Comparison of magnetization transfer methods for assessing macromolecular bound water in the brain and cervical spinal cord

APPENDIX C

Valorisation

The work for this thesis is the outcome of a multidisciplinary research partnership between Maastricht University (Netherlands), GlaxoSmithKline plc (GSK) (United Kingdom), Imanova Ltd (United Kingdom) and the Marie Skłodowska-Curie Actions Innovative Training Networks (MSCA-ITN) (European Commission). The research was performed at the GSK Clinical Imaging Centre and Imanova facilities at the Hammersmith Hospital of Imperial College London with the aim of leveraging interactions between academia and industry in order to maximize the potential valorisation.

There is a long history of productive collaboration between biomedical researchers in academia and in the pharmaceutical industry. The primary beneficiary of this collaboration has been the public, who have benefited from the advances to healthcare and quality of life made possible, as well as the jobs creation and economic benefits arising from this strong sector of the European economy. Translational research interactions with academia have long contributed to the vibrancy of the pharmaceutical and related healthcare diagnostics industry. My research, jointly supervised by academics and industry mentors, provided an excellent opportunity to

contribute to this and to derive considerable personal advantages for development of my capabilities.

The MSCA-ITN programme proved to be an ideal vehicle to overcome and cross boundaries in ways that promise to realise future applications of value for the healthcare, industry and the general public because of its emphasis on bringing stakeholders together for valorisation. In addition, the programme offered high level of mobility for the researcher involved and initiatives that support the process of strengthening knowledge and the experience. The international aspect of the programme made an important contribution to extending the scope of valorisation by helping me to better understand how to diffuse the ideas and work in multiple countries. The project implemented the ideas of Marie Skłodowska-Curie, who wrote: "I believe that international cooperation is a very difficult task, which has to be undertaken, should it even be at the cost of many efforts and true sacrifice"

Multiple sclerosis is an autoimmune disease of the central nervous system. It causes major neurological disability. Currently, there are more than 700,000 people in Europe, 100,000 people in the United Kingdom, 46,000 in Spain, 14,000 in Netherlands and more than 2 million people throughout the world with this disease. It is the most common disabling illness of young adults in the UK and it is twice as common in women as in men. Imaging plays a central role in the diagnosis and monitoring of the disease: the diagnosis made by the neurologists currently is based on the so called McDonald's criteria which allows diagnosis of multiple sclerosis on the basis of clinical findings and supported evidence from tests, the most important of which are magnetic resonance imaging of the brain and spinal cord. Magnetic resonance imaging is used not only to assess the diagnosis, but also to monitor the patients during their life.

Conventional imaging has limitations in the evaluation of the causes of disability and lacks pathological specificity. My work has further explored an advanced method that promises greater sensitivity. Researchers, neurologists and neuropathologists can take advantage of new imaging techniques that can overcome those limitations. Among them is magnetization transfer, which can give quantitative information on the nature of pathological changes and add specificity to diagnostic images, thus enhancing assessment of lesion burden and the degree of disability.

Academia and industry have substantive differences in their approaches, but they share the common goal of improving the health of the patients. Industry relies on academia for basic research that identifies novel molecular targets, which in turn can be used in clinical trials that evaluate the efficacy and safety of derived interventions. Industry does not have the vast basic research laboratories and hospitals that exist in academia. Conversely, academia is reliant on industry for their discoveries to be translated into medicines and technologies used in healthcare. The discovery in the present thesis of potential brain and c-spine biomarkers from a novel quantitative MRI technique promises to allow future translation from academia to industry and healthcare applications. The present thesis invites for testing the proposed methodologies on larger groups of patients, after which further technical developments of developed technologies may become possible. In addition, the discovered biomarkers could be sensitive to other diseases of the central nervous system and could be used in other diagnostic studies, focusing perhaps on other regions of interest in the brain. In addition, the methods developed here could be useful in clinical trials for testing effects of existing and new immunosuppressive drugs.

The implementation of the quantitative techniques performed in this thesis can be achieved in most of the European biomedical imaging research facilities and hospitals of the national health systems using stablished protocols. This provides a wide access to a broad established platform and an operational network where the derived biomarkers and parameters could contribute to the work of industry researchers and clinicians. It has highlighted a research and discovery space in new protocols could be developed to generalize the developed technology to ultra- high magnetic field technologies, as an attempt to overcome previous limitations, to further shed light to the genesis of the microstructural changes of the central nervous system tissues involved in neurodegenerative diseases and to create new opportunities for value realisation.

The pharmaceutical industry lives and breathes translational research. There are few organizations on the planet that can do what it has successfully accomplished repeatedly: transform knowledge of a potential drug target into a medicine for patients around the world. What the pharmaceutical industry does is often referred to as drug discovery using a wide bunch of techniques, among them, quantitative MRI. There are many opportunities for industry–academia collaborations using the big databases that are often collected by pharmaceutical companies (e.g., the GSK-Imperial College collaboration). These collaborations using 'big data' are expected to become increasingly important to achieve progress in the arena of the treatment of both neurodevelopmental and neurodegenerative diseases (such as multiple sclerosis). In this way, collaboration will spur innovation in the development of new medicines and in healthcare delivery. What my thesis work, embedded in an academic programme within industry, is that no single sector working alone can bring the needed medicines, delivery of care, and infrastructure to prevent and treat diseases of the

world's population; collaboration between academia and the pharmaceutical industry is absolutely necessary and our results can be taken as the outcome of such an interaction.