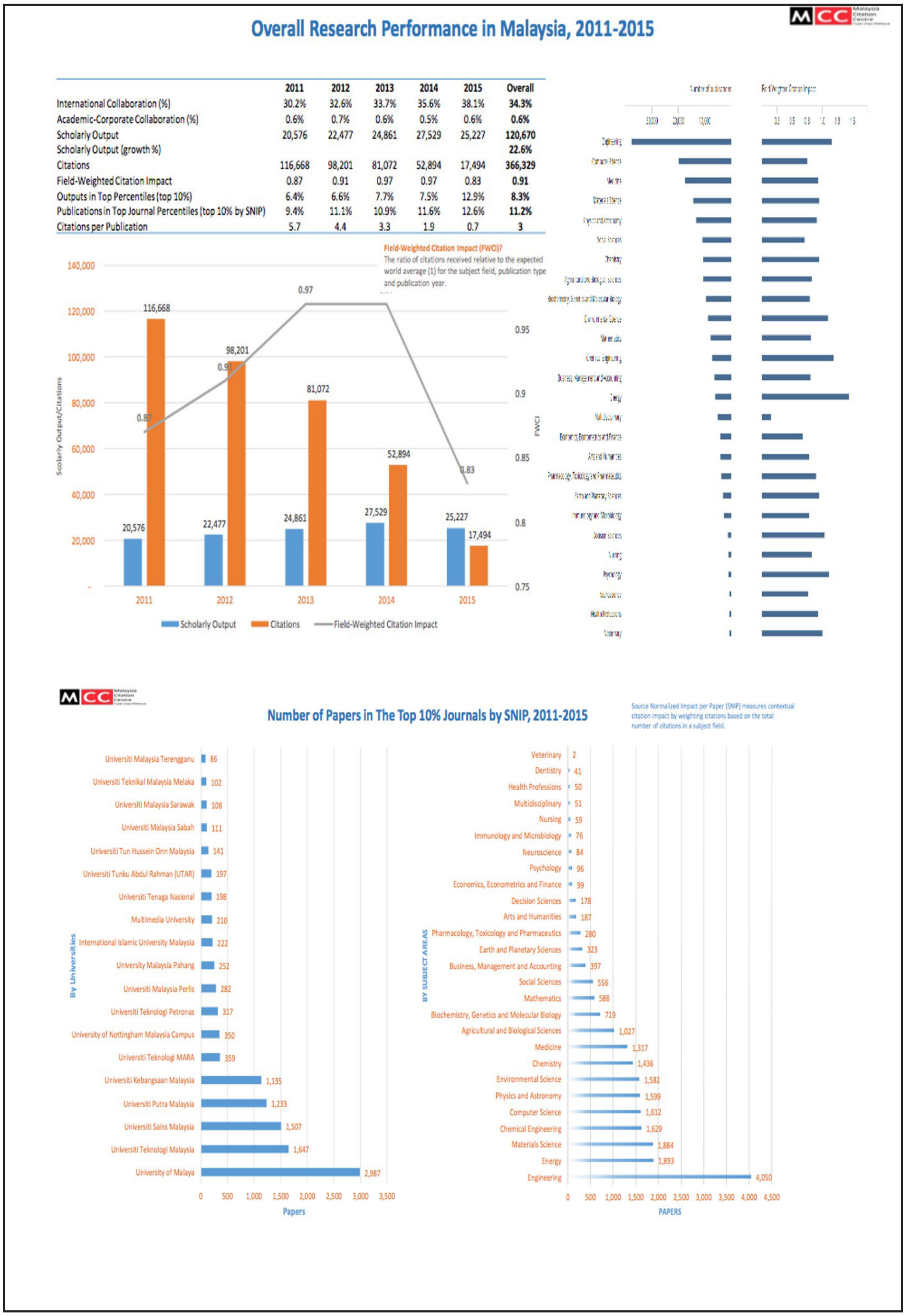


Figure 6. Although the number of papers published in neuroscience in Malaysia is small compared to others, the field-weighted citation impact (FWCI) is good (0.82) but below the world average of 1.0

Recent articles from the journal Neuron in 2016 (11–32) indicates that countries like Malaysia must invest in trans-university and translational efforts with the support of human ethical approval to collect, store and analyse data from humans in states of both wellness and illness to find common effective cures or preventive measures. This will boost both the number of translational data analyses in the field of neuroscience and create at least 10 cognitive scientist in these fields per 100,000 labour force workers by 2025 for Malaysia to enter the 4th Industrial Revolution.

The sharing of data from numerous institutions in the scientific fields mentioned above are crucial (33). Common big data are needed to determine which signal biomarkers from computational neurosciences are important. With the unified support from the Ministry of Health, Ministry of Science, Technology and Innovation and Ministry of Higher Education; such data can be used to ensure that Malaysia achieves a healthy population by 2050 in both mind and body. It is important for a Malaysian brain, mind and neuroscience initiative to be developed as a national project namely "The Malaysian Brain Mapping Project".

Authors' Contributions

Conception and design: PS, ZI, JMA
Analysis and interpretation of the data: JMA
Drafting of the article: PS, ZI, JMA
Critical revision of the article for important intellectual content: PS, ZI, JMA
Final approval of the article: PS, ZI, JMA
Administrative, technical, or logistic support: PS, ZI, JMA
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