A love of 'words as words': metaphor, analogy and the brain in the work of Thomas Willis (1621 - 1675)

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Statement of Originality

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Abstract

Thomas Willis is commonly used as a touchstone for the modern brain sciences: his *Cerebri anatome* (1664) is celebrated as having placed the brain on its 'modern footing,' while Willis is referred to as the 'founding father' of neuroscience. Driven by a set of present-centred and medically orientated concerns, great emphasis has traditionally been placed upon Willis's neuro-anatomy as a precursor to our own ways of thinking about the 'neurological brain'. Such approaches have tended to neglect Willis's broader theoretical contributions, particularly his physiological theories, or have failed to consider how (distinctly early modern) concepts around the soul informed Willis's interpretation of the anatomical brain. This thesis re-examines Willis through his use of metaphors and analogies, exploring the relationship between his use of language and his physical practices around the brain (dissection, chemical experiment). Although recent scholarship on Willis has turned to social or cultural history approaches, there has yet to be a detailed examination of Willis's use of language. Ideas around the appropriate use of metaphor and analogy in scientific writing have long informed responses to Willis. His credibility has been undermined by suggestions of theoretical embellishment and imaginative speculation – charges that necessarily pick up on the use of analogical reasoning. In contrast, this thesis argues that Willis's concept of the brain cannot be viewed independently of the ways in which it was described and represented: rather than mere ornaments, metaphor and analogy were an essential part of Willis's conceptual architecture and tools by which the brain (as an object of knowledge) was made to exist in the world. Willis's use of language embeds his knowledge within a specific set of intellectual, cultural and material contexts of the late seventeenth century. His ideas around the brain cannot, therefore, be straightforwardly appropriated as part of our own understanding of neurology.

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Expressing how I feel about the people in my life does not come especially easily to me; which is perhaps ironic, considering that I have been fortunate enough to find myself working among so many leading scholars of the emotions. Please forgive me any awkward phrasing; it belies a far deeper sense of gratitude.

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Introduction

Thomas Willis, Neuroscience and History

Thomas Willis was once regarded as the most successful English physician of his day. A contemporary, Anthony Wood, noted that Willis had become 'so noted, and so infinitely resorted to, for his practice, that never any physician before went beyond him, or got more money yearly than he'.[1] Despite his many notable achievements, Willis now stands as a relatively marginal and poorly understood figure in the history of medicine. As Michael Hawkins has remarked, Willis appears 'only in passing' in most histories of medicine and science.[2] His contributions are nevertheless frequently invoked within the modern field of neurology, where Willis is widely recognised by medical students on account of the arterial network at the base of the brain bearing his name, 'The Circle of Willis.' Today, his works are predominantly read and written about by retired neurologists, who frequently invoke Willis as a 'founding father' of the modern discipline.[3] This position is reflected in medical histories around the study of the brain and nerves: in 2007, historian George J. Rousseau noted that Willis 'invented the concept of a 'nervous system.'[4] In the same year, C. U. M Smith wrote that those looking for the birth of modern neurology would do well to begin with Willis's *Cerebri Anatome*. This was, he felt, a 'most obvious' starting point.[5] Willis's positioning as a rhetorical anchor for the modern neurosciences is perhaps the single most prominent theme in the body of literature surrounding him. This belies what is actually a rather fractured and controversial historical picture.

Prior to the 1960s, there was a steady, if unremarkable, amount of interest around Willis; following the tercentennial of *Cerebri anatome* in 1964, the period witnessed a marked

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[1] Anthony Wood, *Athenae oxonienses*, (London: Printed for Tho. Bennet, 1691-2), vol. 3, p. 1051.
[2] Michael J. Hawkins, *The Empire of Passions: Thomas Willis's anatomy of the Restoration Soul* (PhD Thesis: University of London, 2004), p. 1.
[3] William Feindel notably repeated the 'founding father' epithet in his introduction to Thomas Willis's, *The Anatomy of the Brain and Nerves,* tercentenary edition (1664-1964), ed. by William Feindel, 2 vols. (Montreal: McGill University Press, 1965). A number of neurologists and clinicians have published studies on Willis: Sir Charles Sherrington (1940); Alfred Meyer and Raymond Heirons (1965); Hansruedi Isler (1968); Kenneth Dewhurst (1982); M.J. Eadie (2002); Mark Wilson (2012).
[4] George S. Rousseau, "Brainomania': Brain, Mind and Soul in the Long Eighteenth Century', *Journal for Eighteenth-Century Studies,* 30. 2 (June, 2007), pp. 161-191 (p. 171).
[5] C.U.M. Smith, 'Brain and Mind in the Long 18th century,' in *Brain, Mind and Medicine: Essays in 18th Century Neuroscience*, ed. by H. Whitaker and others (New York: Springer, 2007), p. 15.

expansion of interest in and a certain 'rediscovery' of his works by medical historians.[6] A little before this in the 1940s, the eminent British neurophysiologist Sir Charles Sherrington commented favourably on Willis noting that he had 'practically refounded the anatomy and physiology of the brain and nerves.'[7] This was a recovery of much earlier assessments, such as by John Friend who, in 1725, had acknowledged Willis as 'the first inventor of the nervous system.'[8] These comments reflected the fact that Willis had been the first to use the term 'neurologia' (translated into the English 'neurologie' in 1681) to describe the study of the structure of the brain and nerves as a self-contained system, which he had termed the 'doctrine of the nerves'.[9] Although this 'doctrine of the nerves' did not specifically address physiology and pathology (which were dealt with by Willis in a later book), our conception of the modern discipline of clinical neuroscience assumes the inclusion of these elements when we refer to his 'neurology'.

Importantly, as Nikolas Rose and Joelle M. Abi-Rached's book *Neuro: The New Brain Sciences* notes, the groundwork for what we would recognise as the modern discipline of neuroscience was being laid in the early 1960s: the same period in which scholarly interest in Willis began to expand. Neuroscience grew out of specific institutions established in the 1960s and 1970s. Francis O' Schmitt first coined the term neuroscience in 1962, closely followed by the creation of the disciplines first major organising body, the Society for Neuroscience (SfN) in 1969.[10] The 're-discovery' of Thomas Willis (from a position of relative obscurity) as the early modern 'founder' of neurology and as a rhetorical anchor for the emergent discipline occurred in conjunction with these developments.[11] The timing suggests that the re-engagement with Willis, although certainly helped by a tercentenary anniversary in this decade, became part of a much broader effort by the new community to forge and promote a 'long history' for itself, rooted in the

[6] Robert Frank Jr. notes that there were between four and eight articles or books per year published on Willis in the 1940s, rising to thirty-three from the 1960s: 'Thomas Willis and His Circle', in *The Languages of Pysche: Mind and Body in Enlightenment Thought,* ed. by G. Rousseau (Berkeley: University of California Press, 1990), pp. 107-147 (p. 109).

[7] Sir Charles Sherrington, 'The Brain and its Work', *Man on his Nature* (Orig. Pub. 1940: Cambridge: Cambridge University Press, 2009), pp. 203-234.

[8] John Friend, *The History of Physick from the Time of Galen* (London, 1725) ii, p. 315.

[9] Clifford F. Rose has discussed the distinction between Willis's use of the Latin and the introduction of the English term by Samuel Pordage in *The History of British Neurology* (London: Imperial College Press, 2012), p. 28.

[10] Judith P. Swazey, 'Forging a Neuroscience Community: A Brief History of the Neurosciences Research Program,' in *The Neurosciences: Paths of Discovery,* ed. by Frederic G. Worden and others (Cambridge: MIT Press, 1975), pp. 529-546.

[11] Nikolas Rose and Joelle M. Abi-Rached, *Neuro: The New Brain Sciences and the Management of the Mind* (Oxford: Princeton University Press, 2013), p. 25.

neurology of the late seventeenth century.[12] Willis's historical position cannot then, be divorced from the institutional history of this profession.

Projecting a set of present-centred concerns back onto historical practices around the brain, modern neuroscience has reproduced historical ways of investigating and thinking about the brain which accord with its own image; this has involved highly selective and teleological readings of historical neurology, especially – but not limited to – the work of Thomas Willis. Outlining a set of emphases that would come to dominate this historical picture, Sir Charles Sherrington made special note of those aspects of Willis's practices which appeared to most directly correspond with his own: namely, the correlation of clinical observation with anatomical inspection and, above all, Willis's emphasis on the physical substance and structure of the brain itself. In so doing, he observed, Willis had put the 'brain and the nervous system on their modern footing so far as that could be then done.'[13] Here, the rather Whiggish implication is that Willis was always striving towards what we know to be true today, but was simply held back by the limitations of his age.[14] This present-centred and medically orientated reading is clearly very much of its time, yet it is an approach that remained remarkably stable in the following decades and which continues to shape responses to Willis.

One of Willis's most prominent biographers from the 1960s, Hansreudi Isler, a retired neurologist, wrote that Willis's hypotheses and observations 'very often come close to what science today thinks important.' For Isler, this proved 'all the more astonishing since the majority of his basic theories must be found wrong today.'[15] He did however note that Willis's language around 'biochemical processes in the body' showed how he was 'transcending the possibilities of his age…postulating something like today's

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[12] Gordon M. Shepherd, *Creating Modern Neuroscience: The Revolutionary 1950s* (Oxford: Oxford University Press, 2010).

[13] Charles Sherrington, *Man and his Nature,* p. 203. Jaime C. Kassler also refers to Willis placing the brain on its 'modern footing' in his 'Restraining the Passions: Hydropneumatics and Hierarchy in the Philosophy of Thomas Willis', in *The Soft Underbelly of Reason*, ed. by Stephen Gaukroger (London: Routledge, 1998), pp. 147-164 (p. 148).

[14] On 'Whig' history and present-centered concerns, see: Herbert Butterfield, *The Whig Interpretation of History* (London: 1931; 1965). For more recent works, see: Adrian Wilson and Timothy Ashplant, 'Whig History and Present-Centered History' and 'Present-Centered History and the Problem of Historical Knowledge,' both *The Historical Journal* (1988), 1-16, 253-74. See also, Andrew Cunningham, 'Getting the game right: Some plain words on the identity and invention of science,' *Studies in History and Philosophy of Science,* 19 (1988), pp. 365-389.

[15] Hansruedi Isler, *Thomas Willis, 1621–75, Doctor and Scientist* (London: Hafner Publications Company, 1968), p. 67.

laboratory-based medicine.'[16] While there is necessarily scope for invention and creativity in a given setting, it is difficult to see how Willis could have transcended the intellectual frameworks of his age considering that new ideas are necessarily produced out of existing categories of knowledge and practices. Another prominent example of scholarship from this period is the comprehensive and much-noted study of Willis's neurophysiology by former consultant neurologists, Raymond Hierons and Alfred Meyer. In 1965, Meyer and Hierons talked about the 'controversial judgement passed by modern historians upon the scientific achievements of Thomas Willis,' even while they attempted to invoke some of those very achievements.[17] They noted in particular that his clinical observations had lent a 'veil' of empirical accuracy to his works, which had helped them 'appear modern,' despite the historical 'jargon' of Willis's discussions of animal spirits and iatrochemistry (medical chemistry).[18] What we see emerging here is the idea that, if medical history was to find any value in Willis's works, it would need to 'recover' his clinical and anatomical observations from the historical language and terminology that accompanied (indeed, obscured) his insights and discoveries. The recognisably 'early modern' aspects of his 'science' were a set of problems to be navigated around and explained away.

Although Willis wrote extensively on matters of physiology, the passions and iatrochemistry, today he is primarily celebrated for his anatomical work on the structure of the brain and nerves in his *Cerebri anatome* (1664).[19] The focus on his anatomical investigations reflects a particular concern to distinguish between what Willis got 'right' or 'wrong,' according, that is, to what we can verify through our own studies of the brain, rather than to attempt to understand his ideas on their own terms. These approaches tend to reproduce a careful selection of Willis's anatomical achievements while overlooking the significance of his broader theoretical explanations concerning the physiological functions of the brain. This assumes that the two discussions – anatomy and physiology - can be separated in his work; that, for Willis, describing the structure of the brain and nerves was an end in and of itself. His attempts to explain how these structures functioned have been frequently dismissed: in 1984, Mary A. B. Brazier remarked that, in spite of Willis's success in exploring brain and nerve structure, 'he

[16] *Ibid.* p. 67.
[17] Alfred Meyer and Raymond Heirons, 'On Thomas Willis's concepts of neurophysiology: Part I & II,' *Medical history*, ix (1965), part II, p. 152.
[18] *Ibid,* p. 292.
[19] Ann Thomson, *Bodies of Thought: Science, Religion, and the Soul in the Early Enlightenment* (Oxford: Oxford University Press, 2008), p. 83.

made little lasting contribution to the underlying mechanisms of their function.'[20] Brazier, in effect, criticised Willis here for daring to stray from simply describing what he could see to offering up his own (physiological) explanations. For Brazier, these were necessarily the 'wrong' explanations (and therefore, of little contemporary value) because they were based upon notions of spirit, rather than electrical impulses.

A more recent example of a 'cherry picking' approach to Willis's contributions is found in Mervyn J. Eadie's 2002 article in the *Journal of Clinical Neuroscience*: 'if Willis's hypothesising about his animal spirit mechanisms and his locations of cerebral function are ignored, most of his account of apoplexy is readily interpreted in relation to modern day knowledge of cerebral vascular disease.'[21] Eadie concludes that 'the deficiencies, limitations and peculiarities of Willis's writing on neurological disease, render them now mainly of historical importance.'[22] Yet, as Eadie's remarks demonstrate, (highly selective) readings of Willis are still often called upon as a means of informing our own current positions. Eadie's work is also notable for having presented Willis's descriptions of pathological disorders in a tabular format. The idea being visually represented here is that the discipline imposed by the template might help to 'recover' the content of Willis's insights apart from the otherwise literary distractions in the text.[23] It is difficult to see what this tabular re-presentation of Willis's work can possibly tell us about his concepts, when they have been so removed from the ways in which he described and represented them within the text.

Willis also features prominently within the growing body of popular publications on the history of neurology, of which Stanley Finger's *Minds Behind the Brain,* published in 2000, is a characteristic example. Here, as in other similar examples, a particular emphasis is placed upon Willis's anatomical discoveries around the brain, over and above his theoretical work concerning chemistry, physiology, and pathology. As Finger writes, Willis 'published one of the most important books in the history of the brain sciences'

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[20] Mary A. B Brazier, *A History of Neurophysiology in the 17th and 18th centuries* (New York: Raven Press, 1984), p. 64.
[21] Mervyn J. Eadie, 'A Pathology of the Animal Spirits - the Clinical Neurology of Thomas Willis (1621-1675) Part I – Background, and disorders of intrinsically normal animal spirits,' *Journal of Clinical Neuroscience*, 10.1 (2002), pp. 14-29 (p. 25).
[22] M.J. Eadie, 'A Pathology of the Animal Spirits - the Clinical Neurology of Thomas Willis (1621-1675) Part II - Disorders of Intrinsically Abnormal Animal Spirits,' *Journal of Clinical Neuroscience,* 10.2 (2003), pp. 146–157 (p. 156).
[23] Eadie, *Pathology of the Animal Spirits,* Part I, p. 17.

with *Cerebri anatome*.[24] He argues, furthermore, that 'the fame associated with Thomas Willis today does not stem from his acumen at diagnosis, his bedside manner…Nor is he well remembered for his chemical theories of medicine. Without question, it was his new way of looking at the brain and behaviour that is his most significant contribution.'[25] In 2014, rather more subtly, Mitchell Glickstein summed up Willis's time at Oxford as a period of 'anatomical studies', thereby ignoring his extensive chemical and physiological experiments conducted there. Glickstein also anachronistically characterised Willis's work as concerning 'mental illness' and stressed its relevance to modern-day psychiatry – categories that did not exist, in the form imputed by these labels, at the time Willis was writing.[26] In a similar vein, philosophers of neuroscience, M.R. Bennett and P.M.S. Hacker (2008) celebrated Willis's 'cortical revolution' (referring to his focus on the structuring work of the cortical substances in the brain) in their textbook on the *History of Cognitive Neuroscience*, but omitted to refer to him even once in their earlier book on the *Philosophical Foundations of Neuroscience* (2003).[27] Willis's historical contribution is routinely and selectively framed in terms of how it appeals to the interests of contemporary scholarship around the brain sciences.

The propensity to stress Willis's neuro-anatomical practices necessarily comes at the substantial neglect of his broader physiological, chemical, natural philosophical and theological interests – elements that, as this thesis will argue, were a vital part of his work around the brain. Moreover, these emphases speak to contemporary assumptions concerning the putatively objective nature of scientific practice and observation, especially in terms of prioritising the physical structures of the brain. These practices, centred on the physical object, are contrasted with the supposedly subjective nature of Willis theoretical explanations. The idea that we can straightforwardly uncover what Willis *saw* when he looked at the brain, without having to also consider how he was able to make sense of and ascribe significance to those sights, strips away the very conceptual

[24] Stanley Finger, *Minds Behind the Brain: A History of the Pioneers and their Discoveries* (Oxford: Oxford University Press, 2000), p. 23.
[25] Stanley Finger, *Minds Behind the Brain*, p. 87.
[26] Mitchell Glickstein, *Neuroscience: A Historical Introduction* (Cambridge, Massachusetts: MIT press, 2014), pp. 324-5. For similar recent examples that emphasise Willis's founding father role in respect of neuro-anatomy, see: Carl Schoonover, *Portraits of the Mind: Visualising the Brain from Antiquity to the 21st century* (London and New York: Abrams, 2010), p. 38; Andrew P. Wickens, *A History of the Brain: From Stone Age Surgery to Modern Neuroscience* (Hove, East Sussex: Psychology Press, 2014), p. 98; Clifford Rose, *History of British Neurology* (London: Imperial College Press, 2012).
[27] M.R. Bennett and P.M.S. Hacker, *History of Cognitive Neuroscience* (Oxford: Wiley-Blackwell, 2008), p. 216. Willis is omitted from the earlier work by Bennett and Hacker on the *Philosophical Foundations of Neuroscience* (Malden, Mass.: Oxford: Blackwell, 2003).

architecture underpinning Willis's account of the brain. This is done in order to help make Willis's account of the brain appear as a more easily recognisable foundation for our own 'neuroscientific' brain.

These themes also overlook how scientific practice is fundamentally constrained and shaped by theory. Similarly, to speak of one single unchanging kind of 'objective practice' is problematic. Early modern notions of 'objectivity' governed how Willis approached the brain (how he chose to cut it open, experimented on it and represented it) and these do not necessarily relate to our own ideas of what an objective account of the brain would represent (perhaps through Magnetic Resonance Imaging (MRI) scans, for example.) The historically-shifting nature of these concepts around objectivity have been notably addressed in the work of Lorraine Daston and Peter Galison.[28]

As Robert Martensen and Michael Hawkins have explored, this situation is partly produced by the disproportionate interest in Willis coming from medical professionals who are, unsurprisingly, interested in how his techniques might fit into a narrative of progressive advances in that area.[29] Writing in the journal *Neurosurgery* in 2006, Bradley C. Lega discussed Willis's influence on John Locke's philosophy, arguing that Willis's philosophical ideas are too often overlooked because of medically-orientated concerns.[30] In 1990, the social historian Robert Frank Jr. reflected on what he termed Willis's 'catch 22' position, arguing that 'then, as now – [Willis] was a writer whose reputation was greatest among those whose professional or technical backgrounds most fitted them to understand the details that he tried to synthesize.'[31] At the same time, this same group of readers were also those most likely to be inclined to critique Willis on the basis of 'incorrect' medical terminology or erroneously named structures. As Frank notes, these writers have been 'vocal in their praise of the accuracy of the anatomy and the quality of the illustrations', while being 'intrigued' by Willis ideas on localisation and 'repelled' and 'befuddled' by his 'speculations' on brain function.[32] The body of scholarship surrounding Willis – particularly from among those who write from a medical-

[28] Lorraine Daston and Peter Galison, *Objectivity* (London: MIT, 2007).
[29] Robert L. Martensen, *The Brain Takes Shape: An Early History* (Oxford: Oxford University Press, 2004), p. 76; Michael Hawkins, *Empire of Passions,* p. 11.
[30] Bradley C. Lega, 'An Essay Concerning Human Understanding: How The *Cerebri Anatome* Of Thomas Willis Influenced John Locke,' *Neurosurgery,* 58.3 (2006), pp. 567-576 (p. 573).
[31] Robert G. Frank, Jr., 'Thomas Willis and His Circle: Brain and Mind in Seventeenth century Medicine,' in *The Languages of Psyche: Mind and Body in Enlightenment Thought*, ed. by G.S. Rousseau (Berkley: University of California Press, 1990), p. 142.
[32] Robert Frank, 'Thomas Willis and His Circle,' p. 129.

professional background – has tended to assume that, regardless of Willis's historical 'jargon', what he observed in the brain is a recoverable set of empirical observations: that it is somehow outside of or beyond culture. This supports broader efforts to trace out the evolution from Willis to modern neurology. These representations intervene to produce a sense of clarity around Willis (as a 'neurologist'), because that is what is most relevant to our current perspectives.[33]

Teleological approaches to Willis are not exclusively the outcome of the interests of retired medical professionals.[34] Historians of medicine have also mined Willis for how he might inform modern science's own ways of understanding and investigating the brain. As we have seen, it is Willis's anatomical activities, rather than his chemical or physiological research, which is most readily appropriated as a way of informing the 'neurological' brain. Supported by narratives of Willis as a 'father' of neuroscience, his work holds a particularly strong appeal for histories of the brain as explored in relation to what has been termed the 'neurosociety' or the 'neuroturn' - a set of discourses that increasingly root models of personhood in the physical structures of the neurological brain.[35] This emphasis is often traced back, through the accounts of medical historians, to Willis's development of what has come to be termed a theory of localisation: this refers to ascribing specific functions to discrete structures inside the brain. As historian Ann Thomson noted in 2008, Willis's study of the anatomical brain constituted his 'primary contribution to medical history' and his books were, she writes, 'particularly important for their attempts to localize brain functions' through an emphasis on the brain's solid (cortical) substance.[36]

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[33] Michael Hawkins, *Empire* (2004), p. 10; Louis Caron, *The Philosophical Reception of Thomas Willis (1621-1675) with Particular Reference to John Locke (1632-1704)* (PhD Thesis: Kings College Cambridge, 2011), p. 11; Robert Martensen, *The Brain Takes Shape* (2004), p. 229.

[34] Louis Caron, *Philosophical Reception of Thomas Willis,* p. 11.

[35] On Willis and the brain as an 'object of knowledge' see: Sarah de Rijcke, *Regarding the Brain: Practices of Objectivity in Cerebral Imaging, Seventeenth Century to Present* (PhD thesis: University of Groningen, 2010); S. de Rijcke and Anne Beaulieu, 'Networked Neuroscience: Brain Scans and Visual Knowing at the Intersection of Atlases and Databases,' *Representation in Scientific Practice Revisited,* ed. by Catelijne Coopmans and others (London: MIT Press, 2014), pp. 131-152 (p. 131).

[36] Ann Thomson, *Bodies of Thought: Science, Religion, and the Soul in the Early Enlightenment* (Oxford: Oxford University Press, 2008), p. 83. Retired psychiatrist and prolific Willis scholar, Kenneth Dewhurst, likewise acknowledged Willis for his 'pioneering' localisation model with its emphasis on solid brain substances but stresses that of 'utmost importance' were his classification of cranial nerves: 'Thomas Willis and the Foundations of British Neurology,' in *Historical Aspects of the Neurosciences*, ed. by F.C. Rose and W. F. Bynum, (New York: Raven Press, 1982), pp. 327-346 (p. 336-7).

The localisation of mental activities to discrete physical locations in the brain has increasingly come to operate as a vital component of our modern concepts of brain function: in 2010, Michael Hagner described the 'episteme of the modern brain' as 'encompassing both a localizationist paradigm' or 'narratives of the brain.'[37] Despite Willis's model of localised function being rooted in specifically early modern notions around the activities of animal spirits, his ideas have been seized upon as a way of informing these particular interests. He is often viewed as foregrounding our modern recourse to the *physical* brain as the locus of mental activities, because he ascribed cognitive phenomena to a material rather than disembodied soul, located within the brain.[38] As Rousseau noted in 2004, Willis's stress on the solid substance of the brain was a paradigm shift that marked out the 'mind' as something that was 'resident in the body'; as a consequence, the mind could become synonymous with the (neurological) brain.[39] This may have been a historical consequence of his work, but it is also more reflective of how we have *used* Willis's ideas rather than the ideas themselves.

What has been lost here, in particular, is an understanding of how Willis conceived of the brain in relation to early modern notions of the soul. As Rousseau has also argued, Willis's new account of the brain aimed, above all, to establish it as the exclusive seat of the sensitive soul.[40] Willis undertook his anatomical research chiefly in order to substantiate an alternative, physiological account of the sensitive soul rather than to simply describe the brain 'as it is' - as I explore in chapters four and five.[41] His ideas of the soul were intrinsic to these anatomical pursuits: when Willis looked at the brain it was through the prism of a worldview that was given meaning by the active principles of spirit and soul. His 'doctrine of the nerves' is, therefore, fundamentally distinct from any of our current understandings of neuroscience, with its language of neurochemicals and electrical impulses, and cannot be in any way straightforwardly 'mapped' onto it.

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[37] Michael Hagner's 2010 lecture is quoted by Joseph Dumit in: 'How (Not) to Do Things with Brain Images,' *Representation in Scientific Practice Revisited,* ed. by Catelijne Coopmans, Janet Vertesi, Michael Lynch, and Steve Woolgar (London: MIT Press, 2014), pp. 291-316, (p. 293). Dumit notes that these ideas are 'quite crucial for an understanding of modern brain research as a human science,' p. 293.

[38] On Willis and 'dispensing' with the soul see: Ann Thomson, *Bodies,* p. 85; Carl Zimmer, *Soul Made Flesh: The Discovery of the Brain - and How It Changes the World* (London: William Heinemann, 2004), p. 229.

[39] On Willis's work as a paradigm shift see: G. S. Rousseau, *Nervous Acts: Essays on Literature, Culture, and Sensibility,* (Basingstoke: Palgrave Macmillan, 2004), p. 360. On making the brain 'co-equal with mind and soul' see also: Rousseau, *Brainomania,* (2007), p. 171.

[40] This argument is originally put in Rousseau's 1975 essay 'Nerves, Fibres and Spirits,' revisited in *Nervous Acts* (2004), p. 165.

[41] Louis Caron makes a similar argument in *The Philosophical Reception of Thomas Willis,* (2011), p. 29.

Part of how we get at this historical difference is by looking at how Willis was able to represent the brain through his writing; that is, through the narrative frameworks provided by his concepts of spirits and the soul. Metaphors and analogies are at the centre of all scientific models; the objects and concepts that were available to Willis when he was attempting to construct his own models of the brain were specific to *his* cultural, material and intellectual contexts. These frameworks are fundamentally different to our own. The further we unpick the meanings and associations entailed within Willis's metaphors and analogies of the brain, the more alien and less 'neurological' his brain appears to be. Equally, though the act of looking at the brain may be shared across many cultures and periods, the means by which we convert those acts into a body of knowledge are inherently bound up in culture and language.

Importantly, a properly contextualized understanding of Willis's physiological and chemical theories can form a vital part of challenging remarkably narrow assessments of his work. For instance, some in the history of psychiatry have favoured the view that Willis's focus on the solid structures of the brain created the conditions for a 'reductive turn' in the field, inventing the medical (or neurological) mind as opposed to the psychological one.[42] However, this view is supported only if we neglect Willis's significant views on vital materialism (the principle of active matter). Were his vital matter theory of the spirits to be taken into account, it would be difficult to present his theory of the mind as a purely anatomical or reductionist model. In 2014, Kathryn Tabb convincingly tackled these misreading's of Willis's work by examining the vitalistic and alchemical influences in his account of the animal spirits.[43] This is a key example of how an appreciation of Willis's broader conceptual influences can counter selective or teleological readings of his work.

Equally problematic is how related fields, beyond neurology, have claimed Willis as a 'founding' figure: Mark Wilson has noted, for example, that 'modern behavioural psychologists claim Willis as one of their early, most ardent champions.'[44] He further

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[42] Gregory Zilboorg, *A History of Medical Psychology* (New York: W.W. Norton and Co., 1941), p. 265. For a more recent discussion of this issue in the history of psychology see: Kathryn Tabb, 'Struck, As it Were, With Madness: Phenomenology and Animal Spirits in the Neuropathology of Thomas Willis,' in *Brain, Mind and Consciousness in the History of Neuroscience,* ed. by C.U.M. Smith and Harry Whitaker, vol. 6 of the series History, Philosophy and Theory of the Life Sciences (Dordrecht: Springer, 2014), pp. 43-57.
[43] Kathryn Tabb, 'Struck, As it Were, With Madness', pp. 43-57.
[44] Mark Wilson, 'The Life And Times Of Thomas Willis And His Impact On Contemporary Medicine,' *Journal Of The History Of The Neurosciences,* 21.2 (2012), pp. 127-131 (p. 127).

argued that Willis's *Soul of Brutes* was the 'first English work in the field of psychiatry' and that it 'incorporated behaviourism' – despite the fact that we can not point to anything that meaningfully approaches our idea of psychiatry or indeed 'behaviourism' before 1800.[45] These were not intellectual categories available to Willis. In 2004, historian Michael Hawkins effectively addressed this use of Willis to speak to overtly modern concepts of mental illness, noting the fundamental incompatibility between Willis's conceptual framework of passion-states (which were bound up in notions of souls, spirits and humors) and modern day ideas of mental health, as rooted in neurons and neurochemicals.[46]

Thomas Kuhn's classic theory of paradigm shifts can be useful here in thinking about the incommensurable nature of Willis's concept of the brain with current neuroscientific ideas.[47] As Kuhn famously proposed, the questions, methods and assumptions underlying any contribution to knowledge are specific to a given time, place or community and can be subject to change; as such, the questions and assumptions driving Willis and his contemporaries' natural philosophical inquiries is necessarily incompatible with what constitutes inquiry and knowledge in neuroscience today. Willis's concept of the brain was ultimately based around a different set of questions and different notions of what constituted a 'fact,' explored within radically different disciplinary boundaries and articulated through a specific cultural and linguistic framework. The arguments against projecting modern categories back onto the past have been well explored by leading scholars. Thomas Dixon's landmark book, *From Passions to Emotions,* for example, is animated by a caution about projecting the category of emotions back onto periods where concepts of affective states were qualitatively different to those signified by the later term 'emotion'.[48] In a similar sense, social historians of medicine have long-criticised the practice of 'retrospective diagnosis', imposing current categories onto contexts where they did not exist.[49] Barbara Shapiro and Mary Poovey's work is also useful here; both have examined the historically specific ways in which facts were produced and signified

[45] M. Wilson, 'The Life And Times Of Thomas Willis,' p. 130. On the idea that Psychiatry did not emerge as a discipline before the 1800s see: Kurt Danziger, *Naming the Mind: How Psychology Found its Language,* (London: Sage Publications, 1997).
[46] Hawkins, *Empire of Passions,* p. 11.
[47] Thomas Kuhn, *The Structure of Scientific Revolutions* (Orig. pub. 1962; London: University of Chicago Press, 1970).
[48] Thomas Dixon, *From Passions to Emotions: the Creation of a Secular Psychological Category,* (Cambridge: Cambridge University Press, 2003).
[49] On these debates, see: Adrian Wilson, 'On the History of Disease-Concepts: the case of pleurisy,' *History of Science,* 38.3 (2000), pp. 271-319; Katherine Foxhall, 'Making Modern Migraine Medieval: men of science, Hildegard of Bingen and the life of retrospective diagnosis,' *Medical History,* 58.3 (Jul., 2014), pp. 354-74.

in the early modern period.[50] Similarly, Andrew Cunningham has emphasised how early modern disciplines do not neatly 'map' onto our own categories or easily translate into our own focus on disciplinary specialism.[51] These are all works that have informed my theoretical approach to Willis, in seeking to examine his works on the basis on his own culturally and historically situated intellectual practices.

'He loved Words as Words': Willis and language

An important set of criticisms often leveled at Willis, which I want to examine in more detail here, relates to an association drawn between (what has been regarded as) his speculative theorising and an ornate or embellished style of writing. Since the early eighteenth century, Willis has been consistently characterised as a figure of 'true imaginative genius,' who despite some notably accurate discoveries and astute clinical observations produced vivid and fanciful speculations on the brain's physiology.[52] Imagination is a loaded term in this context, suggesting a creative endeavour distinct from the work of scientific observation. The undercurrent to these remarks is often that Willis did more than merely speculate, that he luxuriated in imaginative excess in an attempt to compensate for (or distract the reader from) inadequate empirical foundations. Willis's noted biographer, Kenneth Dewhurst, so remarked in 1982 that Willis had a 'proclivity to speculation, which he obviously relished' and that these speculations were, for Willis, 'a necessary embellishment' to his neurology.[53] Dewhurst even comes close to apologising for these excesses, asking 'what more could he have done?' with the clearly inadequate tools then at his disposal. This position assumes that speculative theorising is something modern science has progressed beyond; however, modern string theory requires some notable speculative extrapolations. While this was not a necessarily unorthodox view to have assumed in the 1960s, a current of dismissive assessments of Willis's physiological ideas has remained consistent. In 1984, in her *A History of Neurophysiology,* Mary Brazier remarked that Willis 'must be held responsible for

[50] Mary Poovey, *A History of the Modern Fact: Problems of Knowledge in the Sciences of Wealth and Society* (London: University of Chicago Press, 1998); Barbara J. Shapiro, *A Culture of Fact: England, 1550-1720* (Ithaca, NY: Cornell University Press, 1999).
[51] On the early modern disciplines of physiology and anatomy see: Andrew Cunningham, 'The Pen and the Sword: Recovering the Disciplinary Identity of Physiology and Anatomy before 1800. I. Old Physiology - The Pen', *Studies in History and Philosophy of Biological and Biomedical Sciences,* 33 (2002), pp. 631-665. Michael Hawkins also discusses this issue of distinct and markedly 'nebulous' early modern disciplinary categories, *Empire*, p. 11.
[52] Charles Symonds noted that Willis's deductions from anatomy showed 'true imaginative genius': 'Thomas Willis, F.R.S.', *Notes and Records of the Royal Society of London,* 15 (Jul., 1960), pp. 91-97 (p. 97).
[53] K. Dewhurst, 'Thomas Willis and the Foundation of British Neurology,' p. 343.

some delay in the acceptance of scientific study of the brain, because he did not hesitate to speculate,' instead he indulged himself at the expense of scientific progress.[54] Pre-modern science is characterised, here, by a lack of restraint and control. What I want to explore here is how these accusations recurrently pick up on Willis's use of language - specifically his analogical or metaphorical reasoning, as these are the chief devices by which novel, unseen or hypothetical phenomena are articulated from what is already known.

Suspicion around Willis and his speculative inclinations emerge from among his immediate contemporaries. Some of the most circulated comments on this matter originated with Willis's disgruntled neighbour, Henry Stubbe, in his *Legends no Histories* (1670) - comments soon repeated by the 'waspish' Oxonian, Anthony Wood in his famous *Athenae Oxonienses* (1691).[55] Stubbe had remarked that Willis built a 'hypothesis chiefly of his own framing,' which would therefore be of no lasting value. He premised this claim on the suggestion that Willis had done little more than apply speculative hypotheses to the *practical* achievements and technical skill of his collaborator, Dr. Richard Lower – a skilled dissector. Stubbe claimed that 'whatsoever there is that Piece, which is *Anatomical,* the glory thereof belongs to Dr. Lower.'[56] All that remained to the credit of Willis, then, was his *writing* – his narration of the anatomical 'facts' produced by Lower's hand. As Stubbe concluded, 'all that Dr. Willis contributed…was the *discourses* and conjectures upon the *Anatomical deductions* of Dr. Lower.'[57] Willis used his literary skills, or his 'discourse,' to take credit for the real science of Lower. As we can see, discourse and conjecture are clearly linked in these discussions.

Anthony Wood directly drew on Stubbe's attack, additionally remarking that Willis's 'natural smoothness, pure elegancy, delightful, unaffected neatness of Latin style,' which 'none scarce have equalled,' was nevertheless to be acknowledged.[58] This was a somewhat underhanded compliment: the pairing of Willis's notable talents as a writer

[54] M. Brazier, *A History of Neurophysiology,* p.64.
[55] Henry Stubbe, *Legends no histories…animadversions upon The history of the Royals Society* (London, 1670), p. 95.
[56] Stubbe, *Legends,* p. 62; Anthony Wood, *Athenae Oxonienses,* vol. 3. The idea that Willis took credit for Lower's work is now roundly dismissed. The fact that Lower never mentioned any disagreement between himself and Willis, and that Wood had a longstanding land dispute with Willis, suggests that this was an unsubstantiated claim – moreover, Willis openly acknowledged Lowers (and others) work in his preface. Frank and Dewhurst have both discussed this matter in some detail, see esp. Frank, *Willis and his Circle,* p.128.
[57] Stubbe, p.95.
[58] Quoted by William Feindel, 'Thomas Willis (1621-1675). The Founder of Neurology'*, Canadian Medical Association Journal,* 87 (1962), pp. 289-296 (p. 295-296).

and a Latinist alongside the suggestion that he had benefited from the practical efforts of others was no accident. The stress on his use of and particular skill in Latin, in the context of seventeenth century English natural philosophy and Willis's traditional Oxford education, would have raised associations with the rhetorical vanities and errors of humanist eloquence, rather than the new experimental learning - among whose advocates there was an explicitly polemical stance taken against the potentially misleading effects of language.[59] Accordingly, these remarks pitted Lower's *practice* against Willis's *discourse*, in order to undermine Willis's alternative theories.

Criticism of Willis's use of language really began to take hold in the latter half of the eighteenth-century. The 1781 and 1784 editions of the popular *New and General Biographical Dictionary* recorded that Willis, 'instead of deducing real knowledge from observation and experiment, exercised himself in framing theories.'[60] Again, reflecting the original denouncements by Stubbe and Wood, this remark was coupled with the observation that 'perhaps no writings, which are so admirably executed, and prove such uncommon talents to have been in the writer, were ever so soon laid aside and neglected, as the works of Dr. Willis.'[61] In 1799, Hutchinson's *Biographica Medica* repeated these remarks, noting Willis's 'uncommon' talents as a writer.[62] These assessments continued to be repeated well into the nineteenth century.[63] Much later, in 1980, Robert Frank Jr. again referred to the idea that Willis had imposed a theoretical, chiefly chemical, agenda onto the bare 'facts' produced by Lower's scalpel, exercised through his writing up of the findings.[64]

Perhaps the most memorable attack, however, came from the Cambridge professor of Physiology, Michael Foster, during his *Lectures on the History of Physiology* given in 1901. Describing Lower as the 'henchman of the fashionable Willis' and a 'real man of science,' Foster described Willis as being 'of a different type' entirely: 'love of truth was in him

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[59] For a contemporary example of such attitudes, see: Thomas Sprat, *The History of the Royal-Society of London, For the Improving of Natural Knowledge* (London, 1667), p. 113.
[60] *A New and General Biographical Dictionary*…, (London, printed for W. Strahan, T. Payne et al, 1784), vol. XII, p. 533.
[61] *Ibid*, p. 533.
[62] B. Hutchinson, *Biographica Medica* (London, 1799), vol. II, p. 484.
[63] The noted British biographer, Alexander Chalmers, repeated these remarks almost verbatim in his bestselling, *A New and General Biographical Dictionary* (London, 1814), p. 32. This was further repeated by W. Munk who dismissed Willis's contributions as 'trivial': *The Roll of the Royal College of Physicians* (London, 1861), p. 69.
[64] Frank refers to the 'multitudinous facts' that Lower's 'knife laid bare' for Willis to structure and organise with his intellectual agenda: 'Willis and his Circle', p. 145.

less potent than a love of fame.'[65] Fame is, of course, not the same thing as being excessively figurative or elegant in ones writing, yet there is an underlying connection suggested here: Willis achieved fame not by the hard labour of practice, but by appealing to the ancient art of rhetoric, which aimed to delight and persuade the audience through imaginative tricks and embellishments. Foster continued that, where Lower 'expounded with brevity' and used 'words only as expressing the meaning of things […] Willis's mind was of the rhetorical sort, he loved words as words.'[66] Willis's vanity was served, Foster suggested, by his embellished prose and lazy rhetoric – his love of words for their own sake - rather than through dedicated, scientific practice. Moreover, in having luxuriated over words instead of attending to the experimental method, Willis had himself been deceived by the superficial persuasiveness of his well-crafted words: 'Willis's mind was of that sort which when it has hit on an illustration or discovered an analogy, thinks it has found proof.'[67] Here, Foster referred specifically to Willis's analogy between the soul in the blood and a 'vital flame', which I examine in chapter five. During the 1930s and 1940s, Foster's claims were widely repeated by the likes of K.J. Franklin (1939), F.J. Cole (1944) and C.C. Mettler (1947), who referred to Willis as a 'dandy.'[68]

The tensions outlined in these discussions, between the presumed objectivity of practice and the subjectivity of words in science, continues to present a fraught area of debate. In the 1980s, leading philosopher of science Ian Hacking argued that we should move away from examining how theories represent the world to consider how scientific *practices* enable us to get a more reliable handle on phenomena: he comes to the famous conclusion, 'if you can spray them, then they're real' – that is to say, objects have a real existence outside of the language we use to describe them and this reality can only be accessed through practice. While I do not seek to argue that there is no reality beyond culture or language, this position nevertheless overlooks how we are able to access and

[65] Michael Foster, *Lectures on the History of Physiology During the Sixteenth, Seventeenth and Eighteenth Centuries* (Cambridge: Cambridge University Press, 1901), p. 181, p. 270.
[66] Michael Foster, *Lectures,* p. 270.
[67] *Ibid,* p. 271.
[68] K.J. Franklin, 'The Works of Richard Lower (1631-1691)', *Proceedings of the Royal Society of Medicine,* 25 (1939), pp. 113-118; F.J. Cole, *A History of Comparative Anatomy* (London, 1944), p. 222; C.C. Mettler, *History of Medicine* (Toronto, 1947), p. 73. These works are all quoted and discussed by K. Dewhurst (1982), p. 340. Gregory Zilboorg, notable historian of psychology, also noted that Willis 'sins by his great love for explanations' – pointing to Willis ideas around the animal spirits and his import of chemical analogies to that discussion, *History of Medical Psychology,* p. 264.

make sense those objects and experiences – through language and representation.[69] In contrast, the work of medical anthropologist, Annemarie Mol has argued that scientific practices are not necessarily a more reliable means of producing a single, coherent body of knowledge. She examines how different ways of investigating the body produce ultimately incommensurable versions of the body, through various sets of emphases or exclusions.[70] The practices we adopt, as much as the language we employ, produce different kinds of intellectual objects from the same physical subjects: there is no self-evident way to see and represent the body.

This is something that resonates with Jonathan Sawday's seminal work on Renaissance anatomy, which examines how the anatomical body of this period differed from earlier representations. The early modern body was informed, for instance, by prevailing discourses around the discovery of the new world and the accompanying expansion of cartographic technology; these parallel activities provided new metaphorical registers for understanding and representing the body.[71] In my approach to Willis's work around the brain I adopt a similar stance in arguing that his way of investigating and representing the brain was necessarily bound up with (and limited by) the metaphors and analogies available to him, as determined by the specific cultural, intellectual and material environments in which he lived and worked.

In the 1960s, Meyer and Hierons noted that 'an undercurrent of criticism because of the speculative nature of many of Willis's assertions has never died out completely.'[72] In a startlingly frank dismissal, they concluded that while Willis 'respected' facts, he ultimately believed that reasoning (by analogy) could be used to 'fill in the gaps' – a practice that, for the authors, explained why 'many of Willis's speculations have proved valueless,' according to modern medical interests.[73] His ideas about how the brain *worked* (its physiology) are taken here as little more than quaint embellishments intended to bridge the gap between Willis's empirical practices and his seventeenth century world-view. In the same period, Willis's noted biographer, Hansreudi Isler, spoke of 'the combination of

[69] Ian Hacking, *Representing and Inventing* (Cambridge: Cambridge University Press, 1983). For a critical discussion on Hacking's argument see: William Seager, 'Ground Truth and Virtual Reality: Hacking vs Van Fraasen', *Philosophy of Science,* 62.3 (1995), pp. 459-478 (p. 195).
[70] Annemarie Mol, *The Body Multiple: ontology in medical practice* (London: Duke University Press, 2002), p.viii, pp. 31-33.
[71] Jonathan Sawday, *The Body Emblazoned: Dissection and the Human Body in Renaissance Culture* (London: Routledge, 1995).
[72] Meyer and Heirons, 'On Thomas Willis's concepts of neurophysiology,' part II, p. 151.
[73] *Ibid,* p. 145.

epoch-making scientific ideas and discoveries with reckless speculation and overt nonsense which is typical of Willis's books.'[74] The observations of the brain upon which the 'value' of *Cerebri anatome* was based would therefore have to be picked over and recovered from amongst the imaginative excesses and 'fantasies' of the author.[75] In 1970, Julian Jaynes pointedly remarked that Willis' 'conception of the brain was even more baroque than Descartes', complete with ventricles like halls of mirrors and windows.'[76] The choice of the word baroque, in this context suggests that Willis's use of language was whimsical or florid, and is related to a style of art or architecture. It certainly underlines the point. More recently in 2004, the popular science writer Carl Zimmer commented that while Willis marked a 'defining moment in neuroscience,' in respect to the animal spirits, Willis saw in the brain what 'he wanted to see' and described the 'wanderings of invisible spirits as if he had travelled alongside them.'[77] That is, he projected his own 'imaginary' phenomena onto the empirical possibilities presented by the dissected brain.

Such readings from the outset exclude the possibility that what Willis observed, and what he was able to describe, were fundamentally enabled by the language and metaphors then available to him. Willis's use of the metaphor of the animal spirits continually excites censure, which supposes that he could have somehow described the brain as a neutral, empirical object. As I will explore in the sections below, this denies the role played by metaphor and analogy in generating and constituting the scientific models through which observations are produced. Moreover, these arguments act as a backdrop to the selective uses of Willis discussed above. They are based on the flawed idea that we can recover and draw upon Willis's descriptions of brain structure because, despite his use of language, beneath this, his insights were somehow *disciplined* by his acts of observation and experiment.

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[74] Hansreudi Isler, *Thomas Willis, 1621-1675: Doctor and Scientist,* trans. by H. Isler (New York, 1968), p. 106.
[75] Frank, 'Willis and his Circle', p. 145.
[76] Julian Jaynes, 'The Problem of Animate Motion in the Seventeenth Century,' *Journal of the History of Ideas,* 31.2 (Apr.-Jun., 1970), pp. 219-234 (p. 230). For a more recent example, see: Michael R. Trimble, MD., who describes Willis's description of the brain as 'poetic' in *The Intentional Brain: Motion, Emotion, and the Development of Modern Neuropsychiatry* (Baltimore: Johns Hopkins University Press, 2016), p. 52.
[77] Carl Zimmer, 'Beyond the Ivory Tower,' *Science,* 303 (Jan., 2004), pp. 42-44 (p. 44).

Cultural and Social history

In keeping with wider historiographical shifts, scholarship on Willis since the 1980s has increasingly reflected social and cultural history approaches, which reject these positivistic, present-centered and explicitly medicalised readings. This involves arguing for approaches that situate methods of knowledge within their proper cultural, social and material contexts. These ideas reflect much broader themes emerging from approaches such as the Sociology of Scientific Knowledge (SSK), based at the University of Edinburgh during the late 1970s and early 1980s. It also draws upon anthropological and ethnographic studies of science carried out by pioneers such as Bruno Latour and Steve Woolgar, and later by John Law and Annemarie Mol.[78] The work of prominent historians of science, Steven Shapin and Simon Schaffer, is also highly significant here in having argued that the cultural and social conditions of knowledge production must be taken into account.[79] More recent scholarship on Willis in line with these positions argues that his understanding of the brain cannot be taken as a self-evident account of an empirical, and therefore universally accessible, object that remains stable over time or space. Instead, historians must attend to the specific conceptual underpinnings of Willis's concepts and practices around the brain – what made his theory of the brain possible in that particular historical setting - and not to simply attempt to 'map' these onto our own ways of approaching the subject.

One of the more significant works on Willis reflective of these new approaches is Robert Frank Jr.'s *Harvey and the Oxford Physiologists.*[80] Frank asked how the problem of the brain and mind would have been approached 'in the context of seventeenth century medicine and culture?'[81] He notes that in late twentieth century literature, Willis has been remembered for his 'positive' contributions to neuroscience and not for his 'fantasies' about how the brain worked,' a positioned challenged by Franks' work.[82] Frank also drew attention to the 'constellation of elements' of Willis's career, eclecticism he took as a defining feature of seventeenth century natural philosophy. He therefore attempts to

[78] For a classic example on this field see: Bruno Latour and Steve Woolgar, *Laboratory Life: The Social Construction of Scientific Facts* (London: Sage Publications, 1979); Annemarie Mol, *The Body Multiple* (2002).
[79] Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life* (Princeton, N.J.: Princeton University Press, 2011).
[80] Robert G. Frank Jr., *Harvey and the Oxford Physiologists: Scientific Ideas and Social Interaction* (Berkeley: California University Press, 1980).
[81] Frank, 'Willis and his Circle', p. 110.
[82] *Ibid,* p. 145.

represent Willis not simply as a neuro-anatomist, but as a clinician, devout Anglican, experimental natural philosopher and chemist. [83] Despite this, Frank also observes the difficulties that this eclectic synthesis poses for the modern historian, as he writes, 'it always seems as if Willis is trying to do too much.' There is certainly a significant gap between our modern notions of finely divided, distinct, disciplinary specialisms and the more nebulous early modern disciplines. [84]

The attempt to examine Willis's wider beliefs and values has been similarly tackled in the slightly earlier work of William Bynum in his 1973 *Anatomical Method,* where he argued that Willis's religious views had underpinned his anatomical method. In particular, his religious views informed a correlation between form and function that was then taken as evidence of providential design.[85] As Michael Hawkins also pointed out in 2004, these contributions continue to focus on Willis's anatomical method and largely exclude motivations beyond (an assumed) religious orthodoxy – such as social, political, or philosophical influences.[86] In 2004, Robert L. Martensen's *The Brain Takes Shape* also examined Willis's religious motivations in relation to his 'methods of knowledge' around the brain.[87] At the same time, this book also looked at Willis's role in establishing the modern 'neurological' model of personhood through localising functions to specific, solid structures of the brain and in moving away from its pores and ventricles.[88] Again, the story of the modern neurosciences continues to form the architecture of these accounts, with religious motivations used as a broader context. Drawing on an alternative emphasis, Antonio Clericuzio's 1995 book, *The Internal Laboratory,* paid specific attention to Willis's theories around active, chemical matter, noting that these concepts were vitally important to understanding his physiological theory of the soul, which in turn directed Willis's anatomical interpretations. Clericuzio positions Willis's project, then, not as an anatomy of the brain but a 'chemical reinterpretation of the animal spirits,' which, he argued, could be used to inform early eighteenth century ideas around materialism and sensibility.[89] While Willis's ideas of brain function were not straightforwardly chemical,

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[83] *Ibid,* p. 129.
[84] Andrew Cunningham, 'The Pen and the Sword,' (2002).
[85] William F. Bynum, 'The Anatomical Method, Natural Theology, and the Functions of the Brain,' *Isis,* 64.4 (Dec., 1973), pp. 444-468 (p. 450).
[86] Hawkins, *Empire of the Passions,* pp. 15-16.
[87] Martensen, *The Brain Takes Shape,* p. 76.
[88] Martensen, p. 85.
[89] Antonio Clericuzio, 'The Internal Laboratory: The Chemical Reinterpretation of Medical Spirits in England (1650-1680)', in *Alchemy and Chemistry in the 16th and 17th Centuries,* ed. by Piyo Rattansi and Antonio Clericuzio (Dordrecht; Boston: Kluwer Academic Publishers, 1994), pp. 51-83 (pp. 72-3).

anymore than they were solely anatomical, this particular focus is important for having drawn attention to the intersecting influences involved in Willis's account. The issue of Willis's historical significance was revisited by George Rousseau in 2004, when he noted that Willis remained 'poorly understood' because of approaches that continued to examine him through narrow, modern disciplinary specialisms: that he 'cannot be adequately studied from one disciplinary perspective alone' because his "neurologie" is multidisciplinary.[90] Rousseau therefore called on scholars to examine Willis's work 'as a whole,' adding that 'the cultural, national and political brain must be added to the anatomical one' Willis articulated. [91]

Michael Hawkins's 2004 doctoral thesis is an important contribution to these debates. Hawkins is primarily concerned with resituating Willis's work as an early modern theory of the passions, in order to move beyond narrow, present-centred narratives that seek to make Willis's account speak to mental health interests (a category which did not exist at the time Willis was writing).[92] As Hawkins argues, Willis linked 'matters of physiology and pathology to social, political and religious concerns.'[93] While Willis's work on the physical structure of the brain is celebrated for its 'neurocartographies', Hawkins notes that historians have 'generally avoided examining his works as theories of the passions.'[94] Importantly, Hawkins moves away from a straightforward use of Willis's religious orthodoxy as a way of explaining his physiological theories, instead examining a broader set of medical, chemical, philosophical, political and professional factors. More recently, in 2011, Louis Caron examined the general reluctance within scholarship to view Willis's works as important philosophical, as well as medical, contributions. Caron examines how Willis's broader medical, religious and intellectual practices informed his model of neuro-physiology. He does so in order to situate Willis in an intellectual tradition that includes the philosopher John Locke, a famous student of Willis's.[95] While there is a tendency here to establish Willis's significance by situating him in relation to those he either influenced or was influenced by – rather than looking at him in his own right – this is an important part of addressing those prevailing medical, present-centred interests which have obscured the relevancy of Willis's philosophy of the mind.

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[90] Rousseau, *Nervous Acts,* p. 361.
[91] *Ibid*., p. 360.
[92] Hawkins, p. 10.
[93] *Ibid*., p. 8.
[94] *Ibid*., p.10.
[95] Caron, *The Philosophical Reception of Thomas Willis* (2011).

This thesis, in examining Willis's use of language and how it related to his intellectual and physical practices, builds on the recent work of Hawkins, Caron and Tabb. It therefore addresses a growing field of scholarship, which seeks to add historical, cultural and philosophical dimensions to the prevailing picture of Willis as a 'neuro-anatomist'. While these accounts have, to varying degrees, engaged with Willis's metaphors and analogies, they have not tended to feature as the focus of study in and of themselves. As Hawkins has also noted, despite acknowledging the use of chemical analogy in Willis's works, historians have tended to overlook the significance of his particular selections and use of that imagery.[96] Hawkins' own work discusses Willis's use of monarchical and political imagery, to argue that his theory of the passions was influenced by the politics of the civil war and Restoration. In 2011, Hawkins also examined Willis's pragmatic use of chemical analogies to bridge a gap between his medical training and wealth of chemical experience.[97] In 2014, Kathryn Tabb used Willis's anthropomorphic metaphors of the animal spirits to argue against claims in the history of psychology about Willis's role in the 'reductionist turn'.[98] These are incredibly valuable studies; however, the chosen examples tend to be used to support specific arguments about Willis's motivations - his political commitments, or religious orthodoxy.

Any one set of these analogies, if taken in isolation, can present a too narrow picture of Willis's ideas: for instance, in 2008, Ludger Schwarte used examples of Willis's mechanistic imagery to suggest that his model of the brain and body was, above all, a mechanical philosophy. Conversely, Tabb used a different set of metaphors to argue the exact opposite. It is important, then, to take a much broader view of use of metaphors and analogies, examining them both in terms of their own meanings and associations, but also for how they might inform, alter or extend other images within the same text. Willis's mechanistic images become something quite different when we read them in conjunction with the vital agency of the spirits he had acting within those structures. What these images can do – when taken together – is reveal a multi-faceted, multi-disciplinary model of the brain and body that incorporates a range of sources, influences

[96] Hawkins refers especially here to Kenneth Dewhurst, *Empire,* p. 182.
[97] Hawkins also argued here that there is a disproportionate emphasis on Willis's neuro-anatomy: 'Piss Profits: Thomas Willis, his Diatribae Duae and the Formation of his Professional Identity,' *History of Science,* 49.162 (2001), pp. 1-24.
[98] Kathryn Tabb, 'Struck, As it Were, With Madness,' in *Brain, Mind and Consciousness,* ed. by C. U. M. Smith (2014), pp. 43-57.

and practices and material environments. This will not necessarily furnish us with an internally coherent idea of Willis's brain: the point of metaphors and analogies is not to present a complete picture or idea of an object, it is selectively to develop a given set of relationships or associations, according to what is being said. It is these productive, dynamic tensions between Willis's metaphors and analogies around the brain that are useful in disrupting or unsettling the 'clarity' that modern neurosciences have attempted to create for Willis's body of work.

We might also consider here how Willis's physical or technical practices around the brain were shaped by the ways in which he was able to talk about (and therefore think about) the brain as an object of knowledge. For instance, his new technique for dissecting the brain reflected a concern to retain its 'natural' form but also to gain greater access to new areas at the base of the brain and to retain intact its interconnected arterial and nervous pathways; these concerns drove the nature of his practical innovations. It is a set of concerns that was articulated by Willis through his characterisation of the brain's structures as a set of topographical analogies (river ways, crevices, provinces) which needed to be retained and exposed, rather than sliced and broken as chapter three explores. These considerations complicate narratives that might wish to view Willis's dissection method as the inevitable progression towards more accurate representations of nature or the simple outcome of technological change. This thesis therefore critiques the notion that Willis's observations and descriptions of the anatomical brain can be appropriated – in any meaningful way - without considering the ways in which Willis represented and talked about the brain as an object of knowledge.

Literature and Science

As I have set out above, Willis's position in historical scholarship has been substantially informed by broad conceptions of a binary between 'scientific' and 'literary' uses of language. As James Bono has argued, 'popular and professional images of science' are based around a perception of science as a "mirror" to nature, contrasted with a conception of 'literature enmeshed, if not mired, in language.'[99] This conception of modern science is, in no small part, based around the idea that the late seventeenth

[99] James Bono, 'Science, Discourse and Literature: The Role/Rule of Metaphor in Science,' in *Literature and Science: Theory and Practice,* ed. by Stuart Peterfreund (Boston: Northwestern University Press, 1990), pp. 59-89 (p. 59).

century witnessed a broad program to reform linguistic convention, used to establish a direct, objective and plain use of language that would reliably denote 'facts'. As Clive Sutton observed in 1994, 'the anti-word tradition comes down to us very strongly, and no scientist or science teacher wants to be caught dabbling with 'mere words.'[100] These attitudes, deeply embedded in notions of modern science, are reflected in assessments of Willis's historical contribution.

In addressing these themes, the thesis will draw from the field of literature and science scholarship. This incorporates two broad areas of study: first, literary scholars have examined how literature engages with scientific ideas; second, historians, following a social constructivist model, have examined science as a cultural discourse.[101] A Landmark text in the latter field is George Rousseau's 1979 essay in *ISIS,* 'Literature and Science: the state of the field.'[102] Jonathan Sawday's important book on Renaissance anatomy, *The Body Emblazoned*, examined shared discourses of the body between poetry and anatomy in this period, and showed how a core set of metaphors around the body as a book, or cartographic atlas, shaped the discipline of anatomy as a practice of 'writing' the space of the body.[103] More recently, in 2011, Charlotte Sleigh has pointed to the common origins of the modern novel and modern science, in the last forty years of the seventeenth century. Sleigh notes that both the modern novel and modern science function as new technologies for making versions of truth. Both involve a set of selections and prioritisations that embody 'the contexts and methods' of their making.[104] Likewise, in 2004 Elizabeth Spiller argued that the categories of literature and science emerged out of the same conditions in the seventeenth century, by defining themselves in opposition to one another.[105] What is highlighted in these discussion is how the notion of an essential binary between science and literature emerged from a very specific historical setting: the

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[100] Clive Sutton, 'Nullis in verba' and 'nihil in verbis': Public Understanding of the Role of Language in Science, *The British Journal for the History of Science,* 27. 1 (Mar., 1994), pp. 55-64 (p. 59).
[101] Gowan Dawson, 'Literature and Science under the Microscope,' *Journal of Victorian Culture,* 11. 2 (2006), pp. 301– 15, (p. 302- 303).
[102] George Rousseau, 'Literature and Science: The State of the Field'*, Isis,* 69. 4 (Dec., 1978), pp. 583 -591.
[103] Jonathan Sawday, *The Body Emblazoned: Dissection and the Human Body in Renaissance Culture* (London: Routledge, 1995). Catherine Waldby has likewise argued that the body is not self-evident and comes into being through visual and literary strategies: Waldby, 'Virtual Anatomy: From the Body in the Text to the Body on the Screen,' *Journal of Medical Humanities,* 21.2 (June, 2000), pp. 85-107 (p. 91, 94). Richard Sugg's *Smoke of the Soul: Medicine, physiology and Religion in Early Modern England* (Basingstoke: Palgrave Macmillan, 2013) follows on from Sawday's work by looking at representations of the body between poetry, drama and medicine in the 17th and 18th centuries.
[104] Charlotte Sleigh, *Literature and Science* (Basingstoke: Palgrave Macmillan, 2011), p. 27.
[105]Elizabeth Spiller, *Science, Reading and Renaissance Literature: The Art of Making Knowledge, 1580-1670* (Cambridge: Cambridge University Press, 2004), p. 1.

latter half of the seventeenth century, in Northern Europe, promoted among the fellows of the Royal Society. It is therefore neither an essential nor inevitable to recognise a dichotomy between literature and science. Much has been written about specifically early-modern attitudes to the role of metaphor and analogy, literature and science – this will be discussed in chapter one.

This thesis draws on these areas of scholarship insofar as these discussions inform my critique of modern medical sciences' ahistorical uses of Willis's work: uses that have failed to acknowledge the full conceptual richness of his contributions, bound as they are to his apparently unscientific and rhetorical uses of language. Part of this has involved the 'cherry picking' of Willis's anatomical observations while dismissing his physiological theories as 'fantasies' built upon mere 'words' – matter's of philosophy or literature, but not 'science'. This thesis argues against the idea that Willis's use of metaphor or analogy marks him out as unscientific, particularly by the standards and practices of his own contemporaries, as chapter one will explore. Indeed, even our present-day sciences are very much reliant upon the use of key metaphors and analogies.

This work clearly picks up on social constructivist approaches, which have elicited famous opposition from those in the sciences: in 1998 Alan Sokal claimed that science was not the same as other discourses, as it was able to employ language differently and was 'not a mere reservoir of metaphors' for use by humanities scholars. Rather, he argued, scientific metaphors are distinct because they are disciplined by being rooted in experiments and verifiable hypotheses.[106] The 'science wars' of the early 1990s were particularly fractious over this question of 'reality' and 'metaphor', 'literature' and 'science'.[107] Much of the most heavily-cited literature therefore comes from this period of the late 1980s and early 1990s. While I am not arguing that science or medicine are necessarily the same as other types of discourse – or that they produce the same idea of 'real' – it is important to note that science does not operate outside of culture, nor are its strategies for producing, representing and communicating its ideas beyond discourse.[108]

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[106] Alan Sokal and Jean Bricmont, *Intellectual Impostures: Postmodern Philosophers' Abuse of Science* (London: Profile Books, 1998), p. 177.

[107] These debates can be traced back to C.P. Snow's famous Rede lecture on the 'two cultures' of the 'sciences' and 'arts and humanities': 'The Two Cultures and the Scientific Revolution' (1959). On the 'science wars,' see: *Science Wars,* ed. by Andrew Ross (London: Duke University Press, 1996) and Martin Willis, *Literature and Science: a readers guide to essential criticism* (London: Palgrave MacMillan, 2015), esp. p.7.

[108] Emily Martin's article on the 'egg and the sperm' is a useful study of how science employs literary representational strategies, even when presuming its own objectivity: 'The Egg and the Sperm: How

This is in no small part because language cannot move beyond culture. Scientific 'facts' are necessarily enmeshed in the language that delivers them. As long ago as 1961, N.R. Hanson's *Patterns of Discovery* noted how there is a 'linguistic factor in seeing.'[109] Hanson argued that scientists do not 'see' an object but are actively engaged in 'seeing as' – constantly interpreting phenomena through analogy. Complementing these studies are works that have examined the 'literary structure' of scientific argument; notably, the work of Peter Dear (1991) and Clive Sutton (1994).[110] I am again influenced here by the work of Shapin and Schaffer, who argued that a community (of readers) participate in making the contents of scientific argument emerge as 'public knowledge' as a set of agreed upon facts; literary strategies in science are therefore also social technologies, both of which are part of the production of knowledge.[111] Likewise, Daston and Gallison's work in 2005 around the historical nature of concepts of fact and objectivity is relevant to these discussions.

Metaphor and analogy

The particular focus of this thesis falls on Willis's use of the devices of metaphor and analogy in constructing and representing his ideas around the brain. It aims to show that, despite having been widely criticised for employing these devices as figures of literary embellishment, they were in fact generative and constitutive elements in the 'science' he practiced; this is arguably true in the production of all scientific knowledge. A specific focus on Willis's metaphors and analogies of the brain can be used to offer new insights into his intellectual practices: for instance, while the relationship between form and function is widely accepted as being fundamental to Willis's ideas, as noted by the likes of William Bynum and Robert Frank Jr., it has yet to be examined specifically in light of the literary strategies that were used to support and validate the correlation.[112] In this approach I draw from Hayden White's classic essay on 'Historical Text as Literary

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Science Has Constructed a Romance Based on Stereotypical Male-Female Roles,' *Signs,* 16.3 (Spring, 1991), pp. 485-501.

[109] N. R. Hanson, *Patterns of Discovery: an inquiry into the conceptual foundations of science* (Cambridge: Cambridge University Press, 1961), p.25.

[110] Peter Dear, *The Literary Structure of Scientific Argument* (Philadelphia: University of Pennsylvania Press, 1991). Clive Sutton, *Words, Science and Learning* (Buckingham, Open University Press, 1992), chap. 3-5.

[111] Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump* (Princeton: Princeton University Press, 1985), p. 63.

[112] Bynum (1973); Frank Jr. 'Thomas Willis and His Circle,' *The Languages of Psyche,* ed. by G. S. Rousseau (1990).

Artefact' by examining literary strategies in Willis.[113]

Of course, ideas around the role of metaphor and analogy are themselves culturally and historically contingent; in this section I focus on setting out aspects of the current literature on the topic and debates within the modern sciences, while chapter one examines seventeenth century attitudes in context. The modern definition of metaphor traces its origins to Aristotle, who defined metaphor as the application of a 'strange name' to a new object, carrying the connotations of its previous context over to a new one. This action contained within it the prospect of a disruption to the relationship between words and the things they were meant to represent. It was a disruption, moreover, which served creative ends: Aristotle considered metaphor to be a device of poetry rather than rhetoric or logic – suggestive of a role in imagination and adornment, rather than a structural component of thought and language.[114] As James J. Bono has expressed, the ideas flowing from this philosophy came to view metaphors as fundamentally misleading.[115] Friedrich Nietzsche remarked in the nineteenth century, that truth cannot be un-entangled from the metaphors which describe them; we only forget their metaphorical root. Describing 'a mobile army of metaphors,' he notes that 'truths are illusions of which one has forgotten that they are illusions.'[116]

According to modern definitions, a metaphor is a figurative description used in place of a literal one, to which it is analogous.[117] When we describe the brain as being 'hardwired', for instance, this is not a literal description of the brain's neurological structures, which bear little physical resemblance to the wires or circuit boards; what the metaphor conveys is the idea that there are functional similarities (analogies) that exist between computers and the human brain.[118] The metaphor is intended to further an understanding of the brain by reference to another, more familiar, object: the computer. Additionally, the

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113 Hayden White, 'The Historical Text as Literary Artifact' (1978), *The Norton Anthology of American Literature, Shorter Seventh Edition, Volume 2 1865 to the Present*, ed. by Vincent B. Leitch (New York: W. W. Norton, 2007).

114 David Punter, *Metaphor* (London: Routledge, 2007), p. 12.

115 James J. Bono, *The Language of God and the Languages of Man: Interpreting Nature in Early Modern Science and Medicine* (Madison: University of Wisconsin Press, 1995), p. 9.

116 Friedrich Nietzsche, 'On truth and falsity in their extramoral sense', in *Essays on Metaphor,* ed. by W. Shibles (Whitewater: The Language Press, 1972), p. 5. Cited by Shane Neilson, 'Pain as Metaphor: metaphor and Medicine,' *Medical Humanities,* Published Online First (August 7, 2015), < doi:10.1136/ medhum-2015-010672; p.1>

117 *The Oxford English Dictionary*, "metaphor, n." *OED Online*. Oxford University Press, December 2015. Accessed 4 March 2016.

118 The hardwired metaphor is a common one in neuroscience, for an early example of its use, see: Carl Sagan's *The Dragon's of Eden: Speculations on the Evolution of Human Intelligence* (USA: Random House, 1977).

focus expressed by the hardwired metaphor falls upon shared functional aspects, rather than the brain's material substance or visual likenesses. This recourse to functional narratives is, furthermore, compounded by the advent of neuroimaging techniques which visually highlight neural activity. Metaphors, then, can intersect with technologies in a host of complex ways to steer knowledge in new directions.[119]

Like metaphor, analogies similarly facilitate understanding by comparing an unfamiliar object to a more familiar one. They differ from metaphor in that, as a comparative device, analogy purports only to bear *similarities* to its target object, rather than proposing to stand in place of it. For instance, a biological 'cell' could be said to behave *like* a factory in a given role, whereas the human genome *is* a 'blueprint' for the body.[120] Analogy also tends to focus upon and draw out a specific point of similarity between two objects rather than encompassing all the possible relationships between them – analogy therefore requires greater work on the part of the reader in contextualisation to discern between these possibilities.[121] There is clearly a substantial overlap here: a metaphor works by setting up parallels, via certain analogies or similitudes; both devices work to establish a set of associations between qualitatively different objects; both emphasise common relational abstractions.

Importantly, metaphors and analogies capture a given set of intellectual, technological and cultural contexts. They direct the ways in which we are able to speak about the world, and set the possibilities for new knowledge and invention. As Michael Hunter has it, 'metaphors lay the tracks for trains of associations, they direct the way we think, name and hypothesize…metaphors capture an intellectual climate.'[122] As such, they have their own life cycles, rather than being true for all time; they are, above all, historically situated. It is not just the choice and availability of the objects of comparison that are contingent: ideas about how these devices operate, when or *if* they ought to be used, are also historically defined and subject to change.

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[119] Cornelius Brock, 'Toys are Us: Models and Metaphors in Brain Research,' in *Critical neuroscience: A Handbook of the Social and Cultural Contexts of Neuroscience*, ed. by Suparna Choudhury and Jan Slaby (Chichester, West Sussex: Wiley-Blackwell, 2012), pp. 113-133 (p. 114).

[120] On the DNA as 'blueprint' metaphor, and its recent criticism see: Claire Ainsworth, 'DNA is life's blueprint? No, there's far more to it than that,' *New Scientist,* 3025 (13 June 2015).

[121] As Dedre Gentner and Michael Jezoirski proposed, an analogy is a 'kind of highly selective similarity' which encourages the reader to focus on certain kinds of commonalities at the expense of others: 'The Shift from Metaphor to Analogy in Western Science,' in *Metaphor and Thought,* ed. by Andrew Ortony (Second edition: Cambridge: Cambridge University Press, 1993), pp. 447–480 (p. 448).

[122] *Robert Hooke: Tercentennial Studies,* ed. by Michael Cooper and Michael Hunter (Aldershot: Ashgate Publishing, 2006), p. 121.

The outlines of the modern debate are often traced back to Max Black's seminal work, *Models and Metaphors: Studies in Language and Philosophy* first published in 1962 and later revised in 1979 and 1995.[123] Instead of viewing metaphor as standing in place of what could otherwise be said literally, Black outlined a dynamic 'interaction' model whereby the metaphor is used to actively supress or highlight associations with other objects in order to generate new meanings – a model widely taken up within literary studies.[124] According to these positions, metaphors do more than passively transfer meaning from one object to another by substitution or comparison; they actively constitute new meanings and new knowledge.[125] They work to embed objects into broader webs of meaning, into culture, in a myriad of ways. For instance, we can consider how the selection of one object (apart from any other) to act as the 'figure of transport' or comparative object is itself a highly interpretive and creative act, designed to draw out a specific set of connections and relationships. As Black's work outlined, the metaphor works by selectively emphasizing, organising, or suppressing certain features of the primary object. By steering and directing our 'sight' in this way, one set of associations or relationships is highlighted to the exclusion or obscuring of other possibilities of knowledge. These connections are selectively drawn so that the given object is understood through the desired epistemological prism – the choice of a metaphor or analogy does more than make an object vivid or comprehensible, it is a part of the social and cultural production of knowledge.[126]

Revisionist perspectives, influenced by Black's work and its uptake within literary scholarship, have sought to attribute 'cognitive value' to metaphors.[127] George Lakoff and Mark Johnson's classic text *Metaphors We Live By* (1980) has been highly influential in

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123 Max Black revisited and revised his original essay 'Metaphor' (1962) in 'More about Metaphors', in *Metaphor and Thought*, ed. A. Ortony, pp. 18-41.

124 Douwe Draaisma has talked about the enthusiastic uptake of Black's dynamic, interaction model in *Metaphors of Memory: A History of Ideas about the Mind* (Cambridge: Cambridge University Press, 2000), pp. 10-11.

125 Janet Martin and Rom Harre have noted that metaphor is an 'intercourse of thoughts, as opposed to a mere shifting of words or crude substitution,' see: 'Metaphor in Science,' in *From a Metaphorical Point of View: A Multidisciplinary Approach to the Cognitive Content of Metaphor,* ed. by Zdravko Radman (Berlin: de Gruyter, 1995), pp. 289-308 (p. 294).

126 On how analogies in science are used to emphasize one set of relationships as part of the act of obscuring another see: Bruno Latour and Steve Woolgar, *Laboratory Life,* p. 179.

127 This attempt has proved quite controversial, as Ladina Lambert writes: 'in acknowledging the cognitive value of metaphoric meaning, many revisionists are concerned that metaphors might get out of hand.' Science responds to these discussions by emphasizing its rhetoric on metaphors as "managed" tools. Ladina Bezzola Lambert, *Imagining the Unimaginable: the Poetics of Early Modern Astronomy* (Amsterdam-New York: Editions Rodopi B.V., 2002), p. 19.

this regard, arguing that all thought and language are fundamentally metaphoric.[128] Lakoff and Johnson defined metaphor as a means of 'conceiving of one thing in terms of another', whereby we come to conceive of the target in terms of the characteristics of the source object.[129] All new ideas and concepts are produced in this way, by referring to what we already know. We might think here of the modern metaphor of DNA as a 'code' or 'book' to be read: we might *use* DNA in a way that is comparable to how we read and interpret a set of codes, but neither codes nor books are substantially like the actual 'stuff' of DNA. This metaphor instead helps to establish an idea of how DNA functions as a an object knowledge, by drawing on existing models for producing knowledge of the world – it is a visual code that we study or 'read' in order to ascertain the 'blueprint' design of the body. These metaphorical devices direct how we think about and use the concept of DNA, rather than acting as an illustrative substitution standing in place of a literal definition.

Since the 1980s, integrationist models have set out to express the explanatory power of these devices and have proved to be more widely accepted. In 1987, scientist Stephen Jay Gould stated that 'theory informed by metaphor and observation constrained by theory – marks any major movement in science.'[130] New discoveries are always governed by and embedded within existing tropes of knowledge; it is impossible to construct a theory without drawing on existing categories of knowledge, through metaphors and analogies. In turn, observation is necessarily guided by those theories. In the 1990s, James Bono, following on from Black's interactional model, argued that metaphors are generative and transformative in his *Science, Discourse and Literature*.[131] Slightly later, in 2003, Theodore Brown's *Making Truth: Metaphors in Science* argued something similar.[132] Andrew Pickering also notably proposed that metaphors and analogies are at the core of all scientific modelling: scientific models are metaphors, based around similitudes, as they only project what we imagine or expect something to be like, rather than what we think it is.[133] Joseph Dumit's *Picturing Personhood* (2004) has similarly examined the formative role of

[128] George Lakoff and Mark Johnson, *Metaphors We Live By* (Chicago: University of Chicago Press, 1980), p. 59. See also: Mary Thomas Crane 'Analogy, Metaphor, and the New Science: Cognitive Science and Early Modern Epistemology,' in *Introduction of cognitive Cultural Studies,* ed. by Lisa Zunshine (Baltimore: John Hopkins University Press, 2010), pp. 103 -114 (p. 103).
[129] *Ibid.*
[130] Stephen Jay Gould, *Times Arrow, Time's Cycle: Myth and Metaphor in the Discovery of Geological Time* (Cambridge: Harvard University Press, 1987), p. 8.
[131] Bono, 'Role/Rule,' p. 61.
[132] Theodore M. Brown, *Making Truth: Metaphors in Science* (Chicago: University of Illinois Press, 2003).
[133] Andrew Pickering, *The Mangle of Practice: Time, Agency and Science* (London: University of Chicago Press, 1995), p. 19.

metaphors in the modern brain sciences. He traces out certain historical metaphors on which neuro-technologies 'depend', such as electrical telephone wires.[134] The use of these metaphors is governed or informed by the availability of certain technologies, epistemological or social frameworks: metaphors of the brain are broadly governed by what is perceived to be the most complex or sophisticated technologies of a particular period, from the clock to computational machines and latterly, the internet.

Metaphors and analogies also offer us a way to see the interactions between language, practices and material culture within certain historical settings. Gerd Gigerenzer in his 'Tools to Theories Heuristic' (1992) notes how our scientific tools can slide into informing the kinds of theories we have about things, becoming metaphors for objects. He uses the example of statistical choice models, used in looking at cognition, which then become metaphors of the mind - leading to some researchers talking as if the brain actually functions in that way.[135] Indeed, modern science has displayed a remarkable reliance upon metaphors and analogies in communicating its discoveries and ideas – from Richard Dawkins' 'selfish gene' to the 'hardwired' brain of neuroscience, scientific discourse has been shaped by a set of highly effective metaphors. Today, they are generally viewed as useful devices that can help the public understand complex models and are a particularly vital part of the public relations effort undertaken by modern science. In 1998, Timothy Lenoir, for example, notably pointed to the continuing relevance of metaphorical language in science today.[136] While there is still much debate about the role and limits of their use in scientific work, there is little outright hostility and few would entirely dismiss the significance of their work in relation to producing scientific knowledge.[137]

The embracing of metaphor by modern science - what was once considered by Thomas Hobbes to be a chief 'abuse of language' - rests, however, on a very specific way of representing the role of metaphor within the contemporary scientific setting. Modern science has carefully promoted the idea that it has a privileged means of employing

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[134] Joseph Dumit, *Picturing Personhood: Brain Scans and Biomedical Identity* (Princeton: Princeton University Press, 2004), p. 181.
[135] Gerd Gigersenzer, 'From Tools to Theories: A Heuristic of Discovery in Cognitive Psychology,' *Psychological Review,* 98.2 (1991), pp. 254-267 (p. 254).
[136] Timothy Lenoir (ed.), *Inscribing Science: Scientific Texts and the Materiality of Communication* (California: Stanford University Press, 1998).
[137] Sabine Maasen, 'Metaphors in the Social Sciences: Making Use and Making Sense of Them,' in *Metaphor and Analogy in the Sciences,* ed. by Fernand Hallyn (Dordrecht; London: Kluwer Academic Publishers, 2000), pp. 199-240 (p. 200).

language transparently, wherein metaphor can operate as a neutral and objective "tool" used to inform rather mislead an audience. According to this view, the use of metaphor in supporting scientific understanding and communication is disciplined by being tethered to clearly stated research goals and the experimental context. Literary uses, set up in contrast to these accounts, employ metaphors in an open-ended context and for affective capacity.[138] Metaphors in science are considered as being distinct from those in politics or poetry in that they function in the same capacity as 'tools' rather than as features of embellishment. As Dedre Gentner and Michael Jeziorski observed in 1994, Robert Boyle used metaphors and analogies scientifically in that he observed 'firm constraints' in their use; in so doing, he retained *control* over those 'tools.'[139] Pre-modern figures, however, 'embraced' these devices with 'unbridled eagerness' and were this 'owned' by their examples rather than wielding them.[140] It remains unclear, though, how readers might internalise or reproduce this 'discipline' when interpreting the metaphors of science.

The idea of metaphor and analogy as powerful 'tools' presents them as a means by which we might access a fixed and self-evident reality, rather than as devices which help to determine how we are able to conceive of and experience the world.[141] This is part of the rhetoric of modern science, which promotes the sense of a privileged access to a 'reality' beyond culture. However, it is through scientific practice that models – based on metaphors - are made to exist and produce real effects in the world. James Bono and Katharine Hayles have, in particular, addressed the notion that scientists can delimit the role of metaphor through what Bono termed a 'privileged insight' that 'controls the unruliness of metaphoric meaning.'[142] As Hayles argues in *Chaos and Order*, scientific discourse extends the 'belief that a language exists, or can be forged, that is purely

[138] J. Bono, 'Role/Rule', p. 67. On scientific metaphors as working "tools" and literary metaphors as 'emotive and affective' see: Richard Boy, 'Metaphor and Theory Change: What is 'Metaphor' a Metaphor For?' in *Metaphor,* pp. 356-408 (pp. 361-63). Bono offers a critical discussion of Boyd's views on p. 63.

[139] Gentner and Jeziorski, 'The Shift from Metaphor to Analogy,' p. 448.
[140] *Ibid*, p. 448.
[141] Lambert, *Imagining the Unimaginable* (2002), p. 20. On this discussion in the social sciences see: Sabine Maasen, 'Metaphors in the Social Sciences,' p. 203.
[142] Bono, pp. 60-61.

instrumental.'[143] However, 'anyone who has seriously studied how language works is aware…that it shapes even as it articulates thought.'[144]

While metaphor and analogy are clearly used in historically specific ways, there is little to support the positivistic idea that contemporary scientists have found a way to employ the work of comparison in a substantially different – and more objective way - than earlier periods. Despite many obvious differences between Richard Dawkins' metaphor of the 'selfish gene' and Willis's evocation of 'melancholy' animal spirits, for example, both impute human or anthropomorphic characteristics to (what were then accepted as being) biological components of the body in order to say something about the way in which they acted or behaved. Both worked upon broader theoretical frameworks – Darwinism and vital matter theory, respectively. This is not to collapse the wealth of historical and cultural differences between Willis's and Dawkins's examples, but to suggest that modern science has no unique claim to be able to employ metaphor in a neutral way. In effect, the policing of this boundary between modern and pre-modern use of metaphor and analogy is, in itself, part of a broader effort to reproduce and validate the identity of modern science. As this thesis looks to demonstrate, science has – and continues to – employ literary and rhetorical strategies even while presuming its own objectivity.[145]

In the 1990s, Gentner and Jeziorski put forward a new variant upon the scientific 'tools' argument, proposing that a shift from metaphor to analogy characterised the emergence of modern science. As they noted, what has counted as a scientific uses of these devices has changed over time. However, their argument is based not simply on noting difference but on mapping out a linear progression from pre-modern metaphors to modern, scientific analogizing. As they argue, modern scientists recognise 'a set of tacit constraints' in analogical reasoning, which makes them more reliable – an argument I explore further in chapter one.[146] Analogies, they proposed, have been viewed as more acceptable 'tools' of science and are used by (true) scientists wherever it is possible to avoid metaphor. It is not entirely clear how these constraints are to be applied, monitored or how effective they might be; what is significant here, though, is the very

[143] Katherine Hayles, 'Introduction: Complex Dynamics in Literature and Science,' in *Chaos and Order: Complex Dynamics in Literature and Science,* ed. by K. Hayles (London: University of Chicago Press, 1991), p. 5.
[144] K. Hayles, *Chaos and Order*, p. 5.
[145] See Lorraine Daston and Peter Galison, *Objectivity* (Brooklyn; Zone Books, 2007); Emily Martin, 'The Egg and the Sperm,' pp. 485-501.
[146] Gentner and Jeziorski, 'The Shift from Metaphor to Analogy,' p. 450.

application of these notions of discipline and restraint to language as a marker of what makes it 'scientific'. It is also somewhat artificial to have drawn a distinction between metaphor and analogy as they substantially overlap and both are regularly used in scientific discourse; it is done more in the hope of carving out a space for an exclusively scientific use of language. Lastly, the argument assumes, at the most basic level that readers are unable to recognize and appreciate the effects of metaphor while being able to interrogate or reject the implications of an analogy if they so choose. Simply because we, as readers, know that the brain is only being *compared* to a computer, this does not necessarily mean that there is some other 'universal' object of the brain to which we can appeal in order to limit the cognitive effects of the analogy, any more than there is for the metaphor.

It is also an argument that has failed to convince scientists themselves. The boundary between whether an object is intended to act as a comparison (analogy) or used to stand in for an object (metaphor) by the author is elusive, perhaps impossible to pin down. In 2003 M.J. Eadie complained that it is this 'slide' from analogy to metaphor that makes Willis's theories (around chemical physiology) so problematic: 'it sometimes becomes difficult to be sure if he may have slid from analogy into postulated chemical actuality.'[147] Elements of the attacks on Willis reflect a sense in which he intentionally blurred the boundary between 'literary' metaphor and 'scientific' analogy: he is thus less secure historically than Robert Boyle, who is taken as an exemplar of 'scientific analogizing'.[148] This contrast will be revisited in chapter one.

Despite these fears, metaphors and analogies continue to abound in science today. At the same time, it is possible to detect a growing sense of unease around the extent to which science might have come to rely upon the illustrative work of these devices, especially in terms of public communication strategies. This may reflect the beginnings of a renewed backlash against metaphors in particular, which remain a cause of considerable suspicion. As Sabine Maasen notes, metaphors continue to be regarded with equivocation: 'they have been seen as ornamental, yet inessential; educational, yet lacking genuine insight; as economical carriers of complex meaning, yet easily misleading.'[149] A question, continually lurking behind these debates, is that of how we actually distinguish between the function

[147] M. J. Eadie, 'A Pathology of the Animal Spirits,' part I, p. 17.
[148] Gentner and Jeziorski, 'The Shift from Metaphor to Analogy,' p. 457.
[149] Maasen, 'Metaphors in the Social Sciences,' p. 199.

of metaphors in science as opposed to politics or poetry – a distinction that has not been comprehensively settled by any means. An oft-quoted warning among the scientific community comes from cyberneticists Arturo Rosenblueth and Norbert Wiener, who noted that, while indispensible, 'the price of metaphor is eternal vigilance.'[150]

Phillip Ball, writing in the popular science publication *Nature* in 2011, proposed that 'maybe we are too eager to find a neat metaphor rather than just explain what is going on as clearly and honestly as we can.'[151] The metaphor might make the task of scientific explanations easier and more appealing, but Ball does not consider it to count as a constituent part of the process of knowledge production; it is, in contrast, a shortcut and one that obscures vital content in the process. Richard Roche's essay, 'Lost in Translation: the dangers of using analogy in science' (2012) – shortlisted for the Wellcome Trust Science Writing prize – expressed the fear that analogies are limiting as 'tools' and do not always serve scientific knowledge faithfully. Roche described an intellectual 'pay-off' that occurs when scientists employ easily accessible analogies to explain complex scientific ideas or models to the public.[152] Analogies might enable a non-technical audience to grasp difficult ideas, but, as Roche argues, these are over-simplifications that flatten out detail and thereby restrict what it is possible to think about the subject. More recently in 2016, Shane Neilson's article in *Medical Humanities* examines the fundamental yet restrictive role of metaphors in a study on metaphors around pain in medicine, taking them to be a device that both enables and confines the very basis of knowledge. As he writes, 'disciplines progress according to the strength of their metaphors' and can become entirely bound up in their meaning – this can restrict alternative ways of thinking about experiences and objects.[153]

While analogies and metaphors do indeed supress 'detail' to achieve a different kind of intelligibility, it is also difficult to imagine how those details or facts are to gain meaning (as part of a scientific model or concept) without the prism of the analogies and metaphors through which we organise them. Here, they are represented as tools for the

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150 This warning is cited by Richard Lewontin, who noted that the 'risk' of metaphor lay in 'confusing the metaphor with the thing of real interest': *The Triple Helix: Gene, Organism and Environment* (London: Harvard University Press, 2000), p. 4.
151 Phillip Ball, 'A Metaphor too Far,' *Nature* (23 February, 2011)
< www.nature.com/news/2011/110223/full/news.2011.115.html >
152 Richard Roche, 'Lost in Translation: the dangers of analogies in science,' featured on the Wellcome Trust blog (29th Oct, 2012), <http://blog.wellcome.ac.uk/2012/10/29/lost-in-translation/>
153 S. Neilson, 'Pain as Metaphor' (2015), p. 1.

transmission of an already perfect science, rather than as tools for "doing" science; they are a means by which scientists explain themselves to the public, rather than the tools by which they produce knowledge. As mentioned in regards to Pickering's arguments about scientific modelling, all experiments are ultimately based on models of the world, and those models are generated from metaphors or analogies.[154] This is nevertheless a useful example of how popular science discourse continues to project the impression that is has a privileged way of using language to convey a specific kind of reality.

These arguments support my position that in 'cleansing' Willis's clinical and anatomical work of the metaphors and analogies that he employed, we intervene in and distort the meaning and sense he attached to those activities. Notions about the appropriateness of metaphors and analogies in science are, moreover, directly relevant to the way in which Willis has been represented within historical writing. Even where Willis's use of these devices is not explicitly attacked, discussions concerning his 'imaginative', 'embellished' and 'rhetorical' writing speaks to these ideas around the role of language and its relationship to producing a certain kind of scientific knowledge. References to Willis's imaginative genius or speculative reasoning denote his use of metaphor and analogy as a means of drawing an extension between what could be seen to what remained unseen; that he preferred to rely on the creative inventiveness of words rather than empirical observation. Willis's metaphorical and analogical reasoning is, according to such readings, little more than an attempt to conceal inadequate empirical foundations while promoting speculative theories.

Lost in Translation? Willis and Samuel Pordage

Drawing on some the key themes set out above, I would like to turn finally to the matter of translation. In keeping with the tradition of the universities, Willis's major works were written and published in Latin, running to numerous editions at home and on the continent in his lifetime and the decades that followed.[155] However, Willis has been most widely read by scholars in English translation: during the 1680s, following Willis's death in 1675, the English poet and playwright Samuel Pordage (1633 – c. 1691) published edited translations of his key texts, commencing with *The Remaining Medical Works of Dr*

[154] A. Pickering, *The Mangle of Practice,* p. 19.
[155] On the extensive publication of various editions of Willis's works after his death see: Frank, 'Willis and his Circle,' p. 6.

Thomas Willis in 1681, which incorporated his tracts on fermentation and fevers alongside his anatomy of the brain. *The Practice of Physick* followed this in 1684, featuring eleven treatises including Willis's *Soul of Brutes* and his last work, published posthumously, *Pharmaceutice Rationalis* (1675). To the extent that the major themes addressed in this thesis rest on assessments of Willis's use of *language*, it is important to consider more closely the role of Pordage in the transmission of Willis's ideas. We might well ask if the issues taken with Willis's 'flowery' and prolix prose style ought properly to be thought of as responses to Pordage's interventions and what significance, if any, this might hold for the arguments I explore here.

As this section will briefly examine, scholarly assessments of Pordage's contribution have tended to be unforgiving and dismissive. Pordage is often cast simply as a 'minor Restoration playwright' who was, due to his education and background, ill-placed to understand the material he was translating and thus made frequent errors.[156] It nevertheless remains the case that Pordage's translations – though mistrusted – have and continue to be used to inform the vast majority of Willis scholarship, which in itself marks out these editions as a significant historical source on Willis. One difficulty that arises here is that Willis – and his translated texts – are often used interchangeably by scholars: Stanley Finger writes, for instance, that 'Willis was an absolute master of flowery language and an innovator of terminology,' but it is unclear which edition these remarks properly refer to.[157]

It would be inaccurate to suggest that accusations of a 'flowery' or embellished style have been the simple result of a reaction against Willis's decision to publish in Latin when his apparently 'scientific' contemporaries were increasingly favouring the vernacular. Willis's decision to publish solely in Latin was not in any way unusual or counter to the practices of his fellow members of the Royal Society (though contemporary criticisms may well have referred to the *kind* of Latin style - scholastic or humanist - he employed).[158] There

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156 Hansruedi Isler, 'The Circle of Willis', in *Neurological Eponyms,* ed. by Peter J. Koehler, George W. Bruyn and John M. S. Pearce (Oxford: Oxford University Press, 2000), pp. 56 – 62 (p. 58).

157 Finger, *Minds Behind the Brain,* p. 91.

158 There is no sense in which natural philosophers of this period rejected Latin and transitioned to the vernacular; Latin remained the language pf publication favoured by universities such as Oxford, though it was also common for booksellers associated with the Royal Society to produce Latin and Vernacular editions of a text: Isabelle Pantin, 'The role of translations in European scientific exchanges in the sixteenth and seventeenth centuries' in *Cultural Translation in Early Modern Europe,* ed. by Peter Burke and R. Po-chia Hisa, (Cambridge: Cambridge University Press, 2007), pp. 163 – 179 (p. 171). The use – or not – of Latin was based more upon considerations of context and audience - on this see: H. Floris Cohen,

was, however, no sense in which experimental philosophers associated with the Society were straightforwardly anti-Latinate; we need only look to how leading writers in the period employed Latin - Hobbes' *Leviathan* being an obvious example. Pierre Gassendi, whom Willis much admired, was said to have written in a 'prolix' Latin while other notable 'scientific' figures from the period – including Boyle and Harvey – all wrote and published in Latin.[159] Willis, like Harvey before him, wrote and published his works as a Professor of Natural Philosophy at Oxford, educated in a traditional scholastic curriculum based upon Aristotelian natural philosophy.[160] His publications are less to do with his identity as a practicing physician, and more to do with his scholarship. Despite the increased popularity of the vernacular, Latin remained the dominant language of the universities, church and government. It was a mark of a particular authority and learning: medical prescriptions, for example, continued to be written in Latin. Publishing in Latin would have denoted Willis's learned medical education as well as pointing to the international significance of his work, which could be circulated among an English and continental community of scholarly readers.[161]

Notably, it is Willis's Latin prose that has been the most praised for being precise and 'straightforward,' suggesting that it is his poet translator who has tended to draw criticism. We should, however, be careful to critique assumptions around the role of a poet-translator here: for those looking to recover and position Willis as a 'scientist' or proto-neurologist it would be convenient indeed to attribute (what are recognised as being) the literary elements and historical 'jargon' of Willis's texts to the intervention of a poet in what was an otherwise empirical work delivered in a 'straightforward' language. In this reading, we assume that where the scientist sought clarity with an economical use of language, the poet intervenes and obscures with his embellishments. It has yet to be argued, however, that Pordage intervened to the extent that he *invented* the elaborate

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'From *Philosophia Naturalis* to Science, From Latin to the Vernacular,' in *Bilingual Europe: Latin and Vernacular Cultures, Examples of Bilingualism and Multilingualism c. 1300-1800,* ed. by Jan Bloemendal, (Leiden: Brill, 2015), pp.144 - 160 (p. 154).

[159] Harvey, for instance, always published in Latin, while also using English to prepare his notes on anatomy: Roger French, *William Harvey's Natural Philosophy* (Cambridge: Cambridge University Press, 1994), p. 25.

[160] Frank, p. 114. On the arts curriculum at Oxford during the late sixteenth and early seventeenth century, see: Andrew Clark, *Register of the University of Oxford,* vol. 2 (1571-1622), part 1 (Oxford: Oxford Historical Society, 1887). See also: Mordechai Feingold, 'The Humanities,' in *Seventeenth century Oxford,* Vol. IV, ed. by Nicholas Tyacke (Clarendon Press, 1997), p. 247-8.

[161] The international centres of the book trade were located in Germanic parts of Europe where Latin remained the standard of scholarly publication: Pantin, 'The role of translations,' *Cultural Translation in Early Modern Europe* (2007), (pp.169-70, p. 177).

metaphorical and analogical explanations of Willis's prose – and is responses to these features that I seek to address.

Who, then, was Willis's translator? During the 1660s, Pordage published a series of poems reflecting an interest in theological, mystical and alchemical themes, chiefly focused on the nature of spirit. His first, *Mundorum explication,* published in 1661, examined the theme of 'External, Internal, and Eternal worlds' commencing with the fall of man. These interests most likely stemmed from Pordage's father, a follower of the German Christian philosopher Jacob Böhme (1575-1624) whose writing incorporated alchemical and mystical themes within a Lutheran tradition. These themes in turn resonated with Willis's own physiological discourse, which drew upon alchemical principles while outlining a broadly Christian framework for his discussion of the soul. The prefatory pages to Pordage's translation of *Practice of Physick* even included his own verses on Willis's 'Medical-Philosophical Discourses,' highlighting the author's knowledge of the 'intricate and hidden cause of things,' the various motions of the elemental bodies in nature and the spirits moved in the human 'frame.'[162]

Pordage was also vocal politically. Although a loyalist and supporter of the established church, he published a satirical Whig pamphlet attacking Charles II's chief minister, the earl of Danby.[163] He presented Willis's works as a fittingly patriotic dedication for his patron, Sir Theophilus Biddulph, who had shown a 'pattern of Loyalty and Religion' during 'these troublesome times' (Willis was himself a notable Royalist and active supporter of the Anglican Church during the Interregnum years at Oxford).[164] The point to be made here is that, as a translator of Willis's natural philosophy, Pordage was not necessarily a disinterested party or one merely seeking financial profit. He was in fact quite capable of bringing his own intellectual interests, political and social ambitions to the task. As Pordage noted, the work of vernacular translation was, in his eyes, a firmly patriotic exercise - a way of serving his fellow countrymen and 'publick' with valuable learning delivered in the 'mother tongue' – valuable, in particular, to a growing body of

[162] Samuel Pordage, 'On the Authors Medical-Philosophical Discourses,' *Dr Willis's Practice of Physick*, ed. and trans. by S. Pordage (London, 1684), pp. 7-8.
[163] Nigel Smith, 'Pordage, Samuel (bap. 1633, d. in or after 1691),' *Oxford Dictionary of National Biography*, (Oxford: Oxford Univeristy Press, 2004), Web. 25 Sept. 2014.
[164] Pordage, 'To the right worshipful Sr Theophilus Biddulph, Knight and Baronet,' *Practice of Physick* (1684), p. 5-6.

practicing physicians for whom accessible versions of Willis's (chiefly chemical) medical learning would have been useful.

The question, however, is whether we can use Pordage's role to significantly inform any assessment of the transmission of Willis's ideas and his scholarly reception. Since the 1950s, the prevailing consensus has been that Pordage's translation ill-served Willis's original text and has, historically, been a barrier to more positive assessments of his contributions. As Sir Charles Symonds suggested, the English translation was technically 'faulty,' but also 'ponderous and ambiguous,' 'tedious and obscure.'[165] It was not simply inaccurate, but a difficult and unpleasant reading experience. More recently, Willis's notable biographer Hansreudi Isler proved similarly dismissive of Pordage when he described him as a 'minor Restoration playwright,' observing that his work was 'far from accurate' and 'a serious source of misunderstandings since researchers of our time regularly mistake Pordage's translation for Willis's original'.[166] Isler gave no examples of these inaccuracies or an assessment of the impact they were thought to have had on the overall sense and meaning of Willis's work. It is seemingly enough for these scholars to simply note the unreliability of the translator, while also continuing to rely on his work.

Alfred Meyer and Raymond Hierons – notable neuro-physicians who published prominent works on Willis in the 1960s - were clear in their judgement that the more objectionable elements of Willis's text were a product of the poet's intervention. They noted with some the regret the lack of a modern translation of Willis's 'direct and unpretentious Latin diction other than the rather flowery language of Pordage who was a poet.'[167] The undercurrent to these remarks is the assumption that the nature of Pordage's impact must have been, by dint of his literary background, one of embellishment, where science would call for clarity. Yet, as Jonathan Sawday has well explored, the suggestion of any firm distinction between literature and 'science' is an anachronism in these discussions. Poets and anatomists in this period would have recognised significant areas of overlap in their respective projects to examine human nature, drawing upon a shared discourse.[168] For many more recent scholars, Pordage's suitability – as a poet and playwright – to act as a mediator of Willis's 'science' continues

[165] C. Symonds, 'The Circle of Willis' (1955), p. 119; *Notes and Records* (1960), p. 94.
[166] Hansruedi Isler, 'The Circle of Willis', *Neurological Eponyms* (2000), chapter 9.
[167] Raymond Hierons and Alfred Meyer, 'Review of the Tercentenary edition,' *Proceedings of the Royal Society,* Vol. 60 (March, 1967), p. 314.
[168] Jonathan Sawday, *The Body Emblazoned,* (1995), p. ix.

to exercise concern. Clifford F. Rose's *History of British Neurology* from 2012 notes that, though Willis wrote in a 'straightforward' Latin, his translator is generally regarded as unreliable, being clearly 'uninformed' on the subject matter and an 'unsuccessful Restoration playwright.'[169]

Criticisms of Pordage have notably tended to be concerned above all with whether Pordage was sufficiently equipped to translate *scientific* terms from the Latin to English, rather than with broader questions of whether he misrepresented Willis's ideas, metaphors or concepts. They are specifically concerned, that is, with his rendering of anatomical and medical terminology. Tellingly, Meyer and Hierons observed that Willis's most ardent modern critics tended to be 'anatomists,' while his admirers were more likely to be 'historians, clinicians, psychologists and philosophers.'[170] In a 2003 article on Willis's impact in the journal *Paediatrics*, A. N. Williams notes that Pordage's edition was 'incomplete' in that it missed out important patient cases.[171] Even where the English text is defended, it is on the grounds of its anatomical worth: in 2003, M. J. Eadie noted that 'at least in relation to the *Cerebri Anatome,* the general competence of Pordage's translation has been acknowledged.'[172] Zoltan Molnar commented in 2004, 'Pordage had no medical training and probably did not understand much of the text…Nevertheless, some parts of his translation of *Cerebri Anatome* could almost be used today as a standard anatomy text.'[173] Tellingly, the intellectual themes which tie Pordage to Willis (alchemical, mystical, physiological) fail to align with what modern scholarship has tended to value above all in Willis's work: his anatomical and medical expertise. From this rather narrow and present-centred perspective, Pordage can only muddy what is sought in Willis's work.

Part of this anatomical focus also picks up on notions around the unsuitability of English vernacular as a medium for rendering early modern anatomical and medical discourse. Latin had been and remained the technical language of anatomy when Willis was writing: most existing concepts and terms had no obvious correlate in the far more restricted vocabulary of English vernacular. As Roger French notes of Harvey, 'when dealing with

169 Clifford Rose, *The History of British Neurology* (2012), p. 27.
170 Meyer and Heirons, 'On Thomas Willis's concepts of neurophysiology,' part II, p. 151.
171 A. N. Williams, 'Thomas Willis's Practice of Paediatric Neurology and Neurodisability', *Journal of the History of the Neurosciences,* 12. 4 (2003), pp. 350-367 (p. 354).
172 Eadie, *Pathology of the Animal Spirits,* Part 1, p. 15.
173 Z. Molnar, 'Thomas Willis: Founder of Clinical Neuroscience', *Nature Reviews: Neuroscience*, 5 (Apr., 2004), pp. 329-335 (p. 333).

technical aspects of anatomy he used only Latin' because of its vast vocabulary as opposed to the scant provisions of the English language. Moreover, because the study of anatomy was built upon a traditional education in natural philosophy, it was 'best expressed in Latin.'[174] French comments that the Latin of natural philosophy 'bristled with technical terms, the resonances of which were the intellectual world and authority within.'[175] When we examine the content of Willis's writing, it is apparent that the reader he envisaged was required to be conversant in the more technical aspects of natural philosophical discourse, which would have required a certain grasp of this expansive Latin vocabulary. As a mere poet and playwright, Pordage probably lacked the education required to navigate these pitfalls. As John Henry notes, Willis's works displayed a 'level of technicality' that would have excluded most readers beyond his own professional circles.[176]

Pordage's intervention was, of course, aimed at making Willis accessible to the 'vulgar' and unlearned 'publick' – for whom he even included a glossary of Latin and Greek terms, pointing to the challenge faced by the common English reader. There is a sense that Pordage's efforts here have seen him pitted against long-standing ideas both about what Willis's contributions are (anatomical learning) and what that discourse *ought* to be: technical, precise, learned. This is also, then, about authority - Pordage's authority to speak on matters of medical learning. While the general consensus is that the translations are not to be trusted, suggesting a desire to get at the 'truth' of Willis, there is an attendant lack of critical reflection on the nature of what is that might mean in this setting. Why are we so concerned with terminological exactness as opposed to how Pordage might have conveyed the meaning and sense of Willis's physiological explanations, or with how he represented his metaphorical arguments? Judgements as to the value of Pordage's editions are hard to separate from these broader issues. These emphases are, of course, a representation of how we see *Willis,* not Pordage.

It is difficult to unpick whether suggestions of terminological inaccuracy (imposed by Pordage) might also have intersected with issues properly relating to Willis's own writing practices: for instance, it is possible to suggest that Willis's widely noted practice of

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174 Roger French, *William Harvey's Natural Philosophy*, p. 33.
175 French, *William Harvey,* p. 31.
176 John Henry, 'The Matter of Souls, Medical Theory and Theology in Seventeenth century England', in *The Medical Revolution of the Seventeenth century*, ed. by Roger French and Andrew Wear (Cambridge: Cambridge University Press, 1989), pp. 87-113 (pp. 93-4).

appropriating new terms across disciplinary boundaries (often via metaphor) could have come to be read as evidence of the translator's own error or misreading. Did the translator misapply a term, or had Willis *inverted* a commonly established use? Wes Wallace, writing in 2003, argued for instance that what has often been deemed Willis's 'fanciful style' is perhaps an impression 'due in part to unfamiliarity with his chemical vocabulary, which departed from the common usage of his time.'[177] Here, Wallace draws on Michael Foster's rather pointed remarks that Willis 'caught up the phrases of his friends, Boyle and others, without understanding them' – the implied criticism being that the language used is *borrowed,* appropriated without understanding, and is therefore jarring and obscure.[178] Yet, as chapter two of this thesis explores, and as Wallace also argues, Willis's chemical writing was no 'mistake' or simple matter of misappropriated terminology, but a deliberate attempt to forge new kinds of physiological explanation. [179]

A final strand to these discussions, forwarded in the early 1960s by Charles Symonds (since left unchallenged), is that the equivocal nature of Willis's historical position, especially in English scholarship, stems from the poor quality of Pordage's work. As he noted, 'On the Continent, where he was read in the original Latin, the true worth of Willis was earlier appreciated, and his influence probably greater, than in his own country.'[180] This argument ultimately overlooks how the intellectual and philosophical climate among continental audiences might have actively impacted on how Willis's ideas were read and received. It is a position that assumes that the original Latin granted a direct and unproblematic access to Willis's 'true' ideas, from which more favourable assessments inevitably followed; it in turn explains away his English critics as being simply ill-informed, which overlooks the possibility of fundamental objections to what was being proposed by the author. This deceptively neat explanation further neglects the fact that the Latin original of *Cerebri anatome* had been widely reproduced and circulated in England *before* Pordage undertook his translations in the 1680s. Much of the criticisms aimed at Willis's work by his learned contemporaries, such as Walter Charleton, would have been based on reading the Latin.

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[177] Wes Wallace, 'The Vibrating Nerve Impulse in Newton, Willis and Gassendi: First Steps in a Mechanical Theory of Communication,' *Brain and Cognition,* 51 (2003), pp. 66-94 (p. 75)
[178] Michael Foster, *Lectures* (1901), p. 275.
[179] W. Wallace *Vibrating Nerve Impulse* (2003), p. 75.
[180] Symonds, *Notes and Records* (1960), p. 97.

With these issues in mind, how should we approach Pordage when studying Willis? As with the majority of scholars working on these texts, I primarily quote in this thesis from the English edition whilst checking key terms and passages against the Latin. However, I also want to actively defend here the value and usefulness of the English edition as a historical source on Willis. The scholars and retired neuroscientists - who today produce the majority of writing about Willis - assess his historical contributions based on this English edition. We should be cautious, then, of regarding the Latin text as 'authoritative' simply because it is the original (this requires a more extensive discussion of how we recover a 'true' authorial intent from historical sources, which lies somewhat beyond the scope of this thesis). Above all, if we are to evaluate Willis as a historical figure in the history of neuroscience, the English edition must be taken as a primary point of reference.

One's view on the value of the English translation also largely depends on how we choose to approach Willis: if we are interested only in mining his works for his anatomical and medical relevance, then the issue of Latin terminology and its rendering in early modern English vernacular presents a specific set of challenges. If, however, as historians of science and medicine, we want to look at Willis as a natural philosopher (rather than as an anatomist or proto-neurologist) then the English text, while still presenting difficulties, does not present the same set of problems. It is notable that among all the criticism, there is little to suggest the view that Pordage's errors amount to a substantial alteration in the sense and meaning of Willis's arguments or explanations. In the tercentenary edition of *Cerebri anatome,* Dr Lloyd Stevenson contributed a bibliographic assessment which, although noting the difficulties arising from trying to find appropriate equivalents when it came to 'new scientific terms,' nevertheless concluded that Willis was 'well served by his translator.'[181]

Most notably, Willis's 'most ardent critic' Michael Foster commissioned his own translation of the Latin text and yet held firm to his core criticisms.[182] The issues which concerned him rested with what Willis said and *how* he said it - using inappropriately

[181] L. G. Stevenson, 'A Note on Pordage's Translation', in *The Anatomy of The Brain and Nerves*, ed. by William Feindel, (Montreal: McGill University Press, 1965), pp. 61–65. On these discussions see: K. D. Keele, "Thomas Willis on the Brain The Anatomy of the Brain and Nerves, by Thomas Willis, tercentenary edition (1664–1964) edited by William Feindel. Montreal, McGill University Press, 1965, 2 vols.," *Medical history,* 11.02 (1967), pp. 194-200 (p. 194).
[182] Meyer and Hierons, 'On Thomas Willis's concepts,' Part II, p. 151.

metaphorical and 'speculative,' analogical reasoning. These features are not the product of Pordage's particular intervention. Clearly, especially when dealing with metaphors, the use of an alternate object could have considerable implications for the overall sense and meaning of what is being described; my point here is that this is not what criticisms of the English translation have been concerned with. Certainly, I have found no mention concerning inconsistencies between the metaphorical imagery and sense of Willis's (mostly physiological) explanations – the issue here is more that these aspects of Willis's work are altogether overlooked and disregarded.

I would argue that, ultimately, Willis's equivocal position within historical scholarship is not reducible to a straightforward matter of mistranslation, something to be overturned by an appeal to the authority of the 'original' text. As this thesis argues, the issues surrounding Willis run much deeper than this: they significantly rest with his discourse on the soul and with his apparently troubling use of metaphors to transgress certain boundaries in producing that account. It is Willis's metaphors and analogies - and the suspicions they arouse within science - rather than his anatomical discoveries and terminology that inform the specific discussions I seek to address here. The very question of Pordage's 'accuracy' is also skewed in this context by a medicalised focus on Willis's text. This concern speaks more to our *uses* of Willis than to issues of translation. Of course Pordage's version should be read with care and attention; all works of translation are imperfect acts of linguistic negotiation. It is, however, important to critique suggestions that Pordage's text is straightforwardly 'unreliable', especially as we continue to base so much of Willis scholarship on it. These themes have generally been neglected in scholarship on Willis, besides the issuing of caveats concerning reliance on the English edition. There is clearly a need to reflect further on these matters, even though their resolution – which would require a dedicated comparison of the two texts - lies outside the scope of this thesis.

Chapter summaries

Chapter one examines seventeenth century attitudes towards metaphor and analogy in the context of natural philosophical inquiry in England during the 1600s. It will consider that Willis's use of these devices was indeed compatible with the conventions acknowledged at the time, comparing his strategies with other leading figures such as

William Harvey, Walter Charleton and Robert Boyle. It will argue that the idea of a plain and direct use of language in science emerges through the specific rhetoric of the early Royal Society; this was also a political rhetoric, espousing a set of ideals that were not necessarily intended for practice.

Chapter two examines Willis's chemical discourse around fermentation in his first publication, *Diatribae Duae* (1659). It focuses on his use of an important, structuring chemical analogy for the medical spirits of the body, as well as his casting of the brain as a chemical 'alembic'. This last metaphor is tied into his later representations of the brain as the exclusive seat of the animal spirits of the corporeal soul. These chemical analogies were important in helping Willis to import far more familiar terms, categories and practices from the chemical laboratory into the new medical and anatomical setting in which he produced his *Anatomy of the Brain.*

Chapter three deals with Willis's famous work *Cerebri anatome*, and specifically with his new dissection method. It considers how Willis used the claims of his methodology to lay an important foundation for his alternative, physiological model of the soul. In this way, the chapter challenges the view that his methodological changes were the result of an inevitable progression towards more accurate or 'realistic' ways of investigating and representing the brain as an empirical object. It also explores the rhetorical nature of Willis's representation of a naturalistic and unmediated presentation of the brain, intended to embody a specific notion of 'objectivity' as it related to this period.

Chapter four continues to look at Willis's anatomy of the brain, considering in more detail the structural, architectural, and mechanistic metaphors and analogies he used to further his physiological theories in conjunction with anatomical explanations. It considers how these images were used to support broader claims about the role and function of the brain, especially Willis's new ideas around localisation and the involuntary nervous system.

Lastly, Chapter five addresses Willis's physiology and pathology of the corporeal soul in *De Anima Brutorum* (1672). It examines, for instance, his images of the vital flame in the blood and of the passions of the soul as tempests and storms. It also considers how

Willis used certain metaphors and analogies in his discourse on the passions in order to address the political climate of the civil war and the Restoration.

Chapter one

New Inventions by Old Words: Metaphor, Analogy and Rhetoric in the Seventeenth century.

The possibility of achieving an objective and neutral use of language is central to modern science. It draws upon the notion of an entrenched binary opposition between 'scientific' and 'literary' modes of speaking about and representing the world in text. The former denotes a literal use of language for the purposes of instruction, whereas the latter signifies meaning and uses symbolic representations; it ornaments and embellishes. Bound up within these ideas is a particular suspicion of the work of figurative language and the devices of metaphors, analogy, and simile. While they are accepted as useful tools of communication, they are not generally accepted as having any creative or constitutive role to play in scientific discovery and invention. The over-arching argument of this chapter is that these ideas – of the *virtue* of restricting and excluding metaphors from the realm of scientific knowledge - are historically and culturally rooted, rather than universal and ahistorical. Importantly, while the functions of similarity and comparison (which are at the centre of metaphor and analogy) are widely acknowledged, the meanings that are attached to these categories and the roles we ascribe to them are certainly not stable. Quite the opposite: ideas around what constitutes a 'right' or 'wrong' way to employ such devices have been the subject of historical change. As Dedre Gentner and Michael Jeziorski have noted, analogizing is never absent from scientific discourse; what is to be examined, rather, are the conditions under which the applications of analogy have been considered 'scientific', historically. [1]

This chapter examines seventeenth century ideas about what would constitute an appropriate use of metaphor and analogy. The ideal of a 'scientific' way of using these devices, as 'tools' rather than 'ornaments', traces its historical roots to the debates that accompanied the rejection of scholasticism and humanism and the rise of the 'new sciences' between the sixteenth and seventeenth centuries. As a number of leading historians of science have noted, the distinction between what counted as 'knowledge'

[1] Dedre Gentner and Michael Jeziorski, 'The shift from metaphor to analogy in western science', in *Metaphor and Thought*, ed. by A. Ortony (Cambridge: Cambridge University Press, 1993), pp. 447-480.

and 'opinion' was radically reformulated after the 1660s.[2] This reformulation was significantly bound up in ideas about the relationship between words and things – that is to say, the ability of words to directly represent the true nature of things, rather than acting as a veil or mist to the understanding, came under particular scrutiny. Traditional historiographical accounts of this period have emphasised experimental philosophy's complete rejection of rhetorical excess and ornamentation, which had sullied the work of preceding philosophies, as a means of attesting to its successful reform of language.[3] This is most notably represented through the 'plain' style advocated by leading figures of the early Royal Society in England (of which Willis was a founding member). The Society's efforts in this matter are often lauded as laying the foundations of modern science.[4] However, more recent scholarship has questioned this view, proposing that the narrow focus on the activities of the leading protagonists of reform overlooks a range of alternative approaches and views on the matter. As historian of rhetoric, Brian Vickers, among others, has noted of Richard Jones' famous work on English prose style, it was assumed that the 'plain style' was 'reflected in the scientific writings of its members,' while the concessions of important figures, including Robert Boyle and Robert Hooke, have been overlooked by such assessments.[5] Moreover, the notion of an outright hostility to metaphor and rhetoric within this group has been widely overstated.[6] The predominant focus on the activities of the Royal Society's members and the presumed fact of linguistic reform is more an affirmation of present-day values in science than an accurate reflection of historical practices.

Moving away from a focus on an absolute opposition to rhetorical devices, a number of modern scholars have pointed to this period as one in which a 'scientific' use of analogy

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[2] Steven Shapin, 'Pump and Circumstance: Robert Boyle's Literary Technology', *Social Studies of Science,* 14.4 (Nov., 1984), pp. 481-520; Ian Hacking, *The Emergence of Probability* (Cambridge: Cambridge University Press, 1975, 2006), Ch. 3 and 5; Barbara Shapiro, *Probability and Certainty in Seventeenth century England* (Princeton, N.J.: Princeton University Press, 1983), Ch. 2.

[3] The seminal text in this regard is Robert F. Jones's, 'Science and English Prose Style in the Third Quarter of the Seventeenth Century,' *PMLA,* 45.4 (Dec., 1930), pp. 977-1009. For an early objection to this view, see: Robert Adolph, *The Rise of Modern Prose Style* (Cambridge, Mass.: MIT Press, 1968).

[4] Robert Jones, 'Science and English Prose Style,' (1930), pp. 977-1009.

[5] Brian Vickers notes that Hooke, Boyle and Henry Power were 'tacitly taken as supporting his thesis': 'The Royal Society and English Prose Style: A Reassessment', in *Rhetoric and the Pursuit of Truth: Language Change in the Seventeenth and Eighteenth Centuries*, ed. by Vickers and Struever (Los Angeles, California: University of California Press, 1985), pp. 3-76 (p. 17); Jones, *Prose Style,* p. 88.

[6] Ryan J. Stark, 'From Mysticism to Skepticism: Stylistic Reform in Seventeenth century British Philosophy and Rhetoric,' *Philosophy and Rhetoric*, 34. 4 (2001), pp. 322–334 (p. 20); Clive Sutton, 'Nullius in Verba' and 'Nihil in Verbis': Public Understanding of the Role of Language in Science,' *The British Journal for the History of Science,* 27.1 (Mar., 1994), pp. 55-64 (p. 59); Michael Lynch, *Solomon's Child: method in the early Royal Society of London* (Stanford: Stanford University Press, 2002), pp. 152-3.

was first proposed, chiefly in the conventions set out in the work of Robert Boyle. Vickers argued, in 1984, that modern western culture witnessed a shift away from 'occult' notions of identity when thinking about the relationships held between objects in reality and the words used to denote them to a 'scientific' use of analogy – whereby words were distinct from the objects they described, but nevertheless bore the capacity to illustrate relationships between objects themselves.[7] In 1993, Dedre Gentner and Michael Jeziorski argued that the period marking the advent of modern science witnessed a shift away from metaphor to the use of analogy.[8] However, metaphorical language continued to be employed to notable effect in the works of leading figures of the new sciences. As this chapter will outline, experimental philosophers faced a difficult tension in their work: while it was widely recognised that metaphor and analogy could mislead and obscure truth, it was equally acknowledged that such devices were a vital means of furnishing understanding – of making new or difficult phenomena intelligible. While language needed to be reformed by being restricted and reduced, according to the anti-rhetoric stance of the Royal Society, making sense of new discoveries required its expansion. Clearly, then, the issue here is how notions around 'appropriate' uses have been variously asserted and contested, rather than any meaningful expectation of their expulsion. This chapter will not ask whether early modern writers employed figurative devices: they did, to great effect.[9] It will instead consider the ideas seventeenth century natural philosophers had about *how* such devices were to be used, under what conditions and to which ends.

As this thesis concerns Willis's use (or indeed, alleged misuse) of the rhetorical tropes of metaphor and analogy, it is important to begin by establishing what was meant by these terms in the seventeenth century. As I traced out in the introduction to this thesis, ideas around modern science's rejection or suspicion of figurative language have had an impact upon Willis's historiographical position. It is important, then, to consider how his practices compared to those of his close contemporaries and to the standards of the time. The chapter will deal, firstly, with how these devices operated within the classical model of rhetoric – that is, as they applied to the categories of *inventio, elocutio* and

[7] Brian Vickers, 'Analogy versus identity: The rejection of occult symbolism, 1580-1680', in *Occult and scientific mentalities in the Renaissance,* ed. by Vickers (Cambridge: Cambridge University Press, 1984), pp. 95-164.
[8] Gentner and Jeziorski, 'From Metaphor to Analogy,' (1993).
[9] Vickers observed that 'you cannot distinguish anyone from anyone in mid-seventeenth century prose if the use or non-use of metaphor is your criterion, since *everyone used metaphor*,' *Rhetoric and Truth*, p.21.

dispositio.[10] It will then address how the function of rhetoric in relation to the natural sciences came to be restricted and reformulated, over the course of the sixteenth and seventeenth centuries. It will propose that – when situated within his proper historical context – Willis's use of language was neither exceptional nor any less 'scientific' than the practices of other leading figures from the same period. Figurative language was an indispensible tool of both Willis's and his contemporaries' ways of conceiving of and representing their discoveries. How the specific analogies and metaphors used by Willis informed or related to his intellectual concepts and practices will form the focus of subsequent chapters; what I look to sketch out here is a contemporary context in which to situate his practices.

Aristotle and the "Art" of Rhetoric

Before examining the classical model of rhetoric, it is worth noting that from the sixteenth century it was possible to take the 'art' of rhetoric as applying both to speech and written modes of argument. In 1589, English rhetorician George Puttenham, for example, referred to a 'good utterance, be it by mouth or writing.'[11]As Quentin Skinner has noted, the metaphorical presentation of writing as a form of speech – where the text 'speaks' on a subject – emerged in this period and remains with us today.[12] It is therefore a model that also applies to written texts of natural philosophy, which are the focus of this work. The role and application of rhetoric was a significant, and much contested, feature of experimental philosophy's engagement with the written conventions of its enterprise. The classical model of rhetoric is rooted in Aristotle's *The Art of Rhetoric,* which was taken up in the writings of the Roman rhetoricians and widely studied by sixteenth-century humanists.[13] Aristotle classified rhetoric as an 'art' – meaning that is was a system by which the rhetorician constructed and delivered a persuasive argument or speech rather than a science, which deals with the 'nature of any definite subject.'[14] Rhetoric is here defined as 'the faculty of discovering the possible means of persuasion'

[10] On the distinction between modern understandings of rhetoric as a literary strategy and Renaissance models see: Quentin Skinner, Introduction, *Reason and Rhetoric in the Philosophy of Hobbes* (Cambridge: Cambridge University Press, 1996), pp. 1-18.
[11] George Puttenham, *The Arte of English Poesie. Contrived into three Bookes: The first of Poets and Poesie, the second of Proportion, the third of Ornament* (1589), ed. by G. Willcock and A. Walker (Cambridge: Cambridge University Press, 1970), p. 155.
[12] Skinner, *Reason and Rhetoric,* p. 109.
[13] Skinner notes that, of the three, *inventio* was the most intensely discussed, p. 46.
[14] Aristotle, *The "Art" of Rhetoric,* translated by John Henry Freese (London, 1926), Book I, II. 7-8, p. 19. All quotations to this work will refer to this edition and will hereafter use in-text citations.

(I. I. 14-II. 2, p.15). It referred to a method of demonstration, which Aristotle termed a kind of 'rhetorical induction' or syllogism; that is, a mode of argumentation by logical proofs, rather than by the 'matter' of things (I. II. 7-8, p.19). In the classical model of rhetoric, the primary elements were *inventio, dispositio,* and *elocutio*; the first refers to the finding and selection of examples to form the basis of an argument; the second, to the work of ordering and arranging those examples; and the third category, to the means by which the argument is to be put persuasively, by the considered application of words and thoughts.[15] Metaphor and similarity were topics of *elocutio,* as tools of the *style* and presentation of argumentation rather than the basis of its construction.

As we shall see, (aspects of) the art of rhetoric would come to be banished from the natural sciences on the grounds that it sought to inspire confidence on the basis of effective argument, rather than to *inform* on the basis of evidence or matters of 'fact.' It was, as a system of art, concerned with the arrangement of words, not with representing content. The orator's skill and performance, moreover, stood in the way of any direct engagement with the knowledge of 'things.' Even more disconcerting were Aristotle's views on the orator's necessary ability to work on and rouse the passions – rhetoric is, in the first instance, an appeal to the imagination, which leads (and potentially misleads) the more important work of reason (I. II. 3-7, p.17). This appeal to the passions is of course where metaphor and analogy played a key role, in their ability to arouse the delight and attention of the listener. Notably, Aristotle chiefly discussed the work of metaphor in his *Poetics* and *The Art of Rhetoric,* while excluding it from his discussion of logic. He defined metaphor in his *Poetics* as,

> The application of an alien name by transference either from genus to species, or from species to genus, or from species to species, or by analogy, that is, proportion.[16]

This transference of an 'alien name' had to observe certain rules, chiefly in adhering to the principle of similarity. He notes that in a metaphor, the replacement or substitution of an object must bear an analogous relationship to the one it is replacing: analogy therefore underpins the work of metaphor. Metaphors based on analogy were, he notes, the most 'popular' and thereby more successful (III. X. 5-7, p.399). Aristotle regarded

[15] *Ibid.*
[16] Aristotle, *Poetics,* part XXI, p. 34.

simile, an explicit form of comparison, as another version of metaphor differing in the form of expression. These devices both worked to cast existing objects in new and, crucially, *unusual* terms in order to aide comprehension but also to make a more striking, memorable and convincing argument. Aristotle viewed the function of metaphor as using existing knowledge to support new learning, as he notes, 'we must give names to things that have none by deriving the metaphor from what is akin and of the same kind' (III. II. 12-13, p.359). Quintilian similarly defined a trope (metaphor) as the 'turning of speech', where sense or meaning of a word was transferred to heightened effect. A figure involved, on the other hand, an unusual or surprising configuration (analogy) – putting the familiar in unfamiliar terms.[17]

The work of learning was, Aristotle claimed, heightened by the specific effect of novelty or strangeness entailed in metaphor. Metaphor, he noted, 'is a kind of enigma,' in that its meaning is not obvious and requires unlocking, such that 'it is clear that the transference is clever' (III.II. 12-13, p.359). Part of the later objections to the use of rhetorical tropes would rest on this sense of deliberate word play and linguistic misdirection. Furthermore, Aristotle outlined an explicit appeal by metaphor to the work of the senses and the imagination; fallible aspects of the human mind, popularly thought capable of overriding or misleading the more important work of reason and the will.[18] As Aristotle directed, metaphor should be derived from what is beautiful, 'the beauty of a word consisting…in its sound or sense.' The selection of the substituted terms or names was important here, as some words are 'better suited to putting the matter before the eyes,' and should appeal either in sound, sight 'or to some other sense' (III.II. 12-13, p.359). Metaphor, then, acts as a kind of word-picture for the mind, by playing on the images of sense (held in memory) to invoke new visual presentations in the imagination by the work of transference. This is where the need for *similarity* at the heart of metaphor originates – the metaphor descends into gibberish if the object is not in some way familiar and conceivable, so metaphors necessarily work to re-present existing knowledge in the mind (memory-images). While familiarity supports comprehension, the strangeness or the 'foreign air' affected by meaning-transfer in metaphor or by unusual configuration in analogy provokes stronger and more striking images in the imagination.

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[17] Quintillian, (1920-2), VIII. VI. 1, p. 300; Quoted and discussed by Skinner, (1996), p. 50.

[18] Metaphors used by the rhetorician could make objects appear near and more immediate, making them more likely to be objects of passion, which could unseat reason: Susan James, *Passion and Action: The Emotions in Seventeenth century Philosophy* (Oxford: Oxford University Press, 1997), p. 217.

Aristotle viewed rhetorical tropes as playing a part in achieving the quality or style of 'perspicuity', meaning clarity or transparency. For Aristotle, the pleasant effects of metaphor were not opposed but joined to the work of clarity: he observed, that 'metaphor above all gives perspicuity, pleasure, and a foreign air' (III. II. 7-10, p. 355). By this account, metaphor could enhance learning and work against conceptual obscurity, owing to the striking impression occasioned by its strangeness and the support offered by the use of familiar and easily-pictured objects. This notion of metaphor as an aide to learning was directly undermined, for later writers, by Aristotle's observation that metaphor and similitudes also had a key role to play in ornamenting and amplifying the presentation of argument, as a function of *elocutio* or style. This effect would be achieved by selecting a comparative object from a more elevated domain than the target object (for example, if we were to compare the processes of the animal body to the harmony of celestial motions). Aristotle observed that if 'we wish to ornament our subject, we must derive our metaphor from the better species, under the same genus' (III.II. 7-10, p. 355). A metaphor is not in itself ornamental, as opposed to illustrative, but through the choice and selection of comparative objects the subject in question could indeed be elevated. The metaphorical casting of metaphor as 'adornment' goes to the root of its contested role, as a means of appealing to passions and the senses over reason and judgement.

Of course, this does not mean that Aristotle did not also advocate certain restrictions or limitations in the use of metaphor. He also directed that, while 'it is a metaphor above all that gives perspicuity,' the metaphor must also be 'appropriate,' which is ensured by 'due proportion' (III.II. 7-10, p. 355). Proportion was achieved both in terms of not using metaphor too often and in being careful with the selection of objects (III. III. 3-4, p. 365). This was intended to act as a means of distinguishing between the metaphors of prose and poetry: it was fine to illustrate by metaphor, but those that were too 'far-fetched' became poetical and obscure (III. V. 6-VI. 4, p. 375). Metaphors, then, achieve clarity of understanding by being both familiar and strangely put (displaced), pleasurable and proportional. Notably, both the language of perspicuity (as visual clarity) and proportionality (as a mathematical notion of economy) would be key features of discussions around a new 'plain' style for experimental writing in the seventeenth century. As we shall see, the question of whether natural philosophers could still utilise

the pleasurable effects of metaphor whilst ultimately taming and disciplining their potential for obscurity, was an important tension in these later debates.

Francis Bacon and the rhetorical invention of science

During the sixteenth-century, the concept of rhetoric became increasingly associated with the categories of *elocutio* and *memoria.*[19] Despite the continuing centrality of training in classical rhetoric to the arts curriculum at universities such as Oxford, polemical arguments were nevertheless being forwarded by humanist scholars against the perceived abuses of language under medieval, scholastic Latin and its proposed detriment to the 'true sense' of words.[20] In the context of discourses on the new learning, advocates of the plain style proposed a reorientation of the work of rhetorical devices to the matter of style (*elocutio*) - but did not in any straightforward sense seek to banish rhetoric from their natural philosophical writing, aware as they were of its potentially beneficial effects.[21] George Puttenham, writing in 1569, retained the Aristotelian definition of metaphor as the 'figure of *transport*' by which features from a 'readily accessible object' are transferred onto another, 'less readily grasped object' and continued to emphasise their work in producing comprehension, so that 'every man can easily conceive the meaning' of the latter.[22] However, Puttenham was also typically expressive of the prevailing sense of mistrust and suspicion associated with metaphors, noting that, while necessary, they were devices that could mislead and ill-inform:

> But if for lacke of naturall and proper terme or worde we take another, neither naturall nor proper and do untruly applie it to the thing which we would seeme to expresse […] it is not then spoken by this figure *Metaphore* or of *inuersion* as before but by plaine abuse.[23]

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[19] On the sixteenth-century re-engagement with rhetoric, and moves towards a restriction of its scope, see Quentin Skinner (1996). Angus Gowland uses the renewed focus on classical rhetoric in England and Europe during the sixteenth century as a context for his examination of Robert Burton's rhetorical strategies in the *Anatomy of Melancholy*: 'Rhetorical Structure and Function in *The Anatomy of Melancholy*', *Rhetorica: A Journal of the History of Rhetoric,* 19.1 (Winter, 2001), pp. 1-48.

[20] Drawing on arguments forwarded by Vickers (1988), Mordechai Feingold discusses the polemical stance of humanist scholars and the continuing influence of Latin culture and classical rhetoric in university education during this period: 'The Humanities,' in *Seventeenth century Oxford,* Vol. IV, ed. by Nicholas Tyacke (Clarendon Press, 1997), pp. 247-8. On Humanist and Medieval Latin towards the end of the sixteenth century see also: Ann Moss, *Renaissance Truth and the Latin language Turn* (Oxford: Oxford University Press, 2003), p. 4.

[21] Skinner (1996), p. 60; Vickers, *In Defence of Rhetoric* (Oxford: Oxford University Press, 1988), p. 206.

[22] George Puttenham, *The Arte of English Poesie* (1589/1970), p. 4-6.

[23] *Ibid.*, p. 150.

Bad metaphors, then – those that were neither 'naturall nor proper' - were examples of linguistic trickery amounting to an 'abuse' of the natural or proper application of terms.[24] This sense – of the work of *misdirection* achieved by rhetorical tropes and figures - was rooted in an emerging commitment to a literal use of language, or a direct equation of words to 'things' in the world. This was accompanied by a corresponding rejection of words as signs, symbols or portents of hidden meaning and ideas. These significant arguments were most influential through the philosophy of Francis Bacon, in whose work seventeenth century discussions in England around the reform of language in science were very much rooted.[25]

In his *Advancement of Learning* (1605) and *Novum Organum* (1620), Bacon set his programme for a new model of natural philosophy, which would be premised on the 'foundation of experience' and direct observation of nature.[26] This was, then, an explicit rejection of what he considered to be the ancients' preoccupation with the study of words and texts, or of 'eloquence' and the 'copy of speech', rather than the actual substance of matter. Their self-referential practices, he argued, had lead directly to a crisis of faith in the body of accumulated knowledge, by which he refers to the rise of scepticism (*AL*, II, p.222). Bacon argued that the deductive reasoning of Aristotle, based on syllogisms, was founded on notions and only the 'propositions of words' and was therefore unfit for the purposes of science (*NO,* p.19). He argued that words had formerly been employed as 'the tokens and signs of notions,' which had abstracted them from any relationship with the empirical constituents of nature. Instead, words were not to be studied as things in themselves, but to be used as tools for communication. More broadly, this philosophical argument marked a shift away from what has been termed the 'emblematic' medieval world-view, conceived of as a system of signs, symbols and correspondences, where words could act as the signs or portents of hidden meanings about the world.[27] This was to be replaced by a literal use of words, where the substantial nature of the world was to act as foundation of language. Words, in this setting, where to be re-tasked with reflecting content (the substantial stuff of 'things'), rather than ideas.

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[24] B. Shapiro, *Probability and Certainty* (1983), pp. 228-9.
[25] C. A. Patrides and Raymond B. Waddington, *The Age of Milton: Backgrounds to Seventeenth Century Literature* (Manchester: Manchester University Press, 1980), p. 329.
[26] Francis Bacon, *Novum Organum* (1620; 1960 facsimile edition), p. 78; *The Advancement of Learning* (1605), in *Francis Bacon: The Major Works,* ed. by Brian Vickers (Oxford: Oxford University Press, 1996), Book I, p.141. All in-text citations will refer to these editions.
[27] Peter Harrison, *The Bible, Protestantism, and the Rise of Natural Science* (Cambridge: Cambridge University Press, 2001).

Bacon cautioned that language ought to return to its pre-lapsarian role as a means of conveying the true 'nature of things' (*AL,* p.20). The reformed and restricted use of words would be used to embody the new category of a 'matter of fact' - conceived of as empirically defined phenomena, strictly demarcated from opinion or interpretative acts. This marked what is often represented as a 'turning to nature,' where philosophers would form an 'acquaintance with things, not notions' (*NO*, I. xxxvi, p.19). In typically vivid, figurative language Bacon described how men had withdrawn from the study of nature 'by observation and experience,' leaving them to 'tumble' within the confines of their 'own reason and conceits' (*AL*, I, p.147). As Amos Funkenstein has noted of Bacon and his followers, 'their philosophy, so they believed, was not the Scholastic preoccupation with words and definitions, but a *philosophia realis,* a turning to nature itself.'[28]

The rhetorical tropes of metaphor and analogy were a specific disruption of this sense that words could directly reflect content, with their borrowed names and substituted meanings. In contrast to Aristotle, Bacon argued that rhetorical argument (which incorporated the tropes of metaphor and analogy) had no place in natural science, but instead belonged to politics.[29] Bacon considered metaphors especially as *idola fori,* the heresies that resulted from a confused use of language. He attacked the use of rhetorical tropes as one of the 'distempers of learning,' occurring when

> Men begin to hunt more after words than matter; more after the choiceness of phrase...the varying and illustration of their works with tropes and figures, than after the weight of matter. (*Advancement*, I, pp.138-9)

The ornaments and amplifications associated with style or *elocutio* were to be banished: 'as for embellishment of Style, metaphorical Expressions, and studied Eloquence […] they should be wholly rejected' (*AL,* III, p.9). The persuasiveness of argument would, instead, be based upon content: as Bacon noted, the 'substance of matter is better than beauty of words' (*AL*, I, p.140). This rejection of figurative language in favour of a literal use continued to draw on the metaphorical language of plainness, transparency or perspicuity - as opposed to a 'smoke' of obscurity or an adornment. Bacon referred, for instance, to the 'propriety of words and perspicuity of narration' (*AL*, I, p.161). This was, of course,

[28] Amos Funkenstein*, Theology and the Scientific Imagination: From the Middle Ages to the Seventeenth Century* (Princeton, NJ; Princeton University Press, 1986), pp. 28-30.
[29] Heather Graves, *Rhetoric in(to) Science: Style as Invention in Inquiry* (New York: Hampton Press, 2005), p. 53.

itself a particular concern with *style* – albeit a 'plain' one – rooted in a metaphorical model that united visual or optical qualities of transparency and clearness with a conceptual clarity or insight. This is a theme that I will come back to later in the chapter. These ideas around plainness and clarity fed into a necessary reformulation of the experimental text or essay as an extension of experiential observation (as the basis of knowledge): if words could be relied upon to directly represent their objects, then the reader could be afforded the privilege of (indirectly) 'witnessing' the evidence 'demonstrated' by the scientist's own experience.[30]

Importantly, this did not mean that rhetorical tropes were to be rejected outright, or that Bacon himself managed to adhere to these standards when forwarding his own arguments. Brian Vickers has argued that Bacon was not necessarily opposed to eloquence or metaphor, but was concerned more specifically with the inappropriateness of these features in 'collections of data'.[31] Moreover, Bacon asserted his model of reform in opposition to what he saw as the mystical and occultist uses of analogy by the inferior 'sciences' - alchemy, astrology and natural magic. [32] He wrote of the alchemists, that their method 'rests not so much upon evidence of truth proved' but by 'arguments, authorities, similitudes, examples' (*AL,* I, p.141). Pointing to the polemical nature of these discussions, Bacon described how the alchemical philosophers were part of a deliberate attempt to 'to veil over and conceal by enigmatical writings' (*AL*, I, p.143). He further noted that they sought a direct 'confederacy' with the imagination over reason, and were full of 'error' and 'vanity.' He objected, in particular, to the correspondences drawn by astrologers, for instance, in their comparisons of celestial and sub-lunary realms (*AL*, I, p.143). These were tokens of amplification, intended to inflate and cloak natural objects in fanciful notions and ideas. Johannes Kepler (1571-1630) would also later attack analogies that appeared to conflate domains, confusing that which was real (in nature) and that which was only imagined. He noted of Ptolemy that he 'luxuriates in using comparisons in a poetical or rhetorical way, since the things that he compares are not real things in the heavens.'[33] It is the acknowledgment of the essential demarcations between knowledge categories – and a restriction to those of the natural world - that

[30] Shapin, 'Pump and Circumstance', p. 491. See also: Scott Black, 'Boyle's Essay: Genre and the Making of Early Modern Knowledge', in *Making Knowledge in Early Modern Europe: Practices, Objects and Texts, 1400-1800,* ed. by Pamela H. Smith and B. Schmidt (London: University of Chicago Press, 2007), pp. 178-195 (p. 179).
[31] Vickers, *Rhetoric,* p. 11-12.
[32] Ryan Stark, 'From Mysticism to Skepticism,' p. 323.
[33] As quoted by Gentner and Jeziorski, 'From Metaphor to Analogy', p. 473.

determines whether the analogy could be considered to be purely ornamental or something capable of illustrating the substantial nature of things. This would be a prominent feature of later schemes of 'controlling' analogies.

This was an important opposition to have established; it allowed Bacon to assert his *right* use of analogy and metaphor over others, which thereby allowed him to retain their effects as a means for furthering his own arguments. In a typical caveat to his anti-rhetoric arguments, he proposed that elocution was not to be 'hastily condemned' as it was still necessary to 'clothe and adorn obscurity even of philosophy itself with sensible and plausible elocution' (*AL*, I, p.139). It was not, then, the use of these tropes so much as their excess: as Bacon reminds us, 'but the excess of this is justly contemptible' (*AL*, I, p.140). Indeed, even within philosophy, the demands set by comprehending and communicating what was new and obscure would require a continuing role for similitudes. Whilst metaphor and 'occult' analogies continued to be excluded from methodological or observational testimonies, Bacon did propose a vital (yet clearly defined) role for analogy in the 'rhetorical invention' of science: communicating new discoveries or in reflecting on new findings. It is worth noting that, in these considerations, Bacon paid greater attention to analogies, which although implicated in metaphor, were less ambiguous in their explicit work of comparison – and were conventionally demarcated in the text with the prefix 'like' or 'as it were.' Early modern writers were more concerned over the 'hidden' and misleading work of metaphor.

In Book II of *The Advancement of Learning*, 'The Art of Elocution', Bacon advocated a specific role for analogy.[34] Here, Bacon distinguished between the twofold work of invention in science: this was to be separated into 'true invention', concerning the creation of new facts by experience and experiment, and 'rhetorical invention' conceived as the work of speech and argument.[35] The invention of speech was properly speaking 'no invention' but an act to 'recover or resummon' existing knowledge to make use of the new - a remembrance with application, with the end being the 'readiness' of knowledge (*AL*, II, p.219-222). This re-application of existing knowledge necessarily

[34] Heather Graves notes that Bacon retained 'key elements' of the rhetorical category, such as metaphor and analogy, as part of his concept of 'true' invention in science, *Rhetoric in(to) Science,* (2005), p.59.
[35] On Bacon's distinction between the invention of speech and the rhetorical invention of science, see: Graves (2005), pp. 51-59. See also, Richard Nate, 'Rhetoric in the Early Royal Society', in *Rhetorica Movet: Studies in Historical and Modern Rhetoric in Honour of Heinrich F. Plett,* ed. by Peter L. Oesterreich and Thomas O Sloane (Leiden; Boston, Mass.: Brill Academic Publishers, 1999), pp. 215-232 (p.217-18).

employed analogy and drew on the stylistic work of metaphor. Rhetorical invention was ultimately required to make 'true' invention both *known* and *intelligible*. This went beyond the mere recovery of existing knowledge; analogy and metaphor were indispensible tools in knowledge-creation. As Bacon himself observed, chiefly in respect of analogy, 'there is no proceeding in invention of knowledge but by similitude.'[36]

Moreover, in the case of new or hidden objects, the writer faced a difficult task in adhering to the standards of 'demonstration' (as opposed to figurative argument), as Bacon observed: 'those whose conceits are beyond popular opinions, have a double labour; the one to make themselves conceived, and the other to prove and demonstrate; so that it is of necessity with them to have recourse to similitudes and translations to express themselves' (*AL,* II, p.236). The problem was not fundamentally with the use of such devices, but with their corruption. As Bacon suggested, when the world had been genuinely new and unknown the ancients had relied upon analogy. In these times, similitudes were not used 'for shadowing and concealing the meaning' but simply and directly as a means to make it understood.[37] The new philosophy could, its followers would claim, renew this original use. Bacon was nevertheless somewhat equivocal on the matter. He cautioned that analogies should be used with discretion and only in the 'absence of proper instances'. Yet, he also maintained that 'they are also of great use even when proper instances are available, because they can confirm what we learn from the proper instances.'[38]

A form of managed compromise could be reached, however, if the analogy could be shown to draw on existing, proven objects of nature, then the work of the imagination could be 'disciplined' by being tied to a solid foundation and to those images already located in memory. Hence Bacon's stress on *plausible* elocution: such analogies would, after all, remain grounded in the matter of 'things.' This possibility of a 'managed' or controlled use of analogies within natural philosophy is something that members of the Royal Society would later come to draw upon and assert in their own writing. Bacon's equivocal views point to the inherent tensions within the larger project. As Brian Vickers, Barbara Shapiro and Heather Graves have noted, Bacon never intended to fully eradicate

[36] *The Works of Francis Bacon,* ed. by James Spedding and others, 14 vols., (Cambridge: Cambridge University Press, 2011), Vol. 3, p. 218.
[37] Francis Bacon, 'Of the limits and ends of knowledge', *Valerius Termius: of the Interpretation of Nature* (1603) (Longman: London, 1857), Preface.
[38] *Ibid.,* Book II, pp. 26-43, 42.

rhetorical devices, but to assert his *appropriate* use of those features. He also employed detailed and extensive metaphors and analogies in his own writing.[39] The difficulty of course would lie in managing and continually reasserting the difference between figurative language as a tool of illustration and as unnecessary ornamentation. The quest to retain the uses of metaphor and analogy while at the same time asserting strategies of control was an important element of the debates being had among Willis's more immediate contemporaries in the seventeenth century.[40]

The institutional context: the early Royal Society

Although Bacon's views should not be directly equated with the experimental philosophies that emerged during the second half of the seventeenth century, his ideas certainly formed an important basis for their development. The anti-rhetoric stance of Bacon was taken up by the public proponents of the early Royal Society in England – established in 1660, the Society emerged out of the activities of a group of experimental philosophers associated with the 'Oxford Philosophical Clubbe,' of which Willis had been a leading member.[41] Leading members of the early Royal Society, Thomas Sprat, Joseph Glanvill and John Wilkins were particularly prominent voices on the matter of linguistic reform, calling for member's commitment to a new, 'plain style'. In 1667, Sprat wrote his now famous *History of the Royal Society,* in which he called on members to bring words back into 'an equal number' with things. Sprat outlined the need to reject all rhetorical tropes and figures and instead keep to a succinct and plain language, which would return to a direct relation between words and things.[42] He famously described members commitment to

> reject all the amplifications, digressions, and swellings of style: to return back to the primitive purity, and shortness, when men delivr'd so many *things,* almost in an equal number of *words.* They have exacted from all their members, a close, naked,

[39] Shapiro (1983) notes that Bacon was more of a 'propagandist than practitioner,' employing analogy and imagery to enhance his argument, p. 234-5. Vickers (1985) and Graves (2005) make similar arguments.
[40] Katherine Park, Lorraine Daston and Peter Galison, 'Bacon, Galileo, and Descartes on Imagination and Analogy', *Isis*, 75.2 (June, 1984), pp. 287-289 (p. 288).
[41] On Willis's connections with the club in Oxford see: Kenneth Dewhurst, 'Thomas Willis and the Foundations of British Neurology,' in *Historical Aspects of the Neurosciences,* ed. by F.C. Rose and W.F. Bynum (New York: Raven Press, 1982).
[42] Thomas Sprat, *The History of the Royal-Society of London, For the Improving of Natural Knowledge* (London, 1667), p. 113.

> natural way of speaking […] bringing all things as near the Mathematical plainness, as they can.[43]

This statement itself clearly employed rhetorical strategy and used the metaphorical language of a 'naked' and 'natural' mode of speech, also importing the trope of plainness and proportionality from the mathematical domain into a linguistic one. John Wilkins, in similarly Baconian terms, described in 1668 how 'tis a sign of low thoughts and designs, when a mans chief study is about the polishing of his phrase and words.'[44] The discipline was to be purged, in particular, of what Sprat called the 'trick of Metaphors,' devices that, through their disruption of the direct relationship between words and objects, directly undermined clarity and transparency of thought.[45] Sprat thus pondered, 'who can behold, without indignation, how many mists and uncertainties, these specious *Tropes* and *Figures* have brought on our Knowledge?'[46] William Petty, whom Willis often worked alongside, was also vocal on the matter of linguistic reform and directly critiqued those who were 'charmed with fine Allusions and Metaphors,' in his correspondences with Samuel Hartlib.[47]

Moreover, the concern around a need to restrict and reduce language, to bring it into proportion with things, was being fuelled by the demands of the very enterprise of discovery undertaken by the experimental philosophy. As John Wilkins expressed in his *Essay towards a real character and a philosophical language* (1668), he feared a creeping ambiguity, brought about by the invention of new phrases that could bear several meanings; this lead to a situation where words were 'gobbling up things.'[48] In 1666, another member, Samuel Parker, launched a strongly worded attack on the use of figurative language, describing them as 'wanton and luxuriant fancies climbing up the into the Bed of Reason […] instead of real conceptions and notices of Things.'[49] Notably, the argument was itself put using a striking metaphor. Here, Parker picked up on Aristotelian associations between the art of rhetoric and appeals to the passions, as something designed to stimulate pleasure and undermine reason.

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[43] Sprat, *History of the Royal-Society,* p. 113.
[44] John Wilkins, *An Essay Towards a Real Character and a Philosophical Language* (London, 1668).
[45] Sprat, *History,* p. 113.
[46] *Ibid.,* p.112.
[47] *The Advice of W. P. to Mr. Samuel Hartlib, for the Advancement of some particular Parts of Learning* (London, 1648), Vol. 6, p. 2.
[48] John Wilkins, *Essay Towards a Real Character*, p. 18.
[49] Samuel Parker, *A free and Impartial Censure of the Platonick Philosophie* (Oxford, 1666), p. 76.

These discussions extended across natural philosophical, medical, theological and political domains. Thomas Hobbes, for instance, described figurative rhetoric as a form of deliberate deceit because words were being used 'in other sense than they are ordained for.'[50] As Theodore Brown has outlined, for these philosophers metaphors were a tool of grammar and style, rather than any device for explicating true meaning.[51] The call for linguistic reform was even incorporated into the very fabric of the Society: the statutes from 1728 set out the conventions for all submissions from its members, outlining that 'in all Reports of Experiments to be brought into the Society, the Matter of Fact shall be barely stated, without any Prefaces, Apologies, or Rhetorical Flourishes.'[52] We need only think of the society's motto, *nullius in verba* (take nobody's word for it), or in other words the call to 'see for yourself', to have a sense of the emphasis that was to be placed on direct empirical and experimental observation, and the suspicion of those too closely involved in the study of words.[53] Michael Foster's remarks in 1901 on how Willis love of 'words as words' seem to have been a direct attack on his commitment to these core values of the Royal Society and, by extension, on his right to be included within the scientific community.[54]

The picture is, however, more nuanced than these statements would suggest. The words of Sprat and his associates were public pronouncements that must be read against the work of institutional identity-formation and within the context of contemporary polemical debates. That is to say, they are examples of self-reflexively curated ideals, rather than statements on the actual practices of members. As Barbara Shapiro has argued, the new science needed a new mode of communication to help identify the community as set apart from others.[55] The views outlined above were also a public attack on the 'wrong' use of language by rival philosophies and, by extension, a means of undermining their alternative accounts of nature. As with Bacon, the Royal Society's practices were chiefly set up in contrast to what was to be cast as the excessive, occultist

[50] Thomas Hobbes, *The English Works of Thomas Hobbes,* ed. by William Molesworth, 13 vols. (London: Bohn, 1839-1845; rpt. Aalen: Scientia, 1966) vol.3, p. 20. Quoted by Richard Nate, 'Rhetoric in the Early Royal Society', p. 220.
[51] Theodore L. Brown, *Making Truth: Metaphors in Science* (Chicago: University of Illinois Press, 2003), p. 15.
[52] Chapter V, Article IV as cited by R.F. Jones in 'Science and English Prose Style in the third quarter of the seventeenth century,' p. 84.
[53] Clive Sutton has discussed various misreading's of this motto in his article, 'Nullius in Verba' and 'Nihil in Verbis': Public Understanding of the Role of Language in Science,' *The British Journal for the History of Science,* 27.1 (Mar., 1994), pp. 55-64.
[54] Michael Foster, *Lectures on the History of Physiology* (Cambridge: Cambridge University Press, 1901), p. 70.
[55] Shapiro, *Probability and Certainty*, p. 232.

and pluralistic uses of analogy by 'other' groups, such as the followers of Paracelsus and the alchemists.[56] In 1666, Samuel Parker (later Bishop of Oxford) attacked the Cambridge Platonists' use of metaphor, again using heavily metaphorical language to make the case. He noted that they employed

> nothing but rampant Metaphors and Pompous Allegories, and other splendid but empty Schemes of speech […] true Philosophie is too sober to descend to these wildernesses of Imagination, and too Rational to be cheated by them.[57]

Besides imaginative excess, the alchemists' uses of analogy were taken as linguistic expressions of intellectual secrecy – a deliberate attempt to shroud knowledge in an opaque web of metaphors and allusions. Again, drawing on the trope of visual transparency, Sprat spoke of the secrets 'which makes their style to resemble the *smoak*, in which they deal' and pondered how 'their Writers involve them in such darkness.'[58] In the *Sceptical Chymist* (1661), a prominent example of this kind of attack, Boyle commented on the 'obscure, ambiguous, and almost aenigmatical way of expressing what they pretend to teach.'[59] He argued that the alchemist's linguistic obscurity was intended to conceal the emptiness of their knowledge - the 'inflated' style was an extension of their intellectual poverty. These criticisms were set up in stark contrast to the Society's own stated commitment to public knowledge. Despite Willis's involvement in the Royal Society and his commitment to experimental research, he was vulnerable to the charges of secrecy being levelled at the alchemists since he had refused to publish some of his more famous chemical cures and had drawn on numerous alchemical analogies in his chemical work, *Diatribae Duae* (1659). I return to these specific issues in chapter two.

However, the commitment on the part of the Society's members to the conventions set out by the public reformists within the Society has been much overstated. As Richard Nate notes, the Royal Society has 'become famous for its hostility to rhetoric,' yet, as Ryan Stark has also noted, the leading protagonists of the Society were clearly not averse to employing heightened rhetorical ploys when putting their own arguments across.[60] A significant number neither desired nor imagined the possibility of successfully

[56] Vickers, 'Analogy versus identity,' p. 135.
[57] Samuel Parker, *A Free and Impartial Censure of the Platonic Philosophie* (London, 1666). Quoted by R.F. Jones (1930), p. 1001 (n.44).
[58] Sprat, *History*, p. 37-38.
[59] Robert Boyle, 'Introductory Preface', *The Scepitcal Chymist* (London, 1661; 1911 rpt.), p. 3.
[60] Nate (1999), p. 215; Stark (2001), p. 322.

implementing all of their claims.[61] There were, in fact, important voices in the seventeenth century making reasoned concessions to figurative language in their own work, just as a number of scientists attempted to utilise the notable effects of rhetorical tropes in their own writing.[62] The focus on figures such as Sprat and Glanvill is, in part, a projection of present-centred values and concerns, which still draw on these ideas of a plain and economical use of language in science. Importantly, Vickers that notes that the Society's remarks on style only really gained traction from the twentieth century onwards, whereas, 'contemporary references to it are negligible.'[63] As Charles Wolfe and Ofer Gal argue, by attending to the writings of the 'public champions' of the Society, modern historiography uncritically reproduces the notion that 'the society ushered in the new mode of inquiry and swept all others away,' rather than historicizing those views.[64] More recent scholarship has therefore challenged this reading; shifting emphases and paying greater attention to the more varied attitudes and practices of wider members of this community.

Equivocation and concession: Metaphor and analogy in Experimental Science

Despite his strong denunciations, Sprat would not venture so far as to reject the use of similitudes or tropes altogether. As Richard Nate, among others, has argued, the Royal Society – in keeping with Bacon – were, in reality, more opposed to the language of the 'alchemists, cabbalists and the English followers of Paracelsus,' than they were set against metaphorical language in any meaningful sense.[65] Sprat denounced only the 'specious' tropes and figures used by the Platonists, Pythagoreans, or Alchemists; in contrast, he praised Bacon's 'Treasure of admirable imaginations,' which he had used to better 'express and adorn his thoughts about other matters.'[66] As Alexander Wragge-Morely has

[61] Nate, p. 215.
[62] See for instance Bernard Lamy (1640-1715) *De l'art de Parler* (published in Paris in 1675) and the English translation, *The Art of Speaking* (publ. in 1676). This is discussed by Alexander Wragge-Morley, 'Vividness in English Natural History and Anatomy, 1650-1700', *Notes and Records of the Royal Society,* 66 (2012), pp. 341-356 (p. 343). See also, Vickers, *Rhetoric,* p. 17.
[63] Vickers, *Rhetoric,* p. 4.
[64] Charles T. Wolfe and Ofer Gal (eds.), *The Body as Object and Instrument of Knowledge* (London: Springer, 2010), p. 1.
[65] Nate, *Rhetoric and the Early Royal Society,* pp. 216-18. Stark likewise points out that the language of a plain style more accurately referred to the rejection of 'occult influences in language.' He refers to this as a 'forgotten philosophical sense of "plainness" in 'From Mysticism to Skepticism,' p. 322. Vickers, *Rhetoric*, p. 7.
[66] Sprat, *History,* p. 416.

convincingly argued, equivocation of this kind 'typifies the attitude of Society Fellows to the powers of rhetoric'.[67] What Sprat and other members were essentially promoting was *their* use of metaphor and analogy as an extension of the experimental method, in a way that managed and controlled the unruly potential of those devices.

Moreover, the methodology of the new sciences would, Sprat proposed, work to produce a new set of 'solid and lasting' comparisons.[68] Unlike analogies and similitudes based on imaginary or cosmological schemes, those used by experimental philosophers would draw on the '*Images* that are generally observ'd, and such visible things which are familiar to mens minds.'[69] This was an important means of safeguarding clarity: in the case of a new or unfamiliar subject, a reader's interpretation of meaning needed to be guided and anchored in real (rather than invented) notions through the use of a familiar or sensible comparative object. If the comparison is with something we can see or touch, the more effective it would be through its appeal to the senses. As Sprat writes, the comparison so drawn, 'will be intelligible to all, because they proceed from things that enter into all mens Senses.'[70] Again, this view was tied into the notion that visual images had a greater capacity to excite and move the imagination.[71] Such analogies could work against unfettered imagination. That is to say, if readers are able to picture a given image (based on their own direct observational experiences) then there is less scope for interpretative acts. Words remain tethered to direct observations, even if they must be borrowed into some other context for the purpose of illustration. Bound up in these remarks is the sense that comparative or figurative language could be *managed* and disciplined through the role of the experimental method, and made to operate as neutral tools. The work of linguistic similarity and substitution – which necessarily continued – was instead thought to rest, as Foucault notes, on 'a *known* possibility of substitution' based on demonstrable, *proven* objects.[72]

These statements were of course themselves expressions of a distinctive rhetorical strategy on the part of the new institution. The concern with a 'plain style' reflected a

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[67] Wragge-Morley, 'Vividness in English Natural History,' p. 342. For discussion on the attitudes of the Royal Society towards metaphor see: Mary Crane, 'Analogy, Metaphor, and the New Science', in *Introduction of cognitive Cultural Studies,* ed. by Lisa Zunshine (Baltimore: John Hopkins University Press, 2010), pp. 103-114 (esp. p.103-5).
[68] Sprat, *History,* p. 414-5.
[69] *Ibid.* p. 414-5.
[70] *Ibid.* p. 416.
[71] Vickers, *Rhetoric*, p. 8-9.
[72] As cited in Vickers, *Rhetoric,* p. 65.

self-conscious engagement with literary strategy. As Michael McKeon has noted, 'the fundamental trope of this anti-rhetorical style is the self-reflexive insistence on its own documentary candour'.[73] This was not simply a matter self-contradiction, but an important aspect of institutional identity formation.[74] Indeed, rather than banishing metaphors, they were doing important work in establishing the rhetorical plea of this very programme of linguistic reform. Notably, the shared discourse of plainness, nakedness and transparency of speech was metaphorically put, as was the popular metaphor of words as clothes 'fitted' to things. The language of a 'naked' or 'plain style,' contrasted with notions of obscurity, drew specifically upon the classical idea of *perspicuitas.*[75] Robert Boyle noted, for instance, that 'perspicuity ought to be esteem'd at least one of the best Qualifications of a style.'[76] Perspicuity, from the Latin *perspicuitas,* referred to qualities of translucence, transparency, or to the power of insight and lucidity. It is a term that was also being used in alchemical contexts in this and earlier periods to describe translucent materials; the metaphor had, therefore, some root in sensory or material phenomena.[77] From the mid sixteenth-century, it was used chiefly in reference to clarity of expression or succinctness in speech or writing, and to the 'penetrating' insights of knowledge.

In the context of these debates, 'clarity' of understanding could be challenged by the 'opaqueness' of linguistic excess. Boyle also contrasted the illuminating potential of tropes and figures (as illustration) with their capacity, in the wrong hands, to 'dazzle' and mislead. He wrote in the *Scepitcal Chymist* we should 'not allow ourselves to be dazzled by that light which should but assist us to discern things the more clearly.'[78] These metaphors around *transparency* and clarity of vision clearly drew on leading optical technologies and theories, just as ideas about mathematical plainness and proportionality drew on tropes from other intellectual domains. In a constant recourse to these senses,

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[73] Michael McKeon, *The Origins of the English Novel 1600-1740* (Baltimore, London: Johns Hopkins University Press, 1987), p. 105.
[74] Vickers, *Rhetoric* (1985); R. Stark, 'Mysticism to Skepticism,' (2001), p. 322.
[75] S. Michael Halloran and Merrill D. Whitnurn, 'Ciceronian Rhetoric and the Rise of Science: The Plain Style Reconsidered,' in *The Rhetorical Tradition and Modern Writing,* ed. by James J. Murphy (New York: Modern Language Association of America, 1982), pp. 58-72. Richard Nate traces this back to an older, classical metaphor of linguistic transparency (*perspicuitas*): 'Rhetoric in the Early Royal Society', p. 220.
[76] Robert Boyle, *Certain physiological essays and other tracts written at distant times, and on several occasions by the honourable Robert Boyle; wherein some of the tracts are enlarged by experiments and the work is increased by the addition of a discourse about the absolute rest in bodies,* (London: Printed for Henry Herringman, 1669), p. 12.
[77] *The Oxford English Dictionary,* "perspicuity, n." *OED Online.* Oxford University Press, March 2016. Web. 10 April 2016.
[78] Robert Boyle, *The Scepitcal Chymist* (London, 1661; 1911 rpt.), p. 95.

the ways in which light acted upon sight was being used here a useful model for how words might act upon the mind. It speaks, then, to wider ideas about the significant role played by affective images in processes of reader-visualisation as a mode of cognitive understanding, as represented through the capacity of sense-images to act upon and move the imagination.[79] Of course, the sense of being able to furnish the imagination with a direct or reliable image of the world, via the senses, was being steadily undermined much more widely in relation to art and optical theory.[80] Against the uncertainties of the senses, one could place their trust in the scientific *method,* in which a reformed language (promising instructive clarity, direct transmission) played its part. The considerations around the virtue or style of perspicuity points to members' concern with an effective and appropriate style, despite their leaders' renunciation of such considerations. Both Hobbes and Boyle drew attention to the virtues of their perspicuity as a stylistic quality of their writing, with Boyle noting that 'as for the style of our Experimental Essays […] my expressions should be rather clear and significant, than curiously adorn'd,' to which end 'Perspicuity ought to be esteem'd at least one of the best Qualifications of a style.'[81]

William Harvey is a good example here, as somebody who had considered the tensions that arose from recognising both limitations of language and the impossibility of entirely dispensing with figurative tools, especially given the wealth of new discoveries being produced. Harvey's work was also replete with strong metaphors and analogies. Indeed, his more notable metaphors – comparing the heart to a pump and the circulation of the blood to weather cycles – have been extensively studied, but as a means of examining his intellectual processes rather detracting from them – in some contrast to treatments of Willis.[82] Picking up on Bacon's own consideration of the uses of metaphor and analogy, Harvey notably described how, when entering into the 'new and unfrequented paths' represented by the experimental inquiries into nature, one would inevitably confront by

[79] On how certain physiological theories from this period provided a framework for considering the role vivid images might play in provoking strong responses in the imagination see: Wragge-Morely, 'Vividness in English Natural History,' p. 344.
[80] The invention of the camera obscura is an example of this. See for instance Svetlana Alpers study of Dutch perspectival painters in this period, *The Art of Describing: Dutch Art in the Seventeenth Century* (Chicago: University of Chicago Press, 1983). Stephen Shapin has similarly noted that there is a parallel to be drawn here between the Dutch masters reform of perspective and the English reform of prose, in that both sought to affirm new technologies for accurately representing nature: 'Pump and Circumstance,' p. 481.
[81] Robert Boyle, *Certain physiological essays and other tracts* (1669), p. 12. Skinner makes a similar point in respect of Hobbes, who also acknowledges his own *elocution* in respect of the plain style, p. 362.
[82] For a recent example of scholarship looking at Harvey's metaphors, see: Jarmo Pulkkinen, 'Technological metaphors and history of science,' in *The Global and the Local: The History of Science and the Cultural Integration of Europe. Proceedings of the 2nd ICESHS,* ed. by M. Kokowski (Cracow, Poland: 2006).

'a crowd of observations' and 'exotick shapes.' As Lorraine Daston has noted, in the last half of the seventeenth century: 'facts, conceived as chunks of pure experience detached from inference or conjecture, were new and many, and many of them were strange.'[83] The real challenge of discovery, then, lay not in locating the new but in managing, taming and describing those findings. Harvey concludes, that 'to unfould to others the mysteries himself hath discovered, will be more toyl, then the finding of them out.' This difficulty was compounded by the limitations of language:

> For many things occur which have yet no name; *such is the plenty of things, and the dearth of words.* So that if a man should cloath them in Metaphors, and express his new inventions by old words, and such are in use: the Reader could no more understand them, than canting: and would never be able to comprehend the business, since he never saw it.[84]

The 'dearth' of words Harvey spoke of required that, involved in the act of empirical discovery, would be a corresponding search for and selection of metaphorical tropes. Otherwise, these new objects could never be *made known*. As Bacon likewise wrote in *Novum Organum,* the difficulties arising from the objectives of the new philosophy lay in the fact that 'things that are in themselves *new* will be understood on analogy with things that are *old*.'[85] The metaphor of metaphors as clothing used here picks up on the popular trope of words as *clothes* fitted to things, which featured in an earlier example from 1565, by the Physician and mathematician Girolamo Cardano (1501-1576), who remarked that 'words should fit things as clothes fit the body.'[86] By which he indicated that words are made for things, not the other way round. In the sense that they are *fitted* to their objects, they can be said to speak to the form of their content. However, in Harvey's passage, it is less the direct fittedness of words being suggested as the necessity of cloaking less-obvious objects in the borrowed clothes of metaphor. These new objects could only, then, be viewed indirectly and partially, concealed as they were under the cover of existing forms. Old words, carrying borrowed meanings, would nevertheless be required to construct and deliver the new.

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[83] Lorraine Daston, 'The Language of Strange Facts in Early Modern Science,' in *Inscribing Science: Scientific Texts and the Materiality of Communication,* ed. by Timothy Lenoir (California: Stanford University Press, 1998), p. 20.
[84] William Harvey, 'preface to the reader', *Exercitationes de generatione animalium* (London, 1651).
[85] Bacon, *Novum Organum,* (1620/1960), the first book of Aphorism's, 1-77; 34.
[86] Cardano (1565) quoted by Ian Maclean, *Logic, Signs and Nature in the Renaissance: The Case of Learned Medicine (Ideas in Context)* (Cambridge: Cambridge University Press, 2007), p. 106, n.22.

As Ian Maclean has argued, what Harvey proposed here was a troubling situation whereby the process of invention would in fact be a process of 'linguistic negotiation."[87] This brings us to a recurring tension: the program of the rediscovery of nature relied on existing language and explanatory frameworks to make 'new' objects intelligible. This was not incompatible, but certainly in tension with, the Royal Society's programme of reducing and restricting language – indeed, it calls for an expansion of available 'words'. Moreover, as Harvey observed, this issue here was very much one of reader comprehension. Picking up on Bacon's views on invention in science, Harvey settled on allowing the borrowed or 'unusual terms' of figurative speech to assist the reader in comprehending the distinctly unfamiliar facts of experimental investigations. The invention of scientific knowledge was not, then, simply a methodological task; it necessitated a literary process of invention and communication. However, as Harvey's passage conveys, this process had its own limitations: the reader's inability to conceive of an entirely new or unobservable object would leave them entirely dependent upon the work of the metaphorical explanation. These metaphors could be illustratively useful (if not indispensible), but could prove equally misleading for the reader who, having no prior visual experience in which to anchor their interpretations, would have no means of disciplining all the potential meanings held by a particular metaphor. On the other hand, if the discoverer were to simply 'mint up new and fictitious terms' then this would prove just as confusing for the reader who would be left having to 'unriddle the words.' This would, he wrote, 'rather cast a mist, than enlighten."[88] So, while metaphor (and other modes of comparison) were the only way of achieving some sort of intelligibility, it also meant that readers would never fully comprehend the plain 'truth' of an object. Reading-as-comprehension could never be posited as a direct or equal substitution for knowledge derived from direct observation or experience. There was, though, little option in regards to new discoveries or invisible phenomena: figurative language was flawed but ultimately necessary.

Harvey was not alone in making considered concessions to the tropes of metaphor in order to make effective arguments, especially on the subject of unobservable processes. Robert Hooke also famously used the metaphor of the Bologna stones to express his ideas about visual memory – alongside more explicitly 'elevated' representations of the

[87] Maclean, *Logic, Signs and Nature* (2007), p. 108-9.
[88] Harvey, *Exercitationes de generatione animalium* (1653); quoted in Maclean, p. 109.

soul through metaphors of celestial microcosm. The phosphorescent light retained by the stones acted as an analogy for the ways in which the mind retained visual images transmitted to it. In Europe and England, chemists were searching for processes capable of producing light, highlighting the close relationship between an intellectual climate and the choice, selection or availability of certain metaphors in framing new ideas. As Douwe Draaisma notes, the phosphorescent metaphor aroused suspicion from within the Royal Society, but Hooke nevertheless retained it.[89] Hooke, like Harvey, also considered that metaphors and analogies were essential tools under certain circumstances – unsurprising given the intangible nature of his subject matter. In a paper given in 1682, he remarked that, on the matter of memory, 'It is not, I conceive, possible to be truly understood or described, but only by Similitude.' [90] Hooke nevertheless suggested that some comparisons were more reliably drawn than others, noting that the most effective examples represented familiar, 'mechanical and intelligible ways of working.' In the same address, he noted that

> nothing is so well understood as when it is represented under some sensible Form, I would, to make my Notion the more conceivable, make a mechanical and sensible Figure and Picture thereof, and from that shew how I conceive all the Actions and Operations of the Soul as Apprehending, Remembering and Reasoning are performed.[91]

Hooke in effect argues that we can rely on *mechanical* figures and sensible forms - though he did not restrict himself to such examples. He also refers to using these mechanical principles as a way of *conceiving* of the actions of an immaterial soul. This disrupts the idea of analogy as a tool of illustration anchored to an empirical object, and instead renders the analogy the basis of a conceptual model – of an idea of the soul.

These examples were open to the same sort of charges that would also be levelled at Willis. In his discussion of memory, Hooke used examples from nature and leading technologies of the day (chemical materials, optics), but he did so in order to discourse on certain hidden – and much contested - operations usually ascribed to the mind or

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[89] Douwe Draaisma, *Metaphors of Memory: A History of Ideas about the Mind* (Cambridge: Cambridge University Press, 2000), p. 119.
[90] *Ibid.,* p. 63.
[91] Taken from a paper given by Hooke to the Royal Society on *The Explication of Memory* (June, 1682). See, B. R. Springer, 'Robert Hooke on Memory, association and time perception,' *Notes and Records of the Royal Society,* 31 (1976), pp. 115-31.

soul. The boundary between using figures to merely illustrate or to *create* (speculative theories) is thereby challenged: the examples are being marshalled to fit a pre-existing hypothesis, rather than acting as its foundation. Moreover, in positing an incorporeal model of the soul and memory, Hooke used his metaphors to conflate physical and spiritual domains of knowledge. Of course, many natural philosophers were engaged in using analogies to discuss phenomena that were not directly observable – such as Boyle's work on atomistic bodies and the pneumatic qualities of the air. The issue here was less the visibility of the objects in question, as the amplifications involved in applying those notions to theories of the soul. Hooke nevertheless appealed to mechanistic philosophy in order to represent his ideas via a purportedly verifiable model of action in the world. Mechanical events were, of course, open to physical or experimental demonstration, unlike the actions of memory. The problem remained that Hooke used these figures in order to make sweeping claims about the physiological operations of soul; this is something that also applied to Willis – a tension that I will come back to at the end of this chapter.

The examples touched on above point to a far more complicated approach to the use of figurative devices among writers in this period than would be expected from simply examining the pronouncements of the Royal Society's leading figures. Another noted figure of the new science, the astronomer and mathematician Johannes Kepler (1571-1630), is also often pointed to as having strong objections to figurative language, but he similarly strayed into more elevated metaphors, such as when he spoke of a 'world soul' and music of the spheres.[92] Robert Boyle has likewise been described as a 'prolific analogizer,' while Harvey's training in classical rhetoric and use of prominent metaphors is well established.[93] Clearly, these practices were not entirely incompatible with experimental philosophy, or at least were not wholly eradicable. The issue, seen in this light, is not one of suppression but one of management. As William Lynch concluded in his discussion of the Society's members, 'their goal was not to eliminate metaphor but to find a means of controlling the effects of metaphor'.[94]

[92] Michael Spitzer, *Metaphor and Musical Thought* (Chicago: The University of Chicago Press, 2004), p. 153.
[93] On Boyle's analogizing see: Gentner and Jeziorski, 'The shift from metaphor to analogy,' p. 467. On Harvey's use of rhetoric see: Thomas Wright, *William Harvey's Revolutionary Idea* (London: Chatto and Windus, 2012), chap. 3, pp. 20-29.
[94] Lynch, *Solomon's Child* (2001), p. 152-3.

Robert Boyle and 'scientific analogy'

Of the various schemes to assert an 'appropriate' use of rhetorical figures and tropes by philosophers in the period, by far the most successful model – according to modern scholarship – was forwarded by Robert Boyle (1627-1691). Boyle was another member of the Oxford club of experimental philosophers, of which Willis was a prominent member. Like Willis, Boyle conducted chemical experiments and worked on atomistic principles; Boyle was even called upon to explain the results of one of Willis's reports to Society members and corresponded on the matter of Willis's experiments. Boyle stands out in the discussions around linguistic reform in this period as a figure who is often held as developing the accepted linguistic form of modern science. As Shapin and Schaffer have argued, Boyle's *Proemial Essay* (1661) was a methodological statement setting out the 'rules for the literary technology of the experimental programme.' They concluded that it was Boyle, and not Bacon, who 'developed the literary forms of experimental communication'.[95] Similarly, Dedre Gentner and Michael Jeziorski have also taken Boyle to be the exemplar of modern and 'progressive' practices, specifically in regards to a circumscribed use of metaphor and what they consider to be his 'structural' approach to analogy. They refer to Boyle as expressing the broader shift away from an older, Aristotelian concern with surface qualities to concentrate on the structural relationships between objects.[96] Vickers notably described these themes in 1984, when he spoke of the emergence of modern science in this period as characterised by the move from 'occult' notions of identity to 'scientific' uses of analogies.[97] The fact that *metaphors,* alongside analogies, continue to pervade modern scientific discourse alone suggests that these ideas are the projection of a modern, scientific ideal.

Firstly, these discussions tend to revolve around the development of a specific genre - the experimental essay, or report - attributed to Boyle. Clearly, these texts operated under different conditions to the medical-philosophical texts being produced by the likes of Willis. They described a bounded event, a limited set of variables and were more obviously concerned with describing the (physical) experimental scene*,* and as such had

[95] Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump* (Princeton: Princeton University Press, 1985), p. 63; Shapin, 'Pump and Circumstance,' p. 519. See also, Graves, *Rhetoric in(to) Science,* pp. 61-72.
[96] Gentner and Jeziorski, 'From Metaphor to Analogy' (1993), p. 467. Mary Crane also points to a late seventeenth century 'change in the nature and uses of analogy,' in 'Analogy, Metaphor, and the New Science' (2010), p.111.
[97] Vickers, 'Analogy versus identity,' p. 84; M. Spitzer, *Metaphor and Musical Thought* (2004), p. 153.

less need of figurative language. This was clearly not the only style of writing Boyle engaged in. Moreover, to the extent that Boyle's model (of analogising) has been abstracted from this context, to be used as a more general measure of 'scientific' applications of analogy within modern historiography, it still bears an influence on corresponding evaluations of Willis's own practices and requires some examination here. As Charles Wolfe and Ofer Gal have argued, Boyle's analogies are specifically 'mobilized to give legitimacy to the experimental philosophy,' and so he becomes part of the ways in which Willis's work is valued and assessed as a contribution to that body of knowledge.[98]

A prominent issue here was how the distinction between analogy as unnecessary ornamentation and (necessary) illustration was to be policed or managed. A key feature of Boyle's approach to this issue refers to what Dedre Gentner and Arthur Markman have described as *structure mapping,* which outlines the mapping of knowledge from one domain to another, such that the system of relationships holds between the target objects.[99] These relationships do not require any similarity in terms of appearance. However, the base objects do need to occupy similar *roles* within matching relational structures. They should not, according to the model, cross over widely separated domains (e.g. between corporeal and incorporeal phenomena). The choice and selection of the analogy therefore had to observe certain conditions: they should all hold the same structural relationship with the target object and not seek to extend beyond the limits of a knowledge category; they should be selected from natural and familiar examples. For example, an analogy that compares the force of a river stream and the flow of nervous juice in the arteries would not count as an amplification, because both are part of the natural order and subject to the same physical laws. They share a common structural relationship in that both depict the motion of fluid bodies, within a certain contained space.

Boyle held that any number of analogy-images might be given in sequence to provide evidence for a particular point (multiplication) as long as they each revolved around a shared relationship or common relational abstractions. Instead of merely introducing one figure, he would draw on many at once.[100] This was intended to increase clarity and work

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[98] *The Body as Object,* ed. by C. Wolfe and O. Gal (2010), p. 1.
[99] Dedre Gentner and Arthur B. Markman, 'Structure Mapping in Analogy and Similarity,' *American Psychologist,* 52 (1997), pp. 45-56.
[100] On these arguments see: Gentner and Jeziorski, 'From Metaphor to Analogy,' p. 457. See also, Shapin, 'Pump and Circumstance,' p. 448-9.

against erroneous interpretations – a greater fault - through focusing the reader's attention on a set of shared *structural* relationships with the target object. In effect, a principle is *replicated* by the given analogies, rather than being subject to more creative labours of extension or development. A characteristic example, taken from Boyle's *Of the great effects of even languid and unheeded local motion* (1690) began with Boyle noting the problem of reader comprehension. He complained that men 'undervalue' the effects of invisible bodies, because they cannot be seen, even though their combined effects as 'swarms' allow them to produce all sensible material change. The root of the misunderstanding is itself expressed as resulting from an inadequate analogy: men, he notes, commonly think of atoms as 'grains of dust,' which do not immediately threaten physical harm. To overturn this, Boyle employs an extended sequence of examples of localised particulate motion, all of which produce effects in larger bodies. As he explains, 'if you turn an Ant-hill well stocked with Ants-eggs, upside down, you may sometimes see such a heap of eggs, mingled with the loose earth as a few of those Insects, if they were yoaked together…' But, if each ant were to 'lay hold of her own egge' then this commixture of eggs and earth are quickly 'displaced' en-masse by the motions of each individual ant. Subsequent images extended this theme - such as the 'wind upon a tree in *Autumn,*' which 'withall carries off divers of the leaves.' He then introduces what he terms 'closer instances' of this principle, citing the dissolution of sugar lumps into beer or water. For the learned reader, he includes references to chemical experiments with Mercury and wine.[101] Boyle's analogies thus 'correct' the significant misapprehension wrought by earlier, poorly chosen examples – a preferable state of affairs.

This example presented a distinctly prolix and elaborate passage, densely populated by varied vivid analogies. It is nevertheless assessed as a model of management and constraint: the collected images all served as instances of local (particulate) motion, drawn from natural and observable events; they illustrated vivid yet *familiar* scenes, similar in orders of magnitude. While the chemical experiments were less 'accessible' to the general reader, they were themselves validated by having been produced in what were clearly marked out as first-hand, experimental conditions. Furthermore, Boyle emphasises the role, or at least the potential for, his own first hand observation. This assertion can be read as a means of anchoring and 'testing' analogies against empirical demonstration; a way of directing and limiting the range of possible interpretations. He

[101] Robert Boyle, *Of the great effects of even languid and unheeded local motion,* Chap. IV, (London, 1690), pp. 29-33.

also implies the same opportunities for his readers: many (but not all) of these examples were familiar or easily replicated events – trees in autumn, sugar dissolved in beer. These are all features that have been cited as characteristic of a scientific use of analogy.

As with Harvey's comments, cited earlier in this chapter, Boyle expressed a concern over the (active) role of the reader and their need to comprehend what was being described. He explicitly justified multiplication as a means by which he could increase his support to the reader. In his *The Origin of Forms and Qualities* (1666) he commented,

> I sometimes employ variety of terms and phrases to express the same thing, I did it purposely, though perhaps to the prejudice of my own reputation […] both I and others having observed that, the same unobvious notions being several ways expressed, some readers […] will take it up much better in one of those expressions, and some in another.[102]

Here, Boyle suggests that a variety of expressions ensure that at least one familiar object would be available for any given reader to call upon. If these examples stick to those objects that are familiar or sensible, this will increase the probability that a reader would gain an *accurate* (if, indirect) image of the object, rather than needing to introduce their own interpretations. This is particularly tied then, to a consideration of *difficult* explanations. Of course, the use of many terms and diverse forms of expressions is not necessarily the same as figurative language, but as we see in the example above, Boyle certainly saw fit to express difficult phenomena through long sequences of analogy. This is pointed to in his reference to tackling 'unobvious' notions (such as invisible atoms) where analogies are required to stand in place of literal description. As Bacon had also set out, the usefulness of analogy lies in bringing those things that are not immediately perceptible by observation to 'within reach' of the senses by indirect observation 'of some related body that *is* perceptible.'[103] Multiplication was also a practice intended to encourage the reader to focus upon what linked the chain of images together and to the target object, this was designed to work against the use of a given analogy as an inter-changeable 'symbol' of its object.[104] Boyle's writing was also a further example of the

[102] Robert Boyle, 'The Origin of Forms and Qualities According to Corpuscular Philosophy' (publ. 1666), in *Selected Philosophical Papers of Robert Boyle,* ed. by M.A. Stewart (Cambridge: Hackett Publishing Company, 1991), p. 6.
[103] Bacon, *Advancement of Learning*, Book II: 26-43; 42.
[104] Gentner and Jeziorski, 'From Metaphor to Analogy,' p. 457.

import of rhetorical tropes from mathematical and legalistic discourses: *many* examples increased the weight of 'evidence' or 'testimony' and supported notions of plausibility.[105]

It is important, however, to question how far modern critical assessments of Boyle's 'control' of analogies are a function of current scholarship's own values and interests. Ultimately, these analyses construct a model of what structural analogizing is *intended* to look like, without reference to wider intellectual contexts or knowledge practices of the period. Boyle's approach is made 'scientific' by present-day assessments of it, which includes a series of tabular presentations designed to import an attendant stress on his use of structural relationships and proportionality.[106] This obscures the wider and potentially more dynamic relationships that might operate between analogies. Interestingly, this use of tabular presentations was repeated in M. Eadie's discussion of Willis's descriptions of the pathological states of the animal spirits in 2003.[107] These practices are a means of intervening in historical texts so as to make them appear scientific, by our own definition. In these readings, the active role of the reader (comprehending the meaning of an analogy) is substantially overlooked. This is worth considering: Boyle's use of analogies was not merely about gathering a weight of 'evidence'; he also placed a significant emphasis on *supporting* and *pleasing* the reader. Boyle commented that he hoped his work might '*gratify* many readers and instruct more than a few', rather than causing them to 'despair' at the 'darkness and difficulties' of much philosophical discourse.[108]

Notably, Boyle argued that while a writer must take care not to be 'florid' in his style, he must equally 'be allow'd to take a Care that it disgust not his Reader by its Flatness.' He continued that while the 'ornaments of language' may well 'darken as well as adorn' the subject, if applied with *discretion* – in reflections on findings, rather than in methodologies - then their pleasurable effects could still be retained. To illustrate his argument he uses an analogy drawing again on optical technologies, in this instance the telescope:

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[105] On the shift from conceptions of plausibility and verisimilitude to probability see: Shapiro, 'Probability and Certainty,' p. 230.
[106] Boyle's example on local motion (given above) is presented by Gentner and Jeziorski's article in a table-presentation, p. 457.
[107] M. J. Eadie, 'A Pathology of the Animal Spirits - the Clinical Neurology of Thomas Willis (1621-1675) Part I – Background, and disorders of intrinsically normal animal spirits,' *Journal of Clinical Neuroscience,* 10. 1 (2002), pp. 14-29 (p. 17).
[108] Boyle, 'The Origin of Forms and Qualities,' p. 3. On Boyle's considerations of pleasure, as part of encouraging the reader's learning see: Black, 'Boyle's Essay,' pp. 178-195.

> Thus (to resume our former Comparison) though it were foolish to colour or enamel upon the glasses of Telescopes, yet to gild or otherwise embellish the Tubes of them, may render them more acceptable to the Users, without at all lessening the Clearness of the Object to be look'd at through them.[109]

What Boyle suggests here, is that some degree of ornamental language is required in order to attract readers and to engage them in learning. This picks up on Aristotle's account of metaphors as a means of obtaining the 'goodwill' of the listener. Importantly, he proposes that, with restraint and careful application, such ornaments can be used without obscuring meaning or clarity of sight. Following his own analogy, pleasing figures of speech should not be used as a tool for representing the nature of a subject (through the lens), but can be used to make the process of learning more vivid or striking. What he means here is that his adornments will be applied only in the reflections on findings, not in methodological sections. His telescope analogy stresses once again how notions of unmediated and direct *sight* are used to structure ideas around intellectual clarity and the purity of knowledge.[110] These considerations clearly strike a very different chord to the austere rhetoric of the 'plain' and 'naked' style, as espoused by Sprat and Wilkins and highlight the possibilities for a far more complex or nuanced approach to figurative language in the period.

Thomas Willis and the work of analogy

Taking characteristic examples from Willis's major publication, *Anatomy of the Brain* (1664), does not reveal any sustained transgressions from the measures advocated by his contemporaries. In keeping with Boyle, Willis tended to employ analogy far more often than metaphor; and, as we have seen, even the staunchest critics of rhetoric were not immune to the use of metaphors. He publicly stated his commitment to experience and observation, rejected the 'world of letters' and renounced 'poetical philosophy'. As he stated in the Epistle dedication to *Anatomy,* he had submitted his work to the 'rule of experience':

[109] Robert Boyle, *Certain physiological essays* (1669), p. 13.
[110] Wragge-Morely discusses how for a number of renaissance natural philosophers, the pleasurable effects of metaphor could be retained, under certain conditions of use: 'Vividness,' p. 343.

> Therefore I desire, that all mine may be tried and approved, no less by the demonstration of Piety and Canons of the Church, than by the Rule of Experience and Knowledge, to which I keep. (Epistle)

Importantly, what the various concessions and evocations already explored above express is that there was not, in fact, a sense in which these philosophers would have recognised an insurmountable contradiction between their commitment to experimental values and the use of rhetorical tropes. Furthermore, there was no single 'right' way to use figurative devices to which all could adhere and no reason to suggest that Willis saw his own literary practices as being in any way opposed to the shared values of his fellow experimental philosophers and Society members. Willis was as aware as his contemporaries of the dangers of 'luxuriating' in words and textual learning, and went on to explicitly rejected his earlier 'poetical' philosophy in his *Preface,*

> I do not think of Empires in Arts, nor do I promise to my self Triumphs by overcoming the World of Letters […] I was ashamed that I had been so easie hitherto, and that I had drawn out for my self and Auditors a certain Poetical Philosophy.[111]

When Willis mentions 'Poetical Philosophy', he is referring to his first and only preceding publication, *Diatribae Duae* (1659), in which he set out a chemical theory of fermentation and fevers. Crucially, this was a model supported by an overarching chemical analogy applied to medical 'animal spirits' in the body. It correspondingly formed the basis of much more contentious argument, that the soul had a material component. I will return to these issues shortly. Firstly, having set out how Boyle's model stands as one half of a model against which Willis is implicitly judged, it is revealing to assess an example from Willis according to those same criteria. Clearly, Boyle's model was not the only possible approach available in this period, but in so far as it reflects wider themes of proportion, management and control of rhetorical tropes it remains a useful framework to refer to here.

In the research for *Anatomy of the Brain*, drawing on a new method of dissection, Willis was able to observe detailed interior structures of the brain for the first time. What he

[111] Thomas Willis, 'Preface to the reader,' *Anatomy of the Brain,* translated by S. Pordage (London, 1664), p. 53.

saw – and what his readers would also be required to visualise - was a visceral, chaotic and remarkably alien presentation. The translation of these intricacies into some kind of intelligible form – that is, to render the brain a sensible object of knowledge, would require extensive work on the part of analogous vehicles. In a characteristic example, Willis used the following analogies to depict the complex network of arteries covering the brain's cerebral hemispheres:

> […] the frame of the subject may be seen, covered with the infoldings of Vessels, as it were with a net admirably variegated […] its sight of aspect shews like the picture of a fruit-bearing wood; the Idea of which, the Vessels of the Brain more aptly represent, and are themselves seen better and more distinctly, if you first squirt into the Carotidick Artery some black liqour.[112]

The passage opens with Willis noting that the object in question (the brain) is being *observed*, the initial sight of which he expresses through the analogy of a net - marked out by the prefix 'as it were'. The net analogy uses a familiar and accessible object to illustrate the principle of variegation, which comes from the Latin *variegatus* meaning varied or diverse. Both the net and the vessels of the brain share in this common structural relationship as complex networked structures, both encasing larger objects. As a unified structure, the arteries might replicate the principle of a network but they do not necessarily *look like* a net; there are no clean lines, or proportional divisions. The specific visual aspect of arterial variegation, as it presents in the brain, is drawn out with the additional image of a fruit bearing wood - another familiar and accessible image. Willis is clear that instead of comparing the two objects directly he is using the wood as a means to 'picture' its 'sight or aspect.' These images hold a common relationship in that both represent variegated, interconnected, structural complexities that challenge direct observation. Willis ultimately reinforces these observational challenges by stressing not his own (fallible) eyesight, but the extension of that process afforded to him by the experimental method – in his technique of injecting coloured dyes and ink into the brain. As I have touched upon throughout this chapter, notions of visual or optical clarity are a recurrent rhetorical emphasis in experimental writing. Here, Willis's analogies are supported – or validated by – their association with observational testimony.

[112] Willis, *Anatomy,* p. 59.

These analogies are not significantly ornamental or elevated. The images do clear work in making a complex object intelligible, through easily visualised figures. The observational event, underpinning the example, is clearly indicated. Where he used examples, he consistently adopted the requisite prefix of '*quasi*' or '*velut,*' which Samuel Pordage translated as the phrase 'as it were' in the English edition.[113] If we apply Boyle's own conditions, Willis has used his analogies 'appropriately'. However, it is worth noting that while the two examples do possess common attributes, they also draw out slightly different aspects of the same object. This is as opposed to a strict sense of replication or 'multiplying' which (modern assessments) of Boyle's analogising stress. Of course, it is arguable that the very idea of analogies as adhering to mathematical principles is itself a product of these kinds of modern analysis, which draws attention to and repeats the rhetorical ploys of early modern experimental discourse. The point, however, is not to hold Willis to these standards, which are neither self-evident or neutral; what is instead expressed here, is that Willis can not be thought 'exceptional' in respect of his contemporaries own practices.

What is excluded here of course is the possibility of more dynamic interactions between these images and across the text. Overall, as illustrated in the above example, Willis's use of analogies was not meaningfully at odds with the practices observed by his immediate contemporaries in the experimental community, who all recognised an important and continuing role for figurative writing in their work – especially in regards to unobservable phenomena. As Alexander Wragge-Morely has shown, Willis employed a mixture of 'commonplace, medium size objects' in his comparisons and, while some examples displayed what the Wragge-Morely describes as an 'elevated style,' this would not in and of itself have necessarily marked Willis out from his contemporaries.[114] Importantly, as with Boyle, Willis tended to draw on analogies far more often than metaphor in discussing his findings and chiefly in the assistance of difficult or novel explanations.

However, none of the above is to say that Willis did not, in places, employ distinctly heightened and ornamental metaphors. In the preface to *Anatomy*, for example, he employed the following metaphor:

[113] Wragge-Morely, 'Vividness', p. 346.
[114] *Ibid.* p. 346.

> Minerva was born from the Brain, Vulcan with his Instruments playing the Midwife: For either by this way, viz. by Wounds and Death, by Anatomy, and a Caesarean Birth, Truth will be brought to Light, or for ever lye hid.[115]

Here, Willis employed a literary reference from Greek mythology to argue that the physical practice of anatomy is itself a metaphor for the generation (by 'caesarean birth') of new truth or knowledge. These prefatory remarks could clearly have been viewed as 'embellishing' the arguments of his empirical work, a practice specifically rejected in the stated in the statues of the Royal Society; though, as part of a prefatory passage, they could also have been viewed as remarks used to enhance and inform the experience of the reader, while not directly impinging on the experimental presentations of the book.[116]

Another point to pick up on here is that this kind of prose could have been used to suggest that Willis wrote with a Humanistic (Ciceronian) concern with an elevated style and ornamentation. Anthony Wood had remarked on Willis's 'natural smoothness, pure elegancy, delightful, unaffected neatness of Latin style,' an assessment tellingly coupled with the observation that Willis's experimental contributions were as lacking as his literary skills were evident.[117] These characteristics of Willis's Latin prose could be taken as appearing to contravene a commitment to the 'plain style' advocated by some leading figures associated with the Royal Society at this time. The suspicion of Latin and a commitment to the vernacular by Society members has nevertheless been overstated. Polemicist's calls for a 'plain style' certainly drew on the rhetoric of a rejection of the swellings of style of Humanist Latin or the obscurities of its scholastic variant, such as when Sprat called for members to adopt the 'native easiness' of the language of merchants and artisans.[118] However, many notable natural philosophers associated with the Society, such as Hobbes, continued to routinely publish their works in Latin and thereby secure a learned, continental audience. The Society would certainly have wanted to produce works that could be read by both English and continental colleagues Europe,

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[115] Willis, *Anatomy,* 'Preface.'
[116] Chapter V, Article IV; quoted by R.F. Jones 'Science and English Prose Style in the third quarter of the seventeenth century,' p. 84, (n.45).
[117] Quoted by William Feindel, *Thomas Willis (1621-1675). The Founder of Neurology, Canadian Medical Association Journal,* 87 (1962), pp. 289-296 (p.295-296).
[118] Vickers, *Rhetoric,* p. 9.

especially considering the largest international centres of the book trade were mostly in Germanic parts of Europe, where Latin remained the standard language of scholarship.[119]

The matter is, however, more complicated than this. Natural Philosophers in this period were confronted with the difficulty of translating complex and highly technical terminology from Latin – the traditional language of medicine and university based learning – into what was a relatively restricted English vocabulary. As Vickers has argued, between the 1640s and 1680s it was difficult to view the English vernacular as having the capacity to properly express technical terminology.[120] Walter Charleton, a close contemporary of Willis, published his writing in English but nevertheless remarked in 1680 on the difficulties this involved:

> If my *Stile* shall sound somewhat harsh […] as coming too near to the Latin; I intreat you to consider, this is either no indecency in this place, or such a one at worst, which I could not otherwise avoid, than by involving my sense in the obscurity of words less proper and significant; the nature and quality of subjects treated of, being such, as cannot be fully expressed in our yet imperfect Language.[121]

These remarks again tie into the themes discussed throughout this chapter: of the fraught balancing act that had to be struck between using words in a sense other than they were strictly intended (in this instance, by resorting to an imported or borrowed Latin term) as set against the risk of using unclear (if precise) language – the latter could be more detrimental to clarity of understanding. In this case, a continued use of scholarly Latin rather than the vernacular could be cited as a way of avoiding the ambiguities promised by a new or poorly substituted name. Boyle and Harvey had of course had made similar arguments in respect of analogies and metaphor in relation to new or difficult ideas: it was better to borrow and substitute a term than to risk the confusion of an entirely new or unfamiliar name. Ultimately, metaphors - as devices defined by their specific contexts – do not ever translate effectively: they are always changed as part of the negotiations implicated in an act of translation. In Willis's instance, Pordage's act of translation lifted his writing from the specific, learned Latin discourse in which he had composed them

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[119] Isabelle Pantin, 'The role of translations in European scientific exchanges in the sixteenth and seventeenth centuries' in *Cultural Translation in Early Modern Europe,* ed. by Peter Burke and R. Po-chia Hisa, (Cambridge: CUP, 2007), pp. 163-179 (pp. 169-170).
[120] Vickers, p. 31.
[121] Walter Charleton, *Enquiries into Human Nature, VI. Anatomic Prelections* (London, 1680), 'Preface.'

into the vernacular setting – but this was not the medium originally intended by the author himself and Pordage was himself compelled to retain many of Willis's original Latin terms. The use, or not, of Latin prose is therefore complex and nuanced and is certainly no way of assessing Willis's 'scientific' credentials or not against those of his contemporaries.

Beyond the issue of his Latin style, Willis has also been criticised for making what appear to be very public concessions to the role of beauty and elegance as a function of theoretical speculations. In 1694, Ysbrand van Diemerbroeck (1609–1674), professor of physick and anatomy at Utrecht, wrote of Willis's disregard for plain speaking and accuracy in order to satisfy his vanity: 'he does but explain the lesser Obscurity by the greater Obscurity […] there is nothing in it but Vanity and Ostentation.'[122] In the 1980s, his modern biographer, Kenneth Dewhurst, pointed to Willis's penchant for 'lapidary' passages and polished phrases as a feature of his desire to both instruct and *please* his readers.[123] He cited Willis's remarks at the end of his *Anatomy of the Brain,* that

> In truth, whatsoever of our work is performed without form or beauty may seem as the Foundation of a Building only placed on the ground, in which no elegancy or neatness doth yet shine. A Superstructure indeed may be promised to be put upon this Foundation, perhaps fair and beautiful, whereby the minds of the Beholders may be pleased and instructed.[124]

Here, Willis notably departs from the emphasis, featured at the start of *Anatomy,* on observation and experience and instead begins to speak about the beauty and elegance of (physiological) theory. This takes us back to Aristotle's ideas around the pleasantness of metaphor and the sweetness of 'strange names' as a means of encouraging and supporting learning. We need only think of the comments made by Anthony Wood, to see how such concerns over ornamentation and gratifying the reader could be easily cast as tokens of Willis having placed intellectual vanity and fame-seeking over and above his requirement to instruct and inform.[125] Willis further remarked that, 'the hard sense of our already instituted *Anatomy* may be sweetened with those kind of more pleasant

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[122] Ysbrand van Diemerbroeck, *The anatomy of human bodies, comprehending the most modern discoveries,* translated into English by William Salmon (London: printed for W. Whitwood, 1694), p. 232.
[123] *Thomas Willis's Oxford Lectures,* ed. by Kenneth Dewhurst (Oxford: Sanford Publications, 1980), p. 159.
[124] Willis, *Anatomy,* p. 192.
[125] Anthony Wood, *Athenae Oxonienses* (London: Printed for Tho. Bennet, 1691-2), vol.3.

Speculations, as it were cloathing the Skeleton with flesh.'[126] There is an echo here, in Willis's analogy, of Harvey's comments on metaphors as the clothes that make things intelligible. Willis frames his theoretical speculations as the necessary 'flesh' giving form (and understanding) to the bare 'skeleton' of anatomical fact. Evidently, the writers of the period were required to balance their concern for clarity, brevity and empirical precision against the need to offer effective and appealing arguments to their readers. Ideas about how to bring about new learning and discovery could not be entirely divorced from concepts around the affective power of visual-impressions to act on and move the imagination.[127] Willis was no exception in this matter.

Of course, Boyle had also spoken about the need to please the reader with some degree of ornamentation; the difference being that Willis proposes here to use such devices as means of extending his process of reasoning – from anatomical structure to the workings of the soul. This goes to the root of the issues taken with Willis's use of rhetorical tropes and figures: that he did so in order to furnish himself with speculations on physiological processes, rather than limiting himself to the illustration of anatomical structures. Returning to some of the key historiography examined in the introduction, Alfred Meyer and Raymond Hierons' influential study on Willis's neurophysiology from 1965, for instance, pointed to Boyle's simple statement of facts, against which they noted that while Willis 'respected' facts, he ultimately believed that reasoning (by analogy) could be used to 'fill in the gaps' (with speculation).[128] They cite Willis's own remarks that '…at length, from the analogy and frequent ratiocination, this (as I think) true and genuine use of it occurred.'[129] The problem here being that analogies, according to the new philosophy, were intended to be used as illustrative examples or 'evidence', not as a basis of inductive reasoning. Of course, this becomes more difficult where the subject in question is unobservable. In their experimental work, both Willis and Boyle perused atomistic and physiological explanations that depended on the categories of spirit – hidden, invisible atoms acting beneath the levels of sense. Clearly, in this context, using analogy to 'fill in the gaps' (of what could not be seen directly) was unavoidable. As I

126 Willis, *Anatomy,* p. 192.
127 Stephen Clucas argues that Bacon sought to develop 'an instrumental scientific rhetoric' as a means by which to 'apply Reason to Imagination for the better moving of the will': 'A Knowledge Broken: Francis Bacon's Aphoristic Style and the Crisis of Scholastic and Humanist Knowledge Systems,' in *English Renaissance Prose: History, Language and Politics,* ed. by Neil Rhodes (Tempe, AZ: Medieval and Renaissance Text Society, 1997), pp.147-72 (p. 147).
128 Meyer and Heirons, Part II, p. 145.
129 Willis, *Anatomy*, p. 91.

have been exploring, a number of natural philosophers engaged with 'unobvious' notions, occurring beneath the level of sense – had acknowledged practical concessions to the use of analogy to extend their process of reasoning. Dewhurst (Willis's noted biographer), observed that Willis clearly believed that reasoning from analogy could be justified under certain conditions and, importantly, that he attempted to tether his examples, where he could, to his wider researches in anatomy, physiology and chemistry.[130]

Importantly, chemical and corpuscular philosophies in the seventeenth century *did* propose that the work of atoms was had material and demonstrable effects (indirectly produced through the effects of evaporation, distillation and fermentation or by experiments with air-pumps and vacuums). Whether it was acceptable to use analogies to describe these bodies or if such work strayed into the purely speculative and metaphorical depended on where you stood on the existence of material spirits in this period and their relationship to the soul. Notably, the general thrust of the attacks levelled at Willis have enduringly focused on Willis's physiological or corpuscular language – rather than his (often figurative) illustrations of the brain's anatomy. A prominent trope relied upon by Willis in his physiological writing was an analogy drawn between chemical and medical spirits. The import of new, chemical principles and terms to describe medical or cognitive processes was a particular point of contestation.[131] The Galenic, Irish physician Edmund O'Meara, for example, made a very public objection to Willis's analogous treatment of chemical and medical phenomena. O'Meara claimed that iatrochemist's such as Willis had made pretence of 'wisdom' merely by the trick of 'inventing new terms.'[132] That is, Willis had no solid understanding of the nature of medical spirits but had simply imported categories of explanation, by analogy, from an entirely unrelated domain. The issue here, then, is less about the application of literary convention, and more about how disputes over language are an integral part of the disputed parameters of knowledge within a given intellectual climate.

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130 Kenneth Dewhurst, 'Thomas Willis and the Foundations of British Neurology,' in *Historical Aspects of the Neurosciences,* ed. by F.C. Rose and W.F. Bynum (New York: Raven Press, 1982), pp. 327-346 (p. 343).

131 On O'Meara's objection to this comparison see: Antonio Clericuzio, 'The Internal Laboratory: The Chemical Reinterpretation of Medical Spirits in England (1650-1680)', in *Alchemy and Chemistry in the 16th and 17th Centuries,* ed. by Piyo Rattansi and Antonio Clericuzio (Dordrecht; Boston: Kluwer Academic Publishers, 1994), pp. 51-83 (p. 61).

132 Lyons, J. B. "O'Meara , Edmund (*c.*1614–1681)," in the *Oxford Dictionary of National Biography*. Online ed. Ed. Lawrence Goldman (Oxford: OUP, 2004).

Related to these objections were a broader set of criticisms aimed at Willis's use of anatomical findings to support claims concerning the chemical and physiological properties of the animal spirits comprising the corporeal soul. This concern was at the centre of a vehement attack on Willis from the Dutch anatomist, Nicholas Steno (1638 – 1686). Steno was perhaps Willis's staunchest (or at least, most public) critic. In a Paris lecture on the anatomy of the brain, published in 1669 but delivered earlier, Steno attacked Willis for having used his anatomical observations as a basis for speculating on the operations of invisible bodies - the animal spirits. Steno, in effect, attacked the notion that crude anatomical knowledge could provide any insight into the workings of the soul in humans – which he would later state should be province only of theology. He therefore counted Willis alongside Descartes, as a philosopher whose fanciful and speculative theories were based on the operations of animal spirits, about which 'nothing certain' could possibly be known.

It is important to recognise here that Willis's decision to use his investigations into the body in this manner - as part of a wider investigation into the nature of the soul – was neither radical nor exceptional within the setting of early modern natural philosophy. His efforts fed into a long established tradition of using anatomy to make teleological arguments concerning the nature of the soul, which had proven especially prominent in the Lutheran or Protestant traditions of the Northern European anatomy schools under such figures as Phillip Melanchthon.[133] However, what could (and did) prove controversial in this setting were the kind of conclusions Willis used his anatomical findings to defend: in offering *detailed* arguments on the chemico-medical properties of the animal spirits and their activities, Willis extended his investigations of the body into what was for some an unacceptably speculative realm. It certainly progressed beyond the applications of earlier commentators, such as Galen and Vesalius, who had used the parts of the body to provide a basis for thinking about the tripartite arrangement of the soul in the body.

The brain was – to Steno – a notoriously difficult object of physical inquiry, from which little could therefore be reliably gleaned about the detailed movements, activities or chemical properties of the spirits themselves. As Steno would conclude, in the absence

[133] Vivian Nutton, 'Wittenberg anatomy', in *Medicine and the Reformation,* ed. by Peter Grell Ole (London: Psychology Press, 1993), pp. 11-32 (p. 26); Sachiko Kusukawa, *The Transformation of Natural Philosophy: the case of Phillip Melanchthon* (New York: Cambridge University Press, 2006), p.101.

of reliable empirical facts, Willis's misleading account of the animal spirits was left to rely upon mere *words* and figures. He noted, for example, how 'falsely the figures represent the parts which they are designed for.'[134] He went on to reject such systems of 'art,' built upon the foundations of 'ill chosen' and 'obscure terms, metaphors and comparisons.'[135] He further criticised Willis for having imported *substituted* terms when naming parts of the brain, such as *testes* and *anus,* noting that these names had 'no relation at all to the parts expressed by them in the anatomy of the brain.'[136] Of course, as has been noted throughout the chapter, Steno made his own arguments effective through the use of a striking metaphor: picking up on the trope of *visual* clarity as *intellectual* insight, he suggested that further investigations into the brain were needed in order to 'tear off the glaucoma from the eyes of those who calmly accept the opinions of past ages.'[137]

Some years after Willis's death, in 1684, the Dutch physician Günther Schelhammer (1649-1716) also attacked Willis's use of similarity (analogy) as a means of constructing and demonstrating his arguments. In his *De Auditu* (1684), Schelhammer claimed that Willis was 'unaware that similarities do not prove anything' and should be only used as an 'incentive for obtaining evidence.' [138] Although these comments came a decade after Willis's death, they are nevertheless indicative of how Willis's younger contemporaries were able to draw on his use of similarity as a means of undermining his theories. Schelhammer concluded that he could not have confidence in Willis, a 'famous and, in Medicine, so well-merited man', because he too often 'takes on the role of philosopher, and ponders over the uses of organs or the nature of chemical events.'[139] Once again, the primary issue here was Willis's chemical and physiological *theories*, rather than his medical practice or anatomical observations. Schelhammer – who was promoting his own, alternative account of the ear-drum - went on to specifically tackle Willis's *choice* of a particular comparative object, suggesting that the dispute was over rival interpretations of an analogy, rather than an outright stand against the practice. We can see here how scientific concepts are both built upon and contested through given analogies and

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[134] Nicolaus Steno, 'A Dissertation on the Anatomy of the Brain', translated by G. Douglas (London, 1743); reprinted in Ole J. Rafaelsen MD. (ed.), *Steno in Six Languages* (Copenhagen; Rhodos, 1986), p. 63.
[135] Steno, *Dissertation on Anatomy,* p. 65.
[136] Steno, *Anatomy,* p. 65. For a detailed discussion on Steno's views on the limits of anatomical inquiry, see: Kenneth Dewhurst, 'Willis and Steno', in *Steno and Brain Research in the Seventeenth century*, ed. by Gustav Scherz (London: Pergamon Press, 1965), p. 46.
[137] Steno, p. 46.
[138] C. G. Schelhammer, *De Auditu* (Lugduni, 1684), p. 207. For discussion see: Meyer and Heirons, Part II, p. 147.
[139] Schelhammer, *De Auditu,* pp. 207-210.

metaphors; these are not merely passive tools of communication, but rest at the centre of knowledge-creation.

These attacks were motivated by disputed methods of knowledge and contested disciplinary boundaries, rather than by any overriding concern for literary convention. In Steno's case, he objected to the very idea that the soul was comprised of material agents or a subject for anatomists and physicians, rather than philosophers and theologians. He argued, rather, that tropes and figures were being used in these discourses to compensate for their over-extended reach and insufficient empirical foundations. He objected not so much to the use of metaphor or figures, as their inappropriate applications and the inadequate selection of examples that were 'ill chosen' and 'puzzling.' Willis, though, was not exceptional in this regard; physiological theories of the mind were gaining traction, even while they remained highly contentious and even heretical. As I touched on earlier, Hooke had breached recognised domains of knowledge by comparing physical or mechanical objects with his notions of an incorporeal soul in his discussion of memory. Unlike Hooke, Willis held that the corporeal soul was a material phenomenon and that the physical actions of its spirits could be 'demonstrated' by chemical analysis and were evidenced in the effects of pathological conditions on the body and mind. Depending on whether this stance was accepted or not, it could be claimed Willis was not conflating natural and imaginary domains, but comparing similarly natural objects. Steno, unsurprisingly, had rejected the chemist's philosophical role in medicine and anatomy or its capacity to 'prove' the nature of spirits.[140] What I want to emphasise here is that assessments of Willis's *actual* use of figurative devices cannot be divorced from the broader, polemical context in which such references would have been received and interpreted. This is not about literary convention as much as it is about how contested categories of knowledge.

In another example, Willis pre-emptively defended his import of a chemical analogy used to express the explosive qualities of the spirits as comparable to the action of gunpowder in producing muscular action. He defended this on the grounds that there was no other suitable corresponding term within the field of medical knowledge that could clearly example the kind of action he wished to convey. Of course, Willis *was* saying that the spirits were explosive – a quality rooted in chemical models. The analogy opened him up

[140] Steno, p. 69.

to the charge of having rendered the superior matter of the corporeal soul no different from the crude material of alcoholic liquors and gunpowder.[141] This is a recurring problem with comparisons that are used to illustrate unobservable phenomena: it is impossible to draw limits on the work of the analogy in shaping and directing the possibilities of knowledge. In other words, in cannot be definitely stated that the comparison does not slide into symbolic representation. We might think, for instance, of Harvey's metaphor of the heart as a pump – a far more widely recognised and accepted metaphor from this period. Here, the notion of muscular action conveyed by Harvey is inseparable from the mechanical metaphor that describes it. Today, it is very difficult to determine whether the heart *is* a pump or if this is a metaphor; clearly when Harvey used it, he did so as a mechanical-metaphor, but the heart does indeed *pump* the blood. The muscles of the heart were (and are) understood as literally 'pumping' the blood, just as Willis saw the spirits as 'exploding' when mixed with certain chemical substances.

Of course, Harvey's 'scientific' credentials are not undermined on account of his use of elaborate metaphors in present day historiography in the same way that Willis's use of language is (at least in part), mistrusted. This is a mark of the metaphor's success and is more broadly reflective of the success of mechanistic categories of explanation. If the model is accepted as valid or self-evident, according to the standards of a specific epistemological setting, then the language employed around it can be easily cast as an illustrative 'tool' that has been 'tested' against an empirical fact. It is easier to suggest that the metaphor came after the fact. Whereas, in the absence of empirical 'proof' (i.e. the spirits) the metaphorical basis of the model is more readily exposed and rejected. While Harvey could observe both the heart and a pump, Willis could only observe gunpowder explosions, but not the specific actions of chemical or medical spirits. However, the *success* of the pump metaphor obscures a set of far less-recognisable terms of reference that were also needed to construct this theory of the heart-pump. Harvey didn't just think of the heart as a mechanical pump; his conception of its role was also bound up in his ideas around the vital spirit of the blood – ideas that were also part of Willis's conceptual framework. These will be explored in a later chapter. The point to be made here is that metaphors and analogies, isolated from their wider intellectual and cultural contexts, cannot tell the whole story.

[141] On this see Eadie (2002), p. 17.

Conclusion

The discussions mapped out in this chapter serve to stress the ambiguities of metaphorical and figurative language – variously cast as tools of illustration or ornamentation, as both misleading and illuminating. They also highlight the difficulties we might face if we were try to separate out scientific knowledge from their work and the historical and intellectual climates in which they were employed. Even Harvey's mechanical metaphor of the pump – which can, according to certain perspectives, be easily 'tested' against observation of the heart – belies a more complex conceptual architecture, premised on a set of metaphors that do not 'map' onto our own modern day intellectual frameworks. This is as true for Willis's work as it is of Harvey's. These debates also touch, then, on the cultural invisibility of certain 'successful' metaphorical models. Within the intellectual setting of the seventeenth century, the mechanical metaphor was a particularly dominant model for representing nature, something I return to in chapter three - a metaphor so successful, in fact, that it effectively ceased to act as a metaphor at all. Such metaphors instead come to frame the parameters of thought, much like certain metaphors, including the mechanistic model within neuroanatomy, continue to shape scientific models in the present day. Certainly, Willis's mechanical or hydraulic analogies – even where they were being used to explain the movement of animal spirits – have not proved as contentious as his vitalistic or chemical analogies, used to discourse on matters of brain function. Thinking about spirits as anthropomorphic, reasoned 'agents' does not have any easy modern comparative. The disquiet felt over Willis's 'baroque' and 'fanciful' figures of the animal spirits in some present-day historiography has less to do with the actual conventions for 'scientific analogy,' more than it is a reflection of how difficult it is to stand outside of the prevailing metaphors of our own time. Similarly, seventeenth century attacks on Willis's use of analogical reasoning were not necessarily an attempt to uphold the conventions of the Royal Society, but an issue of the disputed frameworks of natural philosophical knowledge.

This chapter, then, has shown that in the late seventeenth century, scientific writers adopted a far more nuanced, pragmatic or equivocal stance in relation to the work of rhetorical tropes. Their practices reflected a concern for plainness, clarity and empirical accuracy but this was necessarily balanced by the need to explain, through effective illustration, difficult and novel phenomena to their readers. There were widespread

concessions to the effectiveness of analogy (and frequent slips into extended metaphors) by leading figures of the experimental community in this period. This is a far more complex picture than traditional assessments of the Royal Society's hostility to language and rhetoric have tended to suggest. What emerges time and again in approaches to rhetorical tropes and figures in the period, is the desire to mark out science's ability to *manage* their imaginative potential whilst retaining their more pleasurable effects – this feeds into modern science's own notion of analogies as *tools*. Scientific analogies are such when they can be tested, corrected or rejected, while other (literary) analogies easily come to act as 'symbols' for their objects. As I've already touched on, these assertions are based on positivistic accounts of the 'older' style of the alchemical and Paracelsian philosophies, as something that was replaced by the 'modern' conventions of the Royal Society and its members.[142] Language as a 'tool' of science is of course itself a powerful metaphor, to be added to the metaphors of words as clothes, adornments or illustrations.

In modern readings of figures such as Kepler and Boyle the misplaced emphasis on the anti-rhetorical stance of the Royal Society is largely replaced by an equally present-centred emphasis on the possibility of a 'structural' or 'scientific' model of analogising. This is in no small part because their stated ideals have been incorporated into the character of modern science. It is through these sorts of practices - comparing Boyle with Willis - that the boundaries between scientific and non-scientific uses of language are policed and constantly re-affirmed. It has not, however, been my intention here to suggest that Boyle should be considered in any way less 'modern' or that Willis ought to be re-evaulated as 'modern'. The point instead is to question whether the differences noted between Boyle or Willis's approaches are not being invested with meanings that sit at the centre of our own ideas about the character of modern science. As I have explored above, the negative responses to Willis's analogies tended to reflect the tensions arising from the collision of new philosophical models and the inevitable (linguistic) challenges involved in discovery and invention. These tensions will be explored in more detail across the following chapters.

[142] Graves, *Rhetoric in(to) Science,* p. 54.

Chapter Two

The Internal Laboratory: Chemical Ferments and the Body

Thomas Willis is remembered today above all for his contributions to neurology through his work around the structure and function of the brain and nerves. This emphasis has tended to obscure the that fact that, prior to an extended period of anatomical research in the mid-1660s, Willis's reputation had rested on his considerable knowledge and experience in medical chemistry (iatrochemistry).[1]Willis's first major publication, the *Diatribae Duae medico-philosophicae,* published in 1659, offered a principally chemical account of the phenomena of fermentation and fevers.[2] The neglect of Willis's chemical theories and practices is more than an issue of biographical detail: in this chapter, I will argue that Willis's use of chemical modes of explanation in his early physiological writing fundamentally informed his later work on the brain and nerves. His 'neurological' discoveries and practices (dissection, comparative anatomy, clinical observation) cannot be divorced from the intellectual framework that Willis's background in experimental chemistry provided. Robert Frank thus noted that to understand Willis's notion of brain function it is vital to start with his chemical ideas.[3]

The *Diatriabae* reveals a notable reliance upon key, structuring chemical analogies, which Willis applied to physiological and medical problems and explanations. These analogies supported Willis in the development of his career, in that they allowed him to transpose a set of familiar concepts and categories from the laboratory to the distinctly unfamiliar and largely hidden events within the bodies of his patients. They effectively furnished Willis with an accessible intellectual and practical framework for constructing a medical-physiological account of the human 'oeconomy' (a term used by Willis to refer to the

[1] Hansruedi Isler describes an iatrochemist as an early modern physician who 'applied chemical principles, analogies and practices to solve medical problems': *Thomas Willis, 1621-1675: Doctor and Scientist,* trans. by the author (New York: Hafner Publishing Company, 1968), p. 57.
[2] The tracts 'Of Fermentation' and 'Of Fevers' were first published together in Latin with 'De Urinis,' in *Diatribae duae medico-philosophicae* (1659). In this chapter I will use the English translation by Samuel Pordage, *A Medical-Philosophical Discourse of Fermentation, or, Of the Intestine Motion of Particles in every Body* (London, 1681). All further references to this edition are given after quotations in the text with the abbreviation "DD."
[3] Robert Frank Jr., *Harvey and the Oxford Physiologists* (London: University of California Press, 1980), p. 116.

body 'system') and the pathologies that afflicted it.[4] As Michael Hawkins has argued, Willis 'transmuted his expertise in understanding and managing chemical processes in the laboratory into the experience necessary to explain and manipulate the processes occurring within the bodies of his patients.'[5] The function of these chemical analogies was not, then, a straightforward matter of rhetorical *elocutio,* ornamentation or embellishment – they were creative, intellectual tools used by Willis to ground the unfamiliar and the new within a recognisable context.[6]

The primary focus in the first part of the chapter will be on Willis's use of a key analogy between chemical spirits and those found within the body and their involvement in his new account of fermentation and fevers. The second part will then examine some of the controversies that surrounded Willis's account, focusing in particular on questions around the applicability of his chemical analogies to medical explanations. Lastly, I will consider how Willis's core chemical analogies informed and directed his (more famous) work on the brain and its physiology. Before that, I will map out some of the key themes in the responses to Willis's chemical discourse.

Historical reception

Willis's experimental chemical activities during the 1640s formed the basis of his *Diatribae.* A primarily chemical treatise, the work incorporated two tracts, *De Fermentatione* ('Of Fermentation') and *De Febribus* ('Of Fevers'), which presented a medico-physiological application of the principle of ferments. As Willis's noted biographer Hansruedi Isler observed, this work relied upon chemical concepts more than any other of Willis's works.[7] The work was published to a mixed – but certainly not muted – reception. His own contemporaries certainly took his contribution on ferments and fevers to be original and distinctive, and expressed considerable interest in the publication: the physician Matthew Mackaile (1657-1696), for instance, wrote that in

[4] Although from a slightly later example, Samuel Collins used the same term when comparing the 'oeconomy of the Body politick' to that of the body, where body-parts occupied subordinate roles to the head within the same system: 'Preface', *A Systeme of Anatomy,* 2 vols., (London, 1685), I. p. xxviii.
[5] Michael Hawkins, 'Piss Profits: Thomas Willis, his *Diatribae Duae* and the Formation of his Professional Identity', *History of Science,* 49.162 (2001), pp. 1-24 (p. 3). Allan Chapman similarly noted that, for Willis, 'the end of the quest lay in acquiring a proper understanding of fermentation, both in the chemical laboratory and in the sickroom': 'From Alchemy to Airpumps: The Foundations of Oxford Chemistry to 1700', in *Chemistry at Oxford: A History from 1600 to 2005,* ed. by Robert P. J. Williams, Allan Chapman and John Shipley Rowlinson (London: Royal Society of Chemistry Publishing, 2008), pp. 17 – 51 (p. 37).
[6] Hawkins, *Piss Profits*, p. 12.
[7] Isler, *Thomas Willis,* p. 58.

Willis 'you will find many things concerning fermentation which were never heard of before […] all which were but lately published in Latine and came to our hands, two moneths after these [...] And in them is the nature of fermentation more exactly described then ever.'[8] Richard Lower, Willis's collaborator at Oxford, similarly wrote that 'Willis's aetiology of continued fevers too, inasmuch as it is accommodated to more recent discoveries, and the circulation of the blood, is a completely new one.'[9] It was an account that proved highly influential. In 1676, Charles Goodall, a member of the Royal College of Physicians, praised Willis's 'incomparable' work on fevers and fermentation and placed his contribution alongside Sylvius, naming them as two of the greatest chemists of the age.[10] Historian Peter Anstey, has argued that Thomas Sydenham's *Methodus curandi febres* (1666) was 'almost certainly derived from the view of Thomas Willis.'[11]

Willis was recognised by his contemporaries for having incorporated new chemical discoveries into his medical knowledge and practice. As Goodall remarked, 'he hath not only ingeniously communicated many good medicines…but was master of greater *Arcana* in chymistry…none who readeth him, but must admire him for an acute Philosopher as well as a profound Chymist.'[12] The modern historian, Robert Frank Jr., has thus noted that Willis's reputation for being 'innovative' derived, at least initially, from his chemical work and not his anatomical projects. He notes, for example, Samuel Hartlib's reference to Willis's 'ingenious' experimental work.[13] Despite the noted reception of Willis's chemical theories among his contemporaries, this aspect of his contribution has tended to be neglected in the historiographical literature on Willis. As Isler noted in 1968, 'Of Fevers' has been largely forgotten within the history of medicine – an observation he made whilst at the same time acknowledging that it was quite famous in his day: his

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[8] Matthew Mackaile, *Moffet-well, or, A topographico-spagyricall description of the minerall wells, at Moffet in Annandale of Scotland translated, and much enlarged, by the author Matthew Mackaile* (Edinburgh: Printed for Robert Brown, 1664), p. 16.

[9] *Richard Lower's Vindicatio, a Defense of the Experimental Method* (1665), ed. and trans. by Kenneth Dewhurst (Oxford: Sanford Publications, 1983), p. 279.

[10] Charles Goodall, *The College of Physicians vindicated, and the true state of physic in this nation faithfully represented in answer to a scandalous pamphlet, entituled, The corner stone* (London: printed by R.N. for Walter Kettilby, 1676), p. 137.

[11] Peter Anstey, 'The Creation of the English Hippocrates', *Medical History,* 55 (2011), pp. 457-478 (p. 460). On the argument that Sydenham was derivative of Willis's theory of fevers see: Stephen L. Sigal, 'Fever Theory in the Seventeenth Century: Building Toward a Comprehensive Physiology,' *The Yale Journal of Biology and Medicine,* 51 (1978), pp. 571-582.

[12] Goodall, *The College of Physicians,* pp. 137-8.

[13] Robert Frank Jr., 'Thomas Willis and His Circle', in *The Languages of Psyche: mind and Body in Enlightenment Thought,* ed. by George S. Rousseau (Berkeley: University of California Press, 1990), pp. 107-147 (p. 116).

staunch critic, the physician Edmund O'Meara, even referred to it as 'that famous doctrine of the Fevers.'[14] More recently, in 2000, Stanley Finger observed that 'the fame associated with Thomas Willis today does not stem from his acumen at diagnosis…nor is he well remembered for his chemical theories of medicine. Without question, it was his new way of looking at the brain and behaviour that is his most significant contribution.'[15] As Michael Hawkins has well examined, this failure to properly engage with Willis's broader chemical influences is a product of a prevailing, present-centred concern with neurological brain.[16]

Furthermore, of those assessments that have chosen to examine Willis's chemical theories, a number have tended to view his contribution (on fermentation) as little more than an agreeable 'bridge' between older (alchemical) practices and the new 'scientific' chemistry. Willis, it is argued, did little more than make the elements of the former palatable to the latter. Isler, for instance, concluded that Willis's primary contribution was that he 'made (the theory) more attractive to the pioneers of experimental science.'[17] Donald G. Bates has similarly claimed that Willis was of interest here only in so far as he was 'transitional' and 'derivative.'[18] Frank Jr. further commented that, 'in his chemistry, as in most other things, Willis was always the compromiser between ancients and moderns.'[19] It is true that Willis's account of fermentation incorporated aspects of Helmontian chemistry (influenced by the works of Paracelsus) into new corpuscular philosophies, which he achieved by embedding specific chemical properties in new concepts of material corpuscles. However, these readings too often express a concern to situate Willis within much larger intellectual traditions, rather than with examining his specific contributions on their own terms. That is, the specific ways in which Willis was able to construct and express his own ideas – including, but not limited to, his use of chemical analogies in medical-physiological applications.

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[14] Isler, p. 73.
[15] Stanley Finger, *Minds Behind the Brain: A History of the Pioneers and their Discoveries* (Oxford: Oxford University Publishing, 2000), p. 87.
[16] On these discussions see: Michael Hawkins, 'Piss Profits', p. 1. For a recent example of the kind of scholarship in question see: Mitchell Glickstein, *Neuroscience: A Historical Introduction* (MIT Press, 2014), p. 299.
[17] Isler, p. 66.
[18] Don G. Bates, 'Thomas Willis and the Fevers literature of the Seventeenth Century', *Medical History,* 25 (Jan., 1981), pp. 45-70 (p. 53).
[19] Frank, 'Willis and His Circle', p. 116.

In respect of Willis's use of language, historically it has been his chemical-corpuscular writing that has, as Frank Jr. put it, 'repelled' and 'befuddled' commentators, as I have explored in the introduction to this thesis.[20] The medical professor, Mervyn J. Eadie, for instance refers to Willis's 'extraordinary chemical embellishments,' which he apparently 'superimposed' onto his animal spirit concept.[21] Such ornamental impositions suggest, of course, that chemical principles – at least, the early modern kind - had little to offer in elucidating Willis's intellectual contributions. Eadie further argued that, in his chemical discourse on the spirits, it 'becomes difficult to be sure if he may have slid from analogy into postulated chemical actuality.'[22] Willis's chemical discourses are seen, then, as especially problematic from these perspectives because of a sense of his improper reliance upon (or misuse) of chemical analogies. This of course implies that Willis *other* practices (around the brain) had not been subject to such speculative embellishments.

Much earlier than this, in 1901, Michael Foster had also suggested that Willis had effectively 'dressed himself up' in the chemico-physiological 'phrasing' of his eminent colleagues, such as Robert Boyle, and that he therefore misunderstood and misapplied these terms and concepts.[23] Picking up on Foster's claims, in 2003 Wes Wallace suggested that because he had merely borrowed terms he was not familiar with, Willis's chemical language appears both inconsistent and also 'fanciful'.[24] This reinforces the idea that language is part of how we manage disciplinary boundaries; that to transfer terms across this boundary interrupts the relationship between words and their proper meanings. Again, Willis, in seeking to stray beyond accepted disciplinary boundaries, appears to fall foul of the restriction that language and terminology are 'fixed' in relation to the things they denote; rather than allowing for language to be a vehicle by which new meanings are generated - through importing objects, sense and meanings across different intellectual domains.

What these discussions also reference is the idea that Willis's chemical discourse reflected the influence of the alchemical tradition and works of Paracelsus, rather than the

[20] Frank notes that modern commentators remain 'befuddled' by Willis's corpuscular writing, p. 129.
[21] M. J. Eadie, 'A Pathology of the Animal Spirits - the Clinical Neurology of Thomas Willis (1621-1675) Part II - Disorders of Intrinsically Abnormal Animal Spirits', *Journal of Clinical Neuroscience*, 10.2 (2003), 146–157 (p.156).
[22] Eadie, 'A Pathology of the Animal Spirits', Part I, p. 17.
[23] Michael Foster, *Lectures on the History of Physiology During the Sixteenth, Seventeenth and Eighteenth Centuries* (Cambridge: Cambridge University Press, 1901), p. 270, 275.
[24] Wes Wallace, 'The Vibrating Nerve Impulse in Newton, Willis and Gassendi: First Steps in a Mechanical Theory of Communication,' *Brain and Cognition,* 51 (2003), pp. 66-94 (p. 75).

(acceptable) language of 'modern' chemistry - thus supposing that there was a clear distinction between the two that we can point to in this period. As discussed in chapter one, the alchemists were a group attacked, among other things, for their unrestrained use of elaborate and ornamental analogies. However, the idea of a shift from alchemy to chemistry in this period is itself a largely false distinction; it is impossible to meaningfully exclude the influence of the alchemical tradition from the "modern" chemistry of this period.[25] As historian Ferdinando Abbri notes, in the early modern, 'alchemy did not magically transform into chemistry; instead, obscure, volatile, and ancient ideas coexisted with clear and precise concepts.'[26] Alchemical concepts and experiments were employed by a variety of groups, including the physicians and apothecaries - Willis was no exception in this regard.[27] Stanton Linden has thus argued that, during this period alchemy was 'reoriented' towards medical applications rather than being rejected in any straightforward sense.[28] It is to be expected, then, that Willis would have drawn on a variety of alchemical images and tropes, the use of which cannot be said to make him any less 'modern' or excessively ornamental, according to the standards of his time.

Willis, Oxford's Chemist

Willis's formal medical education was interrupted and curtailed by the outbreak of the English Civil War. He graduated with his MA in June 1642, just two months before the outbreak of hostilities and took up arms after only six months of formal training. His eventual award with a licence to practice medicine in 1646 was considered by Kenneth Dewhurst to be a 'belated military honour,' more than an academic achievement.[29] The significance of this less than conventional path was that Willis was left at a considerable disadvantage when it came to medical practice. The deficit in his formal education was, however, augmented by his considerable chemical experience - initially under the wife of Thomas Iles, and later continued in his own rooms at Wadham College.[30] In the early 1640s, John Aubrey reported to Anthony Wood that Willis had 'studied chymistry in

[25] On this see: William R. Newman and Lawrence M. Principe, 'Alchemy vs. Chemistry: The Etymological Origins of a Historiographic Mistake,' *Early Science and Medicine,* 3.1 (1998), pp. 32-65.
[26] Ferdinando Abbri, 'Alchemy and Chemistry: Chemical Discourses in the Seventeenth Century', *Early Science and Medicine,* 5.2, Alchemy and Hermeticism (2000), pp. 214-226 (p. 220).
[27] Stanton J. Linden, *Darke Hieroglyphics: Alchemy in English Literature from Chaucer to the Restoration* (Lexington, Kentucky: The University Press of Kentucky, 1996), p. 11.
[28] *Ibid*, p. 29.
[29] Kenneth Dewhurst, 'Thomas Willis and the Foundations of British Neurology,' in *Historical Aspects of the Neurosciences,* ed. by Frank C. Rose and William F. Bynum (New York: Raven Press, 1982), pp. 327-346 (p. 328).
[30] Hawkins, 'Piss Profits,' p. 3.

Peckewater Inne chamber,' while by 1649 John Lydall was referring to 'Mr Willis our Chymist.'[31] Indicative of his success and commitment to chemical investigation, Willis shared in furnishing a laboratory at Wadham during this time, at great expense.[32]

By 1658, when Willis came to write his tract on fermentation, he had already amassed fifteen years of experience as an itinerant physician travelling between the medical markets around Oxford, where he prescribed a mix of traditional and chemical cures.[33] This background goes some way to explaining Willis's considerable reliance upon chemical categories of explanation and frequent recourse to chemical analogy. His primary expertise and practical experience at this point in his career lay in medical chemistry, rather than anatomy or physiology.[34] Michael Hawkins has aptly demonstrated how this chemical approach aided Willis's professional and social interests; I build on this argument with a particular focus upon how chemical analogies informed (and thereby complicate) his knowledge about the brain and nerves.[35]

Two Chemical Treatises: 'Of Fermentation'

Along with his contemporaries, Willis turned away from Galen to draw on the new chemical-corpuscular principles in forwarding his account of fermentation. Chemistry in England during the seventeenth century was chiefly built upon corpuscularian physics. Imported from atomistic theory in the works of Pierre Gassendi, this sought to explain all natural phenomena according to the size, shape and motion of 'atoms' or 'corpuscles,' which comprised the smallest units of matter. The physical motions of these particles could be used to explain all perceptible changes in matter.[36] Importantly, Willis diverted away from a purely mechanistic version of the corpuscular doctrine by describing chemical reactions both according to the activity and motions of corpuscles or particles, while at the same time maintaining that chemical properties had a 'real existence in

[31] John Aubrey, *Brief Lives,* vol. II (1669 – 1696), p.303. John Lydall to John Aubrey, 23 January (1648/9), Bodleian Library, MS. Aubrey 12 ff. 294r.
[32] Hawkins notes that Willis's considerable expenditure on this laboratory highlights that his medical interests in chemistry, p. 10.
[33] *Willis's Oxford Casebook (1650-52),* ed. by K. Dewhurst (Oxford, 1981), p. 42.
[34] Frank Jr., *Harvey and the Oxford Physiologists* (London: University of California Press, 1980), p. 169.
[35] Hawkins, p. 13.
[36] Antonio Clericuzio has argued that 'in England and in Germany the combination of chemical Helmontianism and Boyle's corpuscular views was fairly widespread': *Elements, Principles and Corpuscles: A Study of Atomism and Chemistry in the Seventeenth Century* (London: Kluwer Academic Publishers, 2000), p. 6.

matter.'[37] In line with these approaches, Willis's account defined ferment by the action or motion of heterogeneous particles, contained within a body or vessel:

> Fermentation is an intestine motion of Particles, or the principles of every Body, either tending to the perfection of the same Body, or because of its change into another (DD, p.9).

Ferments only occurred between particles of different chemical compositions, chiefly as a reaction between volatile alkaline salts or spirits, particles of sulphur and nitre. Under a ferment, the bonds between these particles were broken apart and reformulated; 'intestine' here referred to these internal activities of particles, as they occurred within the body.[38] Particles that were 'of the same kind' did not ferment. In all instances, the product of this particulate 'tumult' was an immoderate heat, violent motion or swelling of the matter (DD, p.1). Fermentation was a concept had long been employed by chemical philosophers as a means of explaining organic processes of growth, change and decay in natural bodies. It was, as Willis observed, a term chiefly associated with human industry – in the baking of bread, the brewing of beer and the production of wine (DD, p.1). It had also been used in alchemical discourses, since the fifteenth century, to describe a concept of an original life-force or 'seminal sparks' hidden in matter – this particular definition carried problematic cosmological associations, which Willis sought to avoid.[39] The term ferment was also employed more broadly in this period as a metaphor for any agitation, violent tumult or agent of change within a body, applicable across medical, religious and political discourses. For example, John Locke, a student of Willis, spoke of his hypothesis laying 'a ferment for rebellion.'[40] It was also associated, through emerging physiological models, with the mental commotion and violence

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[37] Frank Jr., *Harvey,* p. 165; Clericuzio, *Elements,* p. 81. Audrey B. Davis also connected Willis's 'mechanico-chemical' concepts to figures such as Francis Glisson, van Helmont, Harvey, and Sylvius in 'Some Implications of the Circulation Theory for Disease Theory and Treatment in the Seventeenth Century,' *Journal of the History of Medicine,* 26 (1971), pp. 28-39.

[38] "intestine, adj.", *The Oxford English Dictionary Online*, March 2016.

[39] See for example, Ben Johnson's *Alchemist* (1612) which refers to ferment as a seminal spark in matter: 'ferment, n.', in *The Oxford English Dictionary Online* (Oxford University Press). Allan Chapman and Anna Marie Roos both note that Willis eschewed the metaphysical or occult elements of Helmontian chemistry while retaining the basic tenets of his chemical model of ferments: Chapman, 'Alchemy to Airpumps,' p. 37; Anna Marie Roos, *The Salt of the Earth: Natural Philosophy, Medicine, and Chymistry in England, 1650-1750* (Leiden; Boston: Brill, 2007), p. 113.

[40] John Locke, *Two treatises of government*, 1st edition, vol. 1 (London: Printed for Awnsham Churchill, 1690), p. 224.

experienced in an extreme passion as when, in 1671, John Milton spoke of his grief's 'ferment and rage.'[41]

Fermentation, as a subject of medical concern, was not new to Willis. It had long been linked to Aristotelian and Galenic notions of putrefaction and decay in the body. Ferments had, however, traditionally been explained according to humoral frameworks – a model that had, as Willis put it, in the age of 'the circular motion of the Blood', 'began to be a little suspected' (DD, p. 58). Willis's proposed account of fermentation, as a chemical-corpuscular phenomenon, applicable to the blood, marked his rejection of traditional humoral medical theory.[42] Willis also incorporated the new frameworks of Harveian physiology, by building his explanations of the vital heat around the circulation of the blood.[43]

What proved most contentious, though, was Willis's application of the chemical-corpuscular model of ferment from the liquids of the laboratory to the noble, life-giving liquor of the blood. Indeed, the entire basis of Willis's account of fermentation relied upon his proposal of an analogous relationship between chemical spirits and those found within the blood. One of the primary ways in which Willis sought to justify this conflation of chemical and medical spirits was by noting the sheer scale of fermentation as an occurrence found throughout nature. As he reflects at the start of *Fermentation,*

> I thought I had been tyed only to the Bakers oven, and Brewers Furnace, being condemned to the Mill not to have proceeded beyond their limits, unless by chance, or with leave; but after that I had begun to look more deeply into the matter, I perceived I had gotten a far more large Province: Because it plainly appeared, besides these of Art, very many works of Nature, to be not only like, but themselves the effects of Fermentation. (Preface)

As Willis argued here, the concept of ferment was applicable to any 'Effervency or Turgency, that is raised up in a Natural Body, by particles of that Body variously agitated'

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[41]John Milton, *Paradise regain'd, a poem in IV books: to which is added Samson Agonistes*, 1st edition, vol.1 (London: Printed by J.M. for John Starkey, 1671), p. 619.

[42] Isler cites Willis as the next major point of innovation in the history of the concept after Van Helmont and Sylvius, p. 66.

[43] Frank Jr., *Harvey and the Oxford Physiologists*, p. 167. Anna Marie Roos has argued that the *Diatribae* introduced 'iatromechanism' into English medicine by combining physical and chemical explanations within the new Harviean physiology and alongside traditional Galenic therapeutics: *Salt of the Earth,* p. 113.

(DD, p.1). Many diverse bodies were 'apt to a Fermenting' – liquid or solid, animate or inanimate, natural and artificial – from wine to the blood. Any chemical body, that is, which contained a 'heterogeneity of parts or particles' (DD, p.1). By having rendered fermentation as a specifically chemical definition, based on particulate motion, Willis converted what would otherwise have been an analogy between these different substances into a shared feature: by his definition, a ferment is not a specific characteristic of any one kind of material body, but a *mechanism* shared between many. Conveying this greatly enlarged the scope of his examples, Willis also used ferment as a metaphor for the ambitious 'swelling' of his own work: 'I have brought into this Tract, as it were swelled up with a certain Ferment, the whole Provision, and Dowry of all Nature (Preface).

For Willis, the entire natural world was 'pregnant' with 'fermentative particles,' which operated as the agents of all generation, change and growth in nature. Each and every corner of it was busied with a perpetual motion and agitation, just as burrowing 'little Emmits in a Mole-hill' (DD, p.16). As Willis noted, by the 'varieties of Fermentation,' the reasons for 'the beginnings and endings of things' were to be sought (DD, p.2). The operations of the human body were no exception. Just as fermentation could be observed throughout nature, and replicated in the laboratory and, so it could be identified in the body. Willis stressed that these 'many works of Nature' provided him with a certain weight of evidence for his notion that the blood fermented 'just like' other, similarly mixed, chemical bodies. Clearly, the precise action of ferment in the blood (occurring between atoms) could not be directly witnessed or demonstrated and so its 'evidence' remained to an extent based on an analogy drawn between (and ultimately constituted by) some alternative chemical, laboratory-produced counterpart. Importantly, if Willis could propose that ferments in chemical substances occurred by the same mechanism as those within the blood, then the chemist's knowledge of ferments, through their experiments heating and distilling chemical substances, could have a key role to play in furthering medical knowledge. I will return to this discussion later in the chapter.

Problematically, it was unclear as to whether Willis was actually attempting to propose that liquors such as wine merely fermented *like* the blood or if they were being taken as the same event; this lingering ambiguity is left largely unresolved in Willis's text and

created a tricky and contentious path for him to tread with his more critical readers. While many natural bodies appeared to share in the fermentative mechanism Willis explored here – in that they might swell or grow hot - the blood, as a vital, life-sustaining substance in humans and the most subtle of all material bodies ultimately belonged to a different order to the common, gross matter of wine, bread or milk and needed to be somehow made distinct from them. Willis pre-empted the likely objections that would follow from those accusing him of 'prostituting unusual Notions…almost only heard of, in the shops of the Chymists' in respect of the noble substance of the blood (DD, 'Preface'). He nevertheless firmly stated the superior *explanatory power* of chemistry, above all other approaches, as a means of unfolding the 'nature and affections of the blood' (DD, p.3). He considered that the directly perceivable effects of chemical change in matter would better equip him – through his use of analogy – to furnish the reader with intelligible explanations on the hidden events of the blood. As he noted, chemistry allowed the philosopher to 'more easily' represent phenomena 'to the vulgar capacity, and lay them not only before their Eyes, but even into their very Hands' (DD, p.3). This picks up on a particular way of thinking about the work of analogy as a means by which the reader might 'see' a new object through the calling to memory of a familiar one, represented in the text – a model that Bacon has also discussed in relation to rhetorical invention in science.[44] This presentation to the eyes and hands of the reader was, importantly, supported by the fact that the effects of chemical changes in matter were a part of everyday life – from brewing beer to making cheese. Here, Willis appears to position his use of a chemical analogy with the blood as a device intended to support the 'vulgar' capacity of his *readers*; however, in his own writing, a reliance on chemical ferment as a *metaphor* for the properties of the blood suggests a much finer blurring of the boundaries between the image as cognitive support and as an idea which has since come to stand for the phenomenon under discussion.

Willis's application of chemical ferments as an explanatory framework for physiological and pathological events relied, ultimately, on the possibility of his applying a chemical analysis to the blood. As Willis set out in his *preface to the reader,* 'I thought best, the common acception of humors being laid aside, to bring into use these celebrated Principles of the Chymists, for the unfolding the Nature of the Blood and its affections'

[44] Francis Bacon makes an argument about the work of analogy in bringing objects more directly to the senses in his *The Advancement of Learning* (1605), see: *Francis Bacon: The Major Works,* ed. with an introduction by Brian Vickers (Oxford: Oxford University Press, 1996), Book II, pp. 26-43 (p. 42).

(DD, p.59). The blood according to Willis was, like all natural substances, comprised of the five chemical principles embodied within material atoms or corpuscles – this was an amendment of Aristotle's four elemental principles. Willis affirmed 'all Bodies to consist of Spirit, Sulpher, Salt, Water, and Earth' (DD, p.2). These elements differed in their levels of activity: Spirit, sulphur, salt were all highly active while water and earth were of a more fixed state.[45] Willis held that all chemical change occurred through a continuous process of forging new combinations between these particles, each of differing levels of volatility.[46] It was these processes of transformation in natural bodies that the chemists sought to replicate by heating, evaporating, condensing, distilling and separating liquid compounds into vessels. As Willis wrote, it was 'by an Analysis made by Fire,' that chemistry 'resolves all Bodies' into the five principles (DD, p.2). On this basis it could be proposed that the blood acted (and fermented) in a manner comparable to other chemical substances.

Chemistry was itself governed by an overarching anatomical metaphor: Willis proposed that the chemical hypothesis 'determinates Bodies into Sensible parts, and cuts open things as it were to the life', on which basis 'it pleases us before the rest' (DD, p.2). Like the anatomist, the chemist produces new knowledge by reducing a body into its component parts. As Willis wrote of the blood, 'there are therefore in the blood as in all Liquors, apt to be Fermented, very much of Water and Spirit, a mean of Salt and Sulphur, and a little of Earth' (DD, p.59).[47] Moreover, by conceiving of the blood as a chemical compound, this allowed him to suggest that it could be subjected to the same modes of analysis as other chemical substances – including heating and separating it into its constituent parts. The nature of the blood - as a mixed chemical compound, rich in spirit and sulphur - was a key part of Willis's explanation of the blood's constant and self-perpetuating ferment. These chemical ideas did not merely represent devices to be used in illustrating a set of related yet distinct ideas to Willis's readers; they formed a set of shared experimental practices applied to the blood in the same manner that they

[45] Audrey Davis has argued that Willis's concept of abnormal fevers was based around his five chemical principles, itself an extension of Paracelsian iatrochemistry: 'Some Implications of the Circulation Theory', pp. 28-39.

[46] Chapman notes that all chemical change in the seventeenth century was characterised by the 'ceaseless wrestlings' of atoms: 'Alchemy to Airpumps', p. 37.

[47] This was an amendment of older elemental theories see: Jan Prins, *Walter Warner (ca. 1557-1643) and his Notes on Animal Organisms* (PhD thesis: Utrecht, 1992). Audrey Davis notes that in the second half of the seventeenth century many physicians in England, including Walter Charleton, Francis Glisson, and Thomas Willis shared the same opinion on the elemental composition of the blood, 'Some Implications,' p. 73, 82.

would be used in an examination of wine or beer. This approach went someway to justifying Willis's use of analogous comparisons between ferments in the blood and other volatile, chemical liquids - such as with wine, as the next section explores.

The vital flame as ferment

Despite the association with a violent tumult or commotion, Willis considered ferments to be a natural and constant condition of the blood. It was the chief mechanism by which he sought to explain its organic heat, effervescence, motion, consistency and certain pathological conditions. Above all, though, ferments were a means of explaining the vital heat of the blood – upon which all life, motion and sense depended – without recourse to a discernable flame or fire.[48] As Willis noted, ferment came from the word 'Ferviment', or 'growing hot,' from the Latin root *to boil* (DD, p.1). The blood's heat and effervescence was explained by Willis in terms of a nitro-sulphurous ferment, which occurred, he argued, when heavier sulphurous particles (introduced by digestion) and nitrous particles taken from the air in respiration were joined with alkaline salts or spirits contained within the blood - much like ordinary flames received fuel and were sustained by the air.

This ferment in the blood originated with a 'chief ferment' placed by nature within the ventricles of the heart. The 'vital flame' induced or 'inkindled' a ferment among the spirits of the blood, which was renewed each time they circulated through the heart. A fermentative heat was thereby transported to all parts of the body by the continuous circulation of the blood. As Willis wrote, 'the first beginnings of Life proceed from the Spirit Fermenting in the Heart, as it were in a certain little punct,' which in this case referred to the centric point of a geometric system or model (DD, p.13). Drawing on experiences from the kitchen and laboratory, Willis explained this process in the heart as occurring 'much like Water boyling over a Fire,' and as a process that was ignited within the 'chimny' of the heart (DD, p.13). This was explicitly a chemical event, as Willis described the effect on the blood in terms of the loosening of the bonds between spirit, salt and sulphur, which allowed them to break apart and form new bonds.

[48] Frank Jr., *Harvey,* p. 168.

In these discussions, Willis effectively recast the much older notion of a vital flame – commonly used to convey a notion of organic heat and a life force in the blood or heart - in the language of chemical corpuscular philosophy. The 'flame' becomes a metaphor for the literal process of particulate commotion or ferment, rather than a literal representation of fire or an innate heat in the solid parts of the heart, as per Descartes' mechanical theory.[49] Though ferment in this context was itself an analogy – in that it transposed observations from chemical substances to the hidden events of the blood – in the case of the vital heat, fermentation was employed as the *actual mechanism* underlying the analogy or metaphor of the vital flame. Willis frequently sought to make clear that the fermentative event behind the 'vital flame' was only like or 'akin to' domestic flame or fire, notably establishing it as a distinct form of combustion (non-destructive) based upon his particulate model: a fire without flame. As Frank has argued, Willis's chemical theory of fermentation had obviated the need for an *actual* flame by explaining the production of heat as a particulate agitation.[50] Willis drew upon many traditional terms and images in his discussion, but his idea of 'enkindling' the vital spirits of the blood was substantially new and chemically defined.[51] In referring to the heart as a 'hearth', 'furnace' or 'fireplace,' Willis conveyed the *conditions* under which heat was applied to the blood, just as it was in the furnaces of the laboratory when heating wine – but this did not necessarily demonstrate the presence of a literal flame in the blood itself.

Despite these assertions, Willis continued to (heavily) employ what was viewed as the traditional language of the vital flame and fire, such as when he spoke of the blood growing 'impetuously hot and as it were inkindled into a flame.' Willis certainly stressed a significant degree of proximity between ferments and the flame of the chemist, in terms of their shared effects and outcome. He used the terms almost interchangeably in his discussions: ferments are like a 'flame put to wine' while the 'alteration which the blood receives in the Heart, may be equally deduced from a flame, or a Nitrous Sulphureous ferment' (DD, p.66). Just as the flame in the kitchen or the chemist's fire acted on and transformed matter, the vital heat in the blood gave rise to all organic changes, growth or decay in the body. This language was more a means of translating Willis's familiar experiences and practices in the laboratory to the body, than it was indicative of his belief in an actual flame or fire. The use of this analogy was, however, far too vague for some

[49] Frank Jr., p. 291.
[50] *Ibid,* p. 165.
[51] *Ibid,* p. 190.

contemporary commentators and a number queried whether the flame was being taken in a literal sense by Willis. These debates were properly addressed by Willis in an amendment featured in his later work during the 1670s, and will be returned to in greater detail in chapter five.[52]

The resulting state of a boiling 'tumult' or 'turgency' within the blood, its swelling and expansion, similarly helped Willis to express the energy or force granted to the blood for its circulation about the body. Drawing here on topographical analogies, Willis expresses how when the blood is delivered to heart by the veins it is 'running gently like a River,' where after contact with the ferment, it becomes 'like a Torrent' with 'noise and rage' (DD, p.13). As Willis notes in the second tract on fevers, this fermentative force ensured that the blood 'might be carried forward to all the parts of the whole body' (DD, p.65). Willis therefore uses chemical ferments at least as a supplement to Harvey's mechanical metaphor of the heart as a pump in explaining the circulation of blood. Willis still employs a mechanistic explanation here in that ferments involve the physical properties and motion of particles, but it is also explained by recourse to the specific chemical properties of certain particles. Certainly, Willis talks elsewhere about the blood being 'wheeled about after a constant manner, as it were in a water Engine' (DD, p.64). We therefore have two different types of analogy – one chemical, one mechanical – being used to express the same thing (the circulation of the blood) in different parts of the discourse. These were not mutually exclusive analogies, as they refer to different aspects of a complex model – they nevertheless complicate any straightforwardly mechanistic reading of Willis.

Chemical analogy: blood into wine

Willis's model of ferments in the blood was primarily built upon an analogy that he sought to establish between the chemical properties of spirits in blood and those found in wine. As he observed, ferments were chiefly met with in the blood as in 'the working of Wine, and of other Liquors' (Preface). Willis identified rich wine as a similarly volatile

[52] Robert Boyle and John Mayow were especially hostile to Willis's explanation of the vital flame, which Boyle directly attacked in his *The Sceptical Chymist* (London, 1661). On these debates see: Antonio Clericuzio, 'The Internal Laboratory: The Chemical Reinterpretation of Medical Spirits in England (1650-1680)', in *Alchemy and Chemistry in the 16th and 17th Centuries,* ed. by Piyo Rattansi and Antonio Clericuzio (Dordrecht; Boston: Kluwer Academic Publishers, 1994), pp. 51-83 (p. 65-6); Ann Thomson, *Bodies of Thought: Science, Religion, and the Soul in the Early Enlightenment* (Oxford: Oxford University Press, 2008), pp. 80-81.

liquid and proposed that both liquids were very much inclined to ferment (to a comparable degree) when heat was applied. The appropriateness of the wine analogy was defended by his noting that, 'excepting the Blood of Animals, there are no Liquors that grow hot, like Wines,' and in no other substances were there to be found such a supply of spirits, salt and sulphur (DD, p.23). What this meant was that the results produced by heating and experimenting with wine in the laboratory came closest to what Willis conceived of as the qualities of the blood, from his (limited) experiments on it, in terms of its notable effervescency and self-producing heat. The self-perpetuating ferment in the blood was, for example, 'continually conserved; as is perceived in Wine, Beer, and other Liquors' (DD, p.58). Wine *behaved* in a manner that fitted with and represented Willis's physiological ideas about the blood – effervescency and heat were features already conceptually tied to the blood, which Willis was attempting to demonstrate (rather than discover) in a new *chemical* context through this useful analogy. The comparison of the blood with wine - especially as a context for thinking about the blood's vital and life-sustaining properties – clearly also drew on one of the most significant cultural repositories for imagery and metaphor in this period: the Bible. Its use in this context helped to plug a discussion of hidden and difficult chemical processes into the much more familiar and resonate language and imagery of liturgical life.[53] It was no great leap to think about the blood and wine as sharing in a symbolic resemblance, though it was far less clear to what extent this was to function as an analogy in the sense that Willis employed the comparison.

The comparison with wine proved to be a central organising analogy, which helped unite Willis's explanations across the tract on ferments and fevers. The visible and violent effervescence of wine and its explosive ability to break apart containing vessels – either when heated in the laboratory or left to ferment too long in barrels – notably informed Willis's discourse on fevers. He noted, for instance, that when 'new Wine, or new Ale or Beer, be closely Bottl'd up, or put into Vessels of small vent, they will grow so very hot, that often the Vessels are in danger of breaking' (DD, p.1). This provided Willis with a

[53] On the Bible as a rich source of narrative and imagery within representations on the early modern stage see: Helen Wilcox, 'Biblical Presences in Shakespeare's Tragicomedies,' in *Early Modern Drama and the Bible: Contexts and Readings, 1570-1625,* ed. by A. Streete, (London: Palgrave Macmillan, 2012), pp. 48-67 (p. 51). As Wilcox notes, the Bible was 'a major source of English vocabulary and style, rich in metaphor, turns of phrase and varieties of rhetorical forms.' This familiarity was enhanced with the addition of the newly translated vernacular edition in this period. On the relationship between the body (as a source of evidence about nature) and religious metaphor in this period see: Peter Harrison, 'The Book of Nature and Early Modern Science,' in *The Book of Nature in Early and Modern History,* ed. by Klass van Berkel and Arjo Vanderjagt (Leuven: Groningen Studies in Cultural Change, 2006), pp. 1-26 (p. 6).

fitting and accessible analogy by which to express the symptomatic experiences of a fever, long expressed in terms of boiling or 'raging' of the blood. Fermenting liquors of wine and beer were particularly useful analogies to draw upon here as they were also familiar and common phenomena.

The perceived proximity of bodily spirits with those found in wine (in terms of their states of volatility and reactivity) was reinforced or demonstrated by the commonly observed association between alcohol consumption and cognitive impairment. This relationship suggested the susceptibility of bodily spirits to reactions with the spirits contained in wine. As George Acton remarked in 1668, writing about Willis's work on fermentation, 'wee see how soon a little Spirit of Wine cheers and quickens the vital Spirit, by mingling it self presently with it by reason of their Analogie.'[54] Moreover, according to the logic of the comparison, wine responded to the introduction of certain chemicals in a manner analogous to the blood's own response to diet and other ingested substances or medical preparations. Just as salt 'fixes' wine in the alembic (making it less volatile), so the 'Blood, being become salt, by means of an ill dyet, becomes less Spiritous' (DD, p.7). This extends the analogy from the shared effects of ferments within wine and blood (as in heat or effervescence), to offer up a chemical framework for pathological explanations and even a model for medical care of the body – as I return to shortly.

Besides wine, Willis also drew upon analogies from the domestic and agricultural setting to express his theory of fermentation. Ferments were commonly implicated in the coagulation of milk, making cheese or baking bread. Willis thus noted that milk and blood both soured and became 'corrupt' when spirits and sulphur 'fly away' from the mixture (DD, p.5). In his tract on fevers also, Willis identified 'a similitude of it with Milk,' which he used to explain coagulation of the blood into separate parts in instances of disease or post-mortem (DD, p.62). Taking wine and milk together, Willis further noted that the 'Analogy of it with Wine and Milk is yet further confirmed by the use of them in our diet, out of which the blood is generated' (DD, p.63). He observed that babies require milk for nourishment, while wine energises and 'restores' the vital spirits in the old. These comparisons were, Willis stated, 'sufficient' for showing the kinds of particles and substances comprising the blood. What he underlines here is that these

[54] George Acton, *Physical reflections upon a letter written by J. Denis…concerning a new way of curing sundry diseases by transfusion of blood* (London: printed by T.R. for J. Martyn, 1668), p. 8.

chemical substances were not so distant from the body after all; they impacted on everyday lived (or embodied) experiences, as substances that were literally assimilated into the body as part of its nourishment and fuel.

This use of common substances from the domestic sphere supported Willis - as much as his readers - in attempting to comprehend alien and hidden events inside the body. As he observed, the 'principles of the blood' would 'better appear' by the comparison with liquors that are 'in dayly use among us' (p.59). It was on this basis that Dewhurst argued in the 1980s that Willis had effected a 'farmyard empiricism', on the grounds that he 'frequently argued by analogy, particularly those based on farmyard empiricism involving various forms of fermentation taking place in the kitchen, brewhouse, dairy, orchards, stables and fields of his North Hinksey farmhouse home.'[55] Of course, Willis was not simply restrained to the kitchen or farmhouse, but significantly rooted his discussion of ferments in the setting of the laboratory – as I have noted in respect of his use of the wine analogy. As Don G. Bates argued (using Willis's own analogy), in adopting new iatrochemical explanations Willis poured 'new wine' into 'old bottles' and conjured 'up the laboratory rather than the kitchen.'[56]

Ferments and Fevers: medical applications

It was in Willis's tract on fevers that the full medical implications of his new chemical definition of the blood and fermentation were set out. Though Willis indicated that his tract, 'Of Fevers' was founded on his extended observations and case histories of febrile diseases in his patients, what it essentially did was to apply his new model of ferments to these experiences. As Willis declared, 'every Disease acts its Tragedies by the strength of some Ferment.' Fevers were, he stated, the 'chief instance' of ferment (DD, p.16). Chemical ferments would, therefore, stand in place of the four humors at the centre of Willis's disease categories.[57] All diseases were ultimately understood by Willis as a perversion of natural ferments in the blood. Under normal conditions, fermentation occurred in a consistent and moderate manner, affecting a 'natural' heat. This worked to maintain a healthy consistency of the blood by separating out and burning up any

[55] Thomas Willis, *Willis's Oxford Lectures*, ed. by Kenneth Dewhurst (Oxford: Sanford Publications, 1980), p. 155.
[56] Bates, *Fevers Literature,* p. 50.
[57] Andrew Wear, *Knowledge and Practice in English Medicine, 1550-1680* (Cambridge: Cambridge University Press, 2000), p. 362; Chapman, 'Alchemy to Airpumps', p. 37.

unwanted substances that had been introduced. However, if from poor diet or internal fault (i.e. faulty digestion), the chemical composition of the blood became improperly balanced or 'corrupted', then a preternaturally vehement commotion and boiling heat would follow. A diet rich in sulphur, for instance, made the spirits more volatile and created a more vehement ferment. As he described,

> The Liquor of the blood, continually boils up with their effervescency or growing hot […] if any Heterogeneous thing, or unagreeable to the mixture, be poured into the bloody mass, presently the Spirits being disturbed in their motion rage, shake the blood. (DD, p.59)

The primary outcome of this event was a fever, which Willis described as 'a Fermentation, or immoderate Heat, brought into the blood' (DD, p.57). The internal motion caused by a fever was considerably violent, and 'as it were truly an intestine war of the blood' (DD, p.64), 'intestine' here meaning something that was internal, referring to the activity of particles contained within the body.[58] Besides faulty digestion, poor diet or some poisonous matter, the heart could also be said to be at fault, when it inkindled the blood too much 'as it were by fires put under it' (DD, p.65). Fevers, then, were an ever-present and lingering threat to the healthy equilibrium of the body. They could arise from a number of causes, but in each case a disruption of the blood's 'natural' ferment was the result.

We see in Willis's Oxford lectures especially, given in 1661, how these ideas shaped his medical approach, which held a particular focus on pathologies associated with the brain and nerves. As Willis had already noted, it was from fevers that the 'great vices of the Natural oeconomy or Government' arose – a metaphor that carried striking overtones in a period that saw society scarred by religious and political ferment and discord (DD, p.57).[59] In his lectures, Willis expanded on the direct consequences ferments had for the brain, being implicated in various states from frenzy, delirium, melancholia, mania, and epilepsy to stupidity. He described, for example, how the circulating blood carrying the 'taint' of feverish imbalances introduced 'heterogeneous matter' that 'boils and swells in the brain,' making it 'completely unsuitable for the cortical regimen' as it 'incites the

[58] "intestine, adj.", *The Oxford English Dictionary Online*, March 2016.
[59] The metaphors of 'oeconomy' and 'government' are discussed in relation to this political context in chapter five of this thesis, p. 193.

spirits to various distractions' in the nerves.[60] Willis also took passion states more generally, such as 'anger, sudden passions, terror, joy, intemperance, drunkenness, immoderate exercise,' as being conditions that could give rise to (as well as be caused by) ferments.[61] Notably, in his approach to treating these pathologies, Willis reasserted the value of chemical analogy, noting that the causes of melancholy, for example, must in the first instance be sought in the analogy between animal spirits and those spirits 'extracted by chymical means.'[62] Any investigation into their causes, effects and treatments was to be guided by chemical analogy.

The language that Willis used to discuss fevers drew directly on his experiences in the laboratory investigating ferments. Fevers, he noted, were exacerbated by adding too much of one substance to a mixture, or when too strong a fire is used, while the blood would 'boil over' as with the 'pot' sat upon a stove. Of course, if the ferments of wine and those of the (diseased) blood were accepted as behaving in comparable ways, as similarly volatile chemical compounds, then the chemist was to be granted a measure of authority in the forwarding of medical explanations. Willis even declared that he could unfold the 'Curatory intentions,' effects and operations of every medicine according to the 'Doctrine of Fermentation' (DD, p.16). Specifically, Willis continued to refer to processes and observations involved in heating and experimenting with wine. Fevers were, he repeatedly stated, 'best illustrated by an example of Wines growing hot' (DD, p.66). In ever more explicit detail, he describes how,

> The Constitution of the Blood in a continual Feaver, is of the same sort as of Wines, when they grow hot […] in an Intermitting Feaver, the Blood is moved after that manner, as Wines […] Moreover, in this Feaver, the disposition of the Blood is of that sort, as of Wines, when in their decay and declination, they become ropy, unsavoury, or acid (DD, p.90).

As we can see here, Willis effectively used levels of fermentative activity in the spirits of the blood to establish a spectrum on which to plot out the boundaries between normal

[60] Willis, *Lectures*, ed. Dewhurst, p. 85.
[61] Willis, *Lectures*, p. 82.
[62] Willis, *Lectures*, p. 122. John Locke made a personal copy of these lectures from his notes, which are still held at the Bodleian library – on this see Dewhurst's introduction to the *Lectures* and Frank, *Harvey,* p. 182.

and pathological states.[63] He attempted to classify different types of fever (continual, intermittent) according to a schema that was, moreover, directly lifted from the different states or stages involved in the production of wine. Importantly, out of this discourse, emerges another related analogy: the work of the physician becomes analogous to that of the vintner.

The physician-vintner

Like the vintner tending to wine, the task of the physician was, according to Willis's comparison, to manage and maintain healthy ferments within the blood. As Willis noted, the vintner's art offered up an analogous model:

> Yea we also endeavour the Cure of Diseases by the help of Fermentation: For to the preserving or recovering the Health of man, the business of a Physician and a Vintner, is almost the same: the blood and humors even as Wine, ought to be kept in an equal temper and motion of Fermentation. (DD, p.16)

A moderate, well-managed ferment acted to maintain health; it sustained a requisite level of heat and could act as a 'cure' in burning up any unwanted and potentially harmful matter introduced to the blood. Blurring professional boundaries still further, Willis even discussed the 'physical science' taught to the vintners as comparable to a 'Method of Medicine' (DD, p.23-4). Interestingly, Willis allows the analogy to extend in the opposite direction too by referring to the condition of wine in medical terms – he notes that when the vintner purges wine of its impurities, its own 'sickness may be healed' (DD, p.23). Wine gets 'sick' in the same sense that the blood 'ferments', in the respect that their 'fault' is rooted in the same mechanism (a chemical imbalance).

Despite his chemical explanation of these events, Willis continued to advocate largely traditional Galenic therapeutics, such as blood letting and purges in instances of fever - perhaps because of the limits of as yet unproven chemical preparations, or because of the more orthodox expectations of patients. He nevertheless advocated these familiar

[63] Frank has argued that, for Willis, ferments were the 'key to unlocking' the 'medical benefits' of Harvey's new theory, *Harvey,* p. 167. Chapman has also argued that an understanding of ferments structured Willis's medical approach, 'Alchemy to Airpumps,' p. 37.

practices according to the discourse of his new fermentation model – that is, by the language of wine production. For instance, he affirmed the usefulness of blood-letting (in specific stages of a fever) by noting that 'when the blood grows too hot, even as Wine, it is usual to empty some out of the Vessels, and to ally its Fervor with temperat things' (DD, p.16). When the blood 'grows less hot that it should do,' the physician should apply 'Cardiacks, Digestives' to restore fermentation in the blood 'no otherwise than Wines growing sour […] are mixed with more rich Lees, whereby they may purge or grow turgid anew' (DD, p.16). Here, the professional discourse of the physician and the vintner merge.

The wine analogy was projected, then, from the vintner's craft, via the laboratory, to the fevered body of the patient – a series of intellectual leaps shortened by the capacity of the wine-analogy to encapsulate widely held notions around fever as a violent heat or raging of the blood. The analogy, supported by the noted effects on wine on an individual's constitution, was an effective one: George Acton writing in 1668, cited Willis's 'excellent' treatise on fermentation and affirmed the analogy between wine and the blood under a fever: the 'motion in the Wine (as in our case of the fever) is stir'd up by the natural force and activity of its Spirit […] the scope of Nature is the very same in the fit of a fever.'[64] Properly speaking, the physician-vintner analogy worked in so far as the intellectual activities of the iatrochemist – mapping chemical-corpuscular explanation onto the body of the patient - made ferments in wine and the body the same *kind* of event. This comparison was not in itself new; Don Bates notes, for instances, that the comparison with wine-making and bodily processes was itself Galenic.[65] The degree to which Willis relied upon the analogy in his explanations was, however, certainly distinctive. As were the implications that he drew from the comparison, namely that the blood really was a chemical compound (rather than a composite of humors), which acted and fermented in a manner so closely united with wine as to be barely distinguishable.

Willis's doctrine proved to be highly influential. Summing up his influence in this matter, in 1684, Robert Boyle invited his readers to consider 'how ordinary it is, especially since the Learned Dr. *Willis's* Writings came to be applauded, to look upon Fevers as

[64] George Acton, *Physical reflections,* p. 5.
[65] Bates, *Fevers,* pp. 45-70.

inordinate Fermentations of the Blood.'[66] However, as I will now show, Willis's doctrine aroused strenuous opposition from some of his contemporaries, much of which centred around the appropriateness (or not) of employing chemical analogies in a medical context. In particular, the close proximity between wine and the blood invited especially critical responses.

Chemical analogies and medical contexts

On the one hand, the spirits of the blood needed to be defined as physical, chemical corpuscles in order to justify investigating their powers along physiological lines. On the other, they needed to remain distinct enough from other types of matter, so as to be situated as a special kind of *vital* matter – that is, as material bodies which performed the life-sustaining operations of the corporeal soul in the body. Willis would have needed to tread a fine line between advocating his chemical-corpuscularian models whilst simultaneously avoiding charges of materialist heresy, which is discussed in more detail in chapter five. These tensions are relevant here in that they framed some of the more critical responses to Willis's doctrine on fermentation. His evident reliance upon the analogy between spirits of wine and the blood in the tract raised the troubling prospect that Willis had failed to maintain a proper distinction between the subject and its object of comparison; that the spirits of the corporeal soul were, in fact, being taken as interchangeable with crude and base liquors. The comparison was so heavily utilised as an explanatory resource, that it is indeed difficult to see precisely where they (blood and wine) might have separated.

Willis's import of terms and explanatory categories from experimental chemistry to forward new physiological theories represented, for some, a serious transgression of disciplinary boundaries and posed a direct threat to a still largely Galenic medical establishment.[67] John Betts, for example, argued in his *De Ortu et Natura Sanguinis* (1669) that the chemists had 'subverted' medicine and that chemistry was only useful if kept within its own bounds.[68] Medicine, he argued, should follow Aristotle and Galen.[69] In

[66] Robert Boyle, *Memoirs for the Natural History of Human Blood, especially the spirit of that liquor* (London, 1684), p. 102.
[67] Hawkins writes that Willis took concepts almost exclusively found in the chemist's laboratory and 'turned them into the essential foundation of medical knowledge': 'Piss Profits', p. 17.
[68] John Betts, *De Ortu et Natura Sanguinis* (London, 1669). Quoted by Clericuzio, 'The Internal Laboratory,' p. 61.

having publishing his chemical theory of the blood, Willis had of course rejected the prevailing humoral definitions of the blood and invited the censure of Galenic physicians. Interestingly, Betts thought physicians could safely prepare chemical remedies but not use chemistry in formulating medical theory.[70] What this suggests is that the issue was one of policing professional interests – of defending medical practice from the new chemical philosophy. Willis's use of chemical analogies in his medical explanations threatened the authority claims of rival groups. This is not to say that Willis did not continue to employ aspects of humoral pathology or retain certain Galenic frameworks, but that his chemical analysis of the blood and fevers was sufficient to gain him a reputation for having set out a challenge to Galenic orthodoxy.

By far the staunchest attack came from the Irish Galenic physician, Edmund O'Meara, who publically objected to Willis's comparison between chemical and medical spirits in all its forms.[71] Chemical analogies, O'Meara argued, had no place in medical explanations. A fellow of the College of Physicians since 1664, O'Meara launched an attack on Willis's *De febribus* in his infamous *Examen diatribae Thomae Willisii* (1665). In it, O'Meara asked why it was that Willis had confused medical spirits with those extracted by chemical distillation – a direct challenge to the use of chemical learning in medical contexts.[72] Reflecting the broader struggles between the chemical physicians and orthodox Galenists, O'Meara claimed that the experimental chemists had made a 'pretence of wisdom' in medicine merely by the trick of 'inventing new terms' – that is, by (analogously) applying chemical terms to new objects. He declared Willis's definition of spirits and fever vague and inadequate, suggesting that fever was an incorrectly applied term.[73] Where Willis saw fevers as arising in the blood (as a chemical event), O'Meara believed that fevers were situated in the solid parts of the body as a form of innate heat.[74] Much of the force of O'Meara's ire came from Willis's failure to follow the strict logic of scholasticism, rather than an engagement with the substance of his arguments.[75]

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[69] *Ibid*, p. 61.
[70] *Ibid*, p. 61.
[71] J.B. Lyons, 'O'Meara , Edmund (*c.*1614–1681)', *Oxford Dictionary of National Biography Online,* ed. by Lawrence Goldman (Oxford: OUP, 2004). Clericuzio, 'Internal Laboratory,' p. 61.
[72] Edmund O'Meara, *Examen Diatribae Thomae Willisii…De Febribus* (London, 1665), pp. 59-60.
[73] Dewhurst, *Vindicatio,* p. 294. On Conlan Cashin's defense of O'Meara see also p. 326.
[74] Frank, *Harvey,* p. 189.
[75] On O'Meara's objection to this comparison see: Clericuzio, p. 61.

In addition to O'Meara's claims, some notable chemical-corpuscular philosophers (who were more closely linked to Willis's interests) also challenged the level of chemical accuracy in his use of the terms spirit and ferment, while nevertheless still accepting the use of chemical explanations in principle. Some of the more substantial criticisms aimed at Willis came from Walter Charleton, a learned physician and physiologist who directly engaged with Willis's neuro-physiological ideas. His concerns, in contrast to those of O'Meara, centred on the choice and suitability of Willis's analogies, in terms of how they reflected certain structural interpretations of the brain.[76] While Charleton's criticisms were significant, he did not dispute Willis's use of chemical analogy but challenged how those comparisons were to be properly applied and interpreted. For instance, in his *Three Anatomic Lectures* (1683), Charleton refuted Willis's theory by claiming that the blood was the liquor least likely in itself to ferment, 'bearing a greater analogy to the nature of Milk, than to that of Wine, whatever the Willisians have said to the contrary.'[77] He accepted that certain ferments occurred in 'preternatural' fevers of the blood, but that this was still less common than 'vulgar physicians' would like to imagine. [78] The analogy with wine, of course, had been selected with Willis precisely because of its notable inclination to ferment.

A further charge made by Charleton was that Willis had used ferment - as an analogy applicable to any tumult in wine or the body - much too loosely. He attacked Willis's theory of fermentation for its 'its explanatory inadequacy' but also because of 'its adoption as a factotum' - a master of everything.[79] The charge here was essentially that the term was being employed to express a variety of unconnected or superficially related events, rather than as a way to name and express *specific* chemical phenomena in the body. This created an over-emphasis on points of similarity, at the expense of empirical accuracy. This is, of course, what analogies do: they isolate some points of similarity whilst obscuring other points of divergence. Echoing these charges in the late 1960's, Willis's modern biographer Isler similarly concluded that 'the term *ferment* is not clearly defined in his [Willis] book' and is used 'with varied connotations, according to the

[76] Michael Hawkins has thoroughly examined Charleton's objections to Willis's account in his doctoral thesis, *The Empire of Passions: Thomas Willis's anatomy of the Restoration Soul* (PhD Thesis: University of London, 2004), p. 23, pp. 193-4. He notes that while he appeared to critique structural details, he did so on the basis of their moral implications, a topic that I return to examine in chapter five of this thesis.
[77] Walter Charleton, *Three Anatomic Lectures* (London: Printed for Walter Kettilby, 1683), p. 6.
[78] *Ibid.*
[79] Emily Booth (ed.), *A subtle and Mysterious Machine: The Medical World of Walter Charleton (1619-1707)* (Dordrecht: Springer, 2005), p. 184.

context.'[80] Again, this is because, for Willis, ferment was an explanatory tool used for describing a process of particulate commotion (rather than a specific quality tied to any one subject). This could, in theory, be applied to any agitated particles contained within a body. While the definition obviously relied upon the presence of certain chemical characteristics (i.e. volatility, heterogeneity), the precise nature of a substance could vary and yet still be said to have fermented. The whole basis of Willis's argument had been that ferments between wine and the blood were a viable comparison because the phenomenon of ferment united a huge variety of natural and artificial events.

This scope was clearly a problem for Willis's contemporaries; it came close to the mapping out of correspondences and sympathies in nature, with its focus on what could connect up disparate events, rather than on the specific empirical attributes of the subject in hand. For Robert Boyle and John Mayow, that the phenomena of spirits and ferments could be so widely and loosely applied was a significant problem. Willis's application of the category of ferments and the term spirit to any volatile body that effervesced and experienced a 'turgency', the blood included, was a particular source of contention here. Willis would therefore come under increasing pressure, moving into the 1670s, to more closely define his use of the category of spirit. Boyle and Mayow asked *exactly* what the (vital) spirits were made of and called on Willis to adopt a stricter chemical definition of the 'vital flame' (i.e. as the actions of ariel nitre), rather than rely on the general mechanism of ferment to express the phenomena. The vital flame analogy remained useful: it carried with it certain continuities with traditional medical tropes, which would help make his new chemical-corpuscular explanations intelligible and recognisable. Moreover, the flame (an everyday phenomenon) was a more accessible vehicle for expressing the quite abstract notion that particulate commotions equated to organic heat. These arguments were properly addressed in Willis's later publications – they are touched upon here to the extent that they highlight the difficulties Willis faced in forwarding new and difficult chemical explanations within existing medical discourses.

For Willis's supporters, the highly polemical attacks issued by the likes of O'Meara represented a deliberate misreading of Willis's use of the notion of ferment. Nathaniel Hodges (1629-1688), a collaborator within the Oxford Philosophical Club, used the flexibility involved in Willis's definition to support the import of chemical discoveries

[80] Isler, p. 65.

into more traditional medical frameworks. He publically defended Willis on the grounds that he had used ferment *only* as a useful analogy with respect to the blood.[81] Referring to the 'learned Treatise of Doctor Willis' on fermentation, which 'hath fully satisfied very many scruples,' Hodges wrote in response to a polemical pamphlet published by the empirical chemical physician Marchmount Nedham against the Royal College of physicians (including Willis).[82] He noted that Willis had only proposed that 'atomical effluviums' act '*Analogously to ferment,'* and criticised Needham for misconstruing Willis: 'for in the whole I observe he *misapplies* the *design* and *intent* of those *learned Authors* he cites."[83]

Willis, for his part, had consistently noted that the blood was not identical to wine and could be said only to *behave* like wine under certain conditions. Despite Hodges' defence, the blood really did *ferment* according to the chemical-corpuscular terms set out by Willis. But, crucially, it didn't necessarily ferment in exactly the *same way* that wine or beer does. As Willis noted, wine and blood ferment 'after a like (tho not wholly the same) manner' (p.67). Wine was as proximate as it was possible to get in respect of the chemical character of the blood, yet, as fine as the gap between them was, it was still there. Though Willis was not explicitly clear about where these vital differences lay, what these debates failed to acknowledge was that Willis's account included some important (if nuanced) distinctions between spirits of the body and other kinds of chemical spirit - so as to safeguard the superiority of the former. These distinctions related to Willis's discussion of the role of the heart and the brain in supporting chemical processes in the body, as the next section examines.

Ferments and the body

Despite the arguments put forward by Willis's critics, he did in fact propose important distinctions between the nature of chemical and medical spirits in the body. One of the chief ways in which this was addressed was through the role of the body itself. Willis not only mapped chemical principles onto specific physiological events, but also looked to support those analogies by representing the anatomical design of the body as a form of

[81] Frank, *Harvey*, p. 240.
[82] Nathaniel Hodges, *Vindiciae medicinae et medicorum: or an apology for the profession* (London: Printed by J.F. for Henry Brome, 1666) pp. 149-150. See also, Bates, p. 61.
[83] Hodges, *Vindiciae medicinae,* p. 150.

chemical apparatus. In his tract on fermentation, the body reveals itself as a structure designed to operate as a site of chemical processes and operations. Ways of conceiving of a relationship between (anatomical) form and (physiological) function therefore played a considerable role in supporting Willis chemical arguments.[84]

On the one hand, the body conceived of as proto-laboratory underpinned the wider analogy between chemical and medical spirits as they could be taken as bodies that were produced by or subject to the same kinds of processes and conditions. Willis could propose that the spirits of the blood were of a chemical kind – and could be studied by the chemist's methods - precisely because the body revealed its own design as a chemical apparatus. By another reading, it could be said that Willis used the unique design and role of the body as a means of *separating* ferments in blood apart from all other forms of chemical ferment. Importantly, the brain – as the seat of a corporeal soul - performed its 'chymical' operations far beyond the skill of human artifice. The spirits of the body – and their medical ferments - were therefore of a similar but ultimate superior kind. In a sense, the chemist's art replicated this superior and original work of nature.

The first part of this argument concerned the role of the heart. While it performed its role in a manner analogous to a 'flame put to wine,' as a furnace or 'fire-place,' Willis also established the heart's vital ferment was unique in nature. Firstly, it was ignited (at the point of generation) by nature itself and represented a continuous and self-maintaining life-force, sustained for as long as the organism lived. Secondly, it imparted a ferment of particular force and energy unmatched in other chemical substances or artifice. As Willis notes, when the blood 'enters the Ventricles of the Heart, there suffers a greater effervescency,' on which the vital heat of organisms depended (DD, p.59). Accordingly, the speed and effervescency of these spirits was always 'above what is in Wine,' as they derived their energy from the 'Ferment of the Heart' (DD, p.59). The fermentative power of the spirits in the body thus exceeds any comparative liquor found in nature. This helped Willis to explain how the motion of ferments in animals differed from that observed in vegetables – the latter being 'slow and insensible,' whereas in animals it was rapid and 'conspicuous to the Eyes.' This demonstrable effervescency was also

[84] On Willis's concept of the relationship between form and function in his work see: William F. Bynum, 'The Anatomical Method, Natural Theology, and the Functions of the Brain,' *Isis,* 64.4 (Dec., 1973), pp. 444-468 (p. 450).

commonly observed in wine, which is why Willis so often used it as a point of comparison, yet Willis maintained that the heart's 'chief' ferment was ultimately superior.

Where Willis *was* explicit about the distinctiveness of bodily spirits, however, was in his discussion of the brain's work in producing or 'procreating' the animal spirits. Willis presupposed that the animal spirits represented the highest and most subtle form of spirit and that they were exclusively seated in the brain and nerves. They were, he would argue, the primary instruments of the corporeal soul in man and were responsible for all acts of life, sense and motion. He conceived that these spirits were created out the raw spirituous materials carried by the blood from the heart to the brain. For Willis, this process was expressed through the work of the brain as a distillatory organ, meaning that it worked to distil and extract subtle spirits from the larger or gross particles of matter contained within the blood.[85] By a localised ferment inside the brain, these spirits were further refined and subtilized by its operations. The resultant animal spirits were thereby made 'fit' for the works of animal government and were extended to all parts of the body through the nerves and blood. Whilst spirits of wine were both agile and volatile, the animal spirits of the blood were uniquely refined and volatilised, having been perfected by the brain's distillatory processes. The nature and powers of these spirits were properly dealt with by Willis is his *Anatomy*, but their production – as the outcome of a chemical distillation in the brain – was first set out here, in his tract on fermentation.

We get a sense of how significant this model was from the fact that it features, at some length, early on in the first tract. Here, Willis set out a particularly vivid account of how the brain's structural design revealed and demonstrated its role in chemical distillation. Though he conceded that these events remained 'very much in the dark,' he nevertheless ventured an interpretation of the brain's role in this process based around an analogy with a common piece of apparatus from the laboratory, the alembic. As he observed,

> It seems to me that the Brain with Scull over it, and the appending Nerves, represent the little Head or Glassie Alembic, with a Spunge laid upon it, as we use to do for the highly rectifying of the Spirit of Wine: for truly the Blood when Rarified by Heat, is carried from the Chimny of the Heart, to the Head even as the Spirit of Wine boyling in the Cucurbit, and being resolved into Vapour, is elevated into the Alembick; where the Spunge covering all the opening of the

[85] Clericuzio, p. 68.

> Hole, only transmits of suffers to pass through the more penetrating and very subtil Spirits, and carries them to the snout of the alembic […] Not unlike this manner, the blood being delated into the Head, its Spiritous, volatile, and subtil Particles being restrained within the by the Skull […] as by an Alembick, are drunk up by the spungy substance of the Brain […] derived into the Nerves. (DD, p.14)

The alembic was a two-part vessel commonly associated with the alchemical practice of distillation. It was an object with which Willis would have been intimately familiar as distillation made up a core practice of early modern 'chymistry.'[86] They were used to heat a compound substance so as to separate out (by evaporation) the subtlest or spirituous part of matter, which would be collected as a separate condensed liquid. The alembic actually refers to separate objects: the 'curcurbit,' contained the matter to be heated and was positioned over a fire, it was connected to a glass vessel (the alembic or 'glassie head') on the roof of which the evaporated spirits condensed and were then siphoned off by connected tubes. The alembic set-up became an important intellectual tool in Willis's attempts to interpret the brain's functional role within the terms of his chemical practices and experience.

In this passage, Willis takes the brain and heart together as two chief components of the alembic apparatus – the chemist's fire connected to the distillatory apparatus positioned above it. The 'chief ferment' in the heart applied heat to the blood and also acted as its cucurbit (the pot placed over the fire). This caused the spirits to evaporate or ascend upwards to the brain, via the arteries, where the spirituous vapour condensed on coming into contact with the cold, boggy substance of the brain – like the spirits of wine condensing on the roof of the alembic. These spirits were contained by the skull and 'drunk' up by the 'spungy' material of the brain, which separated out the larger particles from the subtle spirits. The logic of the chemist's distillatory apparatus appears to map reasonably well onto Willis's anatomical ideas about the form and substance of the brain and heart. Willis even managed to propose a correlate for the porous 'spunge' of the alembic in the soft, cortical substance of the brain. Again, the explanation continues to import directly from Willis's experiences experimenting on wine. As he notes, 'For truly the Blood when Rarified by Heat, is carried from the Chimney of the Heart to the Head,

[86] On distillation as a core practice of early modern chemistry see: Mark Haeffner, *The Dictionary of Alchemy* (London: The Aquarian Press, 1991), p. 103.

even as the Spirit of Wine boyling in the Cucurbit, and being resolved into Vapour, is elevated into the Alembick' (DD, p.14). Willis's discourse thus mapped his practical experiences and practices from the laboratory to the anatomical and medical body.

Notably for Willis, distillation was a specifically *chemical* process - as opposed to the mechanical act of sieving and separating particles. As Clericuzio has noted, for Descartes, the production of animal spirits was analogous to sieving while Willis's comparison with the alembic 'saw the genesis of animal spirits as chemical distillation.'[87] Within the alchemical tradition – from which the 'chymistry' in this period derived - distillation suggested either a substantive *transformation* in the nature of the matter or it referred to the extraction of a life essence or the most important part of something.[88] Alchemy, in its broadest sense, referred to a set of principles, techniques and experiments derived from the works of Paracelsus or van Helmont, concerned with the transmutation of metals - often involving evaporation and distillation - which were in the late seventeenth century increasingly applied to medical or pharmaceutical pursuits.[89] Willis thus affirmed in the opening chapters *Of Fermentation* that, 'the Animal Spirit is wrought in the Brain' by a sort of 'chymical artifice,' and is 'performed even as a Chymical Elixir' - a symbol from the alchemical tradition that referred to the transmutation of metals into gold or the liquid form of the philosophers stone - a universal cure (DD, p.42). As Willis employed it, the brain acted as a 'distillatory bath' for the spirits working to transform or refashion them into instruments of the corporeal soul – whereby they were 'made more noble or excellent' than any other kind of material body. Willis proposed that this distillatory transformation also occurred in conjunction with 'a certain Ferment' localised within the brain, which volatised and 'sublimed' the spirits extracted from the blood so as to make them 'fit for the performing the offices of motion and sense' (DD, p.15).

Ultimately, in Willis's model, all varieties of 'spirit' shared certain common chemical attributes, in that they were agile, subtle, volatile, and prone to motion or expansion. The vital and animal spirits were, however, once extracted and perfected within the brain, subtilized to a degree that was unobtainable by any human artifice. They had no direct analogy in nature. Likewise, the chemical operations of the brain and heart were *similar* to

[87] Clericuzio, p. 68.
[88] Haeffner notes that 'alchemical symbolism shows that distillation was a mystic process by which the more gross material elements, earth and water, became rarified and purer, nearer to the divine spiritual quintessence', *Dictionary of Alchemy,* p. 103.
[89] Linden, *Darke Hieroglyphics*, p. 11.

the chemist's own practices, but the actions of both far exceeded the latter. This sense of the brain as the ultimate chemical laboratory, exceeding the art of the chemist or vintner, was echoed by a slightly earlier contemporary of Willis's, Henry Power (1623 -1668). For Power, it was the chemist's art that in fact replicated the work of the soul in the body. Similarly committed to a chemical-corpuscular physiology, he positioned the corporeal soul as a sort of 'proto-chymist' in his *Experimental Philosophy,* published after the *Diatribae* in 1664. It may well have taken influence from Willis's tract on ferments. Power similarly took the practice of chemistry as being analogous to the natural processes found in the body: 'all the operations of nature within us are repractised by the chemists […] most powerfully demonstrated by chemicall Analogy.'[90] He went on to liken the soul to a chemist inside this internal laboratory:

> What does the Soul, but (like an excellent Chymist) in this internal Laboratory of Man […] by these several physic-Chymical operations, but strive all this while to unfix, exalt, and volatise the Spirits conteined in our nutriment, that so they may be transmitted to the Brain, and its divarications.[91]

Willis had likewise suggested, albeit implicitly, a comparison between the chemist's practices and those of the soul by comparing the chief site of the soul's operations (the brain) to the apparatus of the laboratory, through references to chemical objects from the alembic to the *Balneum Mariae*, matrat, and pelican.[92] The corporeal soul, situated by Willis in this body-laboratory, oversaw and ministered to the body's chemical operations. Power spoke in a similar vein to Willis when he considered how the body was 'made in subserviency to the Animal Spirits' by having been designed to support the processes of chemical extraction and distillation. Unlike Willis, he emphasised the role of all organs in these processes, whereas Willis consistently stressed the prime role of the brain in the chemical production of the spirits. Another of Willis's contemporaries, Walter Charleton, was considerably more cautious here: writing in his *Physiologica* (1654) he spoke of the 'Curtain of obscurity' that divided 'Natures Laboratory' (in man) from the investigations of human endeavor.[93]

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[90] Henry Power, *Experimental Philosophy, in three books* (London: printed for John Martin and James Allestry, 1664), p. 65.
[91] *Ibid,* p. 65.
[92] These were all vessels commonly used for heating substances in the alchemical laboratory: Haeffner, *Dictionary of Alchemy,* p. 103.
[93] Walter Charleton, *Physiologica* (London, 1654), p. 342.

Despite this notable role for the heart and the brain in chemical processes of the body, Willis was nevertheless consistently vague about precisely *how* the spirits of wine and the vital sprits substantially differed. The greater energy imparted to the blood by the action of the heart and the distillatory effects of the brain both described the particular conditions and unique processes that bodily spirits were subject to, but did not directly address the nature of the spirits themselves, as chemical bodies. Willis's discussion of the brain as a distillatory organ clearly went part of the way, in that it provided a model for explaining how animal spirits were perfected and refined. But even here, Willis did not give a specific, chemical definition of the term spirit. We might argue, from the standpoint of a theory of knowledge, that such distinctions were impossible; that the analogy drawn between chemical substances (and the attendant practices of the laboratory) set and framed the limits of how Willis was able to conceive of the vital spirits. But for his contemporaries, it was an important point of contention: they sought to define, in a literal sense, what the spirits were.

Returning to O'Meara's attack, it was not just the comparison between the two kinds of spirit that he attacked (though he does this too), but also Willis's suggestion of continuities between *ways of knowing* and demonstrating truths in medicine and chemistry.[94] He dismissed the capacity of chemical methods to say anything about the body, accusing Willis of confusing spirits of the body with those produced by distillation. In contrast, as we have explored here, Willis considered that the body performed its own operations in a way that was entirely comparable to the actions of the chemist. Moreover, he had based his interpretation of the body on those very practices. Indeed, Willis's use of the brain-alembic analogy pushed at the limits of metaphor. After all, the brain did, in a literal sense, 'distil' spirits from the blood as per a chemical operation. It must be viewed as an analogy, though, to the extent that it was based upon Willis's comparison between parts of the brain to laboratory apparatus. But, as with Harvey's pump metaphor, the analogy becomes so closely united with how Willis was able to conceive of the brain and its actions that its limits are blurred: the brain *is,* for him, a distillatory organ. It produces spirits by a specific, chemical process.

[94] On the concept of 'ways of knowing' in science and their involvement in particular metaphors and practices see: John Pickstone, *Ways of Knowing: A New history of Science, Technology and Medicine* (Manchester: Manchester University Press, 2000), p. 5.

As we shall see in the following chapters, Willis represented the brain through a variety of objects – from a clock to a cabinet. No single image entirely encapsulated and represented the function of the brain within his physiological schema. A single analogy can, after all, only extend so far; its particular clarity always comes at the cost of obscuring some other detail or possible relationship. This is the same problem Willis has with his comparison of ferments in wine and the blood: the analogy expressed important shared features (effervescency, heat) while failing to express significant differences (the vital heat and spirits as a unique *life-force,* for instance). These ambiguities are (at least in part) addressed by the notion of the brain as a distillatory organ, which is used here to mark out how the animal spirits were both chemically produced and yet also distinct or transformed beyond what the chemist alone could express.

Finally, beyond the certain provisions of body, we also get a sense of the distinct status of animal spirits directly from Willis's use of language where he describes the actions and behaviours of the spirits. Willis reserved a distinct mode of expression for the chemical reactions of bodily spirits over those of wine; conveying a sense of the vital character of the bodily-spirits, Willis discussed their actions in largely personified terms. For instance, they engaged in mutual 'embraces,' or 'lye quiet, and enjoy a deep peace' (DD, p.16). When stirred up and forming new chemical bonds, they 'variously meet one another, associate themselves, and again depart asunder […] they enter into divers Marriages, and suffer Divorces, on which the beginnings, the death, and transmutations of things depend' (DD, p.16). Similarly, in Willis's 1661 Oxford lectures, he spoke of 'bad' chemical spirits becoming melancholic, 'depraved' or 'more sorrowful from eating food which is salty.' [95] These descriptions work against readings that take the *Diatribae* as a straightforwardly mechanistic chemical philosophy. They also outline a distinct linguistic space for the spirits of the body and suggested a certain vital materialism (where material spirits, rightly disposed, could be said to posses their own, living powers). As Kathryn Tabb has recently argued, it is the consistently anthropomorphised characterisation of the animal spirits in his chemical-pathological discussions that marks out the vitalism and alchemical influences within Willis's account. [96]

[95] Willis, *Lectures,* p. 126.
[96] Kathryn Tabb, "Struck, As it Were, With Madness:' Phenomenology and Animal Spirits in the Neuropathology of Thomas Willis,' in *Brain, Mind and Consciousness in the History of Neuroscience,* ed. by C.U.M. Smith and H. Whitaker, History, Philosophy and Theory of the Life Sciences, vol. 6 (Dordrecht: Springer, 2014), pp. 43-57.

Chemical theory and the anatomy of the brain: limitations

As the passages cited above indicate, Willis made an effort to reconcile his chemical physiology with an anatomical model of bodily function. Though he made quite general references to the structure of the brain - which was to be expected considering his lack of direct anatomical experience at this point - he still appears to have assumed that the structure and design of the brain could be used to say something about chemical events. This endeavour wasn't necessarily considered a success. Charleton attacked Willis on the very grounds that his anatomical account had failed to faithfully replicate the conditions observed in the laboratory. On this basis, Willis's chemical analogies (between the ferments of wine and the blood) fell apart. Here, it was not simply the comparison between spirits that was being challenged, but the nature of the spaces and conditions under which they were said to ferment.

Charleton took particular issue with the anatomical model assumed in Willis's model of fermentation, questioning the kind of *spaces* represented in his account of the body. He noted that because the 'arteries are fill'd with bloud even to distention' there is 'want of a convenient room' to 'permit' the blood to ferment.[97] On this basis, he declared that there was no reason to accept Willis's account. Andrew Brown, a Scottish physician allied with Thomas Sydenham, put the case more strongly in accusing Willis of intellectually 'bending' the subject (the body of the patient) to conform to his chemical analogy. Concerning Willis's use of Harvey's model of circulation in his account of fermentation, Brown suggested that Willis had employed a certain degree of inventiveness in attempting to conflate his experiences of observing fevers in his patients with the kinds of ferments he witnessed in the laboratory. Willis, he wrote,

> […] reasonably rejecting that of the Ancients, placed his in a notable *effervescence* of the *blood & humours:* This *ingenious Philosophical Physician* doth with great fervor bend both his own Brain and the Subject, to establish a certain *effervescence* in the blood of the *Feverish persons,* proportionate to the *Fermentation* of Liquors.[98]

[97] Charleton, *Lectures*, p. 6.
[98] Andrew Brown, *A Vindication of Dr. Sydenhams new method of curing continual fevers* (London: Printed for John Hepburn, 1700), p. 142.

Brown went on to point out that Willis's comparison failed precisely because it supposed that the body would reliably replicate the conditions present in the laboratory. As he wrote, Willis

> nowayes taking notice that all the Circumstances and Conditions requisite to the *fermentation* of Liquors, are not only wanting in the generation of *Fevers* […] the *circuit motion* of the blood will hinder its *fermentation*; as it falls out in Liquors which are to be *fermented* requiring rest.[99]

He argued that while the blood was kept in constant circulation in the body, the fermentation noted in other liquors occurred when they were being held still in isolated vessels and held over a steady flame (a different sort of combustion to that represented by the 'vital' ferment in the heart). The circulating blood was only exposed to a 'flame' at certain intervals. The apparatus that 'produces' chemical spirits in the laboratory does not, therefore, find a fitting analogy in the conditions created within the body. Brown concluded by noting that it was not possible to observe the apparent signs of fermentation in patient's blood (only a 'token of viscosity'); rather, in Willis's case, such interpretations were being 'read' or imposed onto the patient by analogies that reflected his chemical agenda.[100] This is of course the nature of analogy - it comes up against the increasingly public demands in this period for a direct and unmediated encounter with the world. Willis used chemical analogies to express events that could not possibly be directly observed or witnessed.

These are interesting and sophisticated debates, which, although framed by the professional disputes of the day, revolved in part around contested analogies. This is important as it speaks to how scientific knowledge is not necessarily produced out of any direct engagement with empirical objects, but also through disputed interpretations and applications of analogy and metaphor. Moreover, what these debates reveal is that Willis's most prominent analogy, linking ferments in wine and the blood, did not stand purely on its own merits; rather, it relied upon the related work of other supporting analogies – such as the analogy of the physician as vintner, or the brain as an alembic. These images made sense of the initial comparison and located its logic within wider intellectual frameworks – such as medical practice (physician-vintner) or anatomy (brain-

[99] Brown, *A Vindication,* p. 142.
[100] *Ibid,* p. 142.

alembic). The success of Willis's chemical hypothesis would rest as much on the analogy between the blood and spirits of wine or milk as it did on representing the body as part of a chemical *system*. Importantly, what Brown and Charleton both pointed to in their criticisms was the importance of the body in the success of Willis's chemical analogy of the spirits. They ultimately rejected Willis's ferment explanation on the basis that his corresponding representations of the body did not, in their eyes, support the chemical analogy; the body was *not* comparable to the laboratory. This expresses the dynamic, interactive work of analogies within a given text – and their role in gaining assent (or not) for new concepts.

Importantly, Willis's chemical theories would directly inform his work on the anatomy of the brain in his second major publication, *Cerebri anatome* (1664). For example, based upon the knowledge that distillation and fermentation relied on the application of heat, Willis would later suggest that the plentiful supply of blood observed in his dissections of the brain evidenced that the brain had been designed to support those particular chemical processes. Willis's model of the brain as a distillatory organ also had wider implications for his model of pathology in that it made the brain the chief fountain and store-house of the spirits. As Hawkins has noted, by exclusively situating and storing the spirits in the brain Willis created a potential 'powder keg' – whereby any ferment arising from the body could easily erupt these volatile bodies to significant and dramatic effect.[101] These implications are further explored in chapter five. They are touched upon here in order to note how the chemical analogies employed in the *Diatribae* were already structuring ideas that would be pertinent to his later (and far more greatly studied) medical contributions. Moreover, it is Willis's chemistry that gives some context for why he came to study the anatomy of the brain in the manner that he did and the nature of the conclusions that the drew – that is, to provide an anatomical basis for his chemical-physiological model.[102]

Conclusion

[101] Michael Hawkins, "A great and difficult thing': Understanding and Explaining the Human Machine in Restoration England,' in *Bodies / machines,* ed. by Iwan Rhys Morus (Oxford: BERG, 2002), pp. 15–38.
[102] Willis did not simply set out anatomical facts, but rather marshalled specific anatomical interpretations in order to support an existing physiological theory of the corporeal soul. Louis Caron also makes this argument in his doctoral thesis, *The Philosophical Reception of Thomas Willis (1621-1675) with Particular Reference to John Locke (1632-1704)* (PhD Thesis: Kings College Cambridge, 2011), p. 22.

Ultimately, Willis utilised his chemical analogies to great effect: he was able to import and apply his existing knowledge and skills from the laboratory, and especially his experiments with wine, to advance difficult theories and hidden operations in the bodies of his patients.[103] His use of familiar and accessible chemical analogies was a vital conceptual aide to himself and his readers. This supported Willis's efforts in establishing a successful medical career and his reputation as a learned physician: as the physician George Goodall, indicated in 1676, Willis was by this time well regarded as 'a physician indeed and Philosopher by fire.'[104] In these debates we also see how analogies invited multiple and contested readings. The validity of a particular philosophical model could be contested by challenging the interpretation of a key metaphors or analogy. Definitions of fermentation – whether they were applicable across chemical and medical domains or not - were disputed as part of the processes of consolidating the authority claims of two competing approaches to medicine. The disputes around Willis's fermentation doctrine were as much about these contested authorities, than they were about his actual medical practice, which remained largely Galenic. As Goodall noted, Willis was to be owned as a 'Chymical-Galenist' precisely because he had managed to appropriate his new chemical discoveries into largely existing medical frameworks.[105]

As we have seen, Willis determinedly drew on chemical analogies in order to support medical-physiological explanations of disease and their treatment. However, despite the outrage from figures such as O'Meara, Willis did not necessarily always practice chemical therapeutics. While he was famous for a couple of secret preparations, Willis rarely prescribed chemical preparations to his patients, though he still continued to draw upon a chemical *explanation* or analogy to interpret the experience. This is indicative of the explanatory power of chemical analogies for Willis and their key role in underpinning his medical approach.[106] The contemporaneous issues that surrounded Willis doctrine, then, lay with how his ideas on fevers intervened in the polemics of the day, less than it was about his actual medical practice.

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[103] Both Frank Jr. (1980) and M. Hawkins (1995) have explored the benefits to Willis's career in choosing to draw on his chemical expertise to furnish new physiological explanations, see especially: Hawkins, 'Piss Profits,' p. 3, 17.

[104] Charles Goodall, *The College of Physicians vindicated* (1676), p. 107. Goodall was writing here in defense of the Royal College's 'legal jurisdiction' in response to a group of medical chemists whom the Royal College had targeted. On this see also: Harold J. Cook, 'Goodall, Charles (*c.*1642–1712)', in the *Oxford Dictionary of National Biography Online*, ed. by Lawrence Goldman (Oxford: Oxford University Press, 2004).

[105] Goodall, *The College,* p. 66.

[106] Hawkins, 'Piss Profits', p. 17.

Involved in the core analogy, between spirits of wine and the blood, were numerous related tropes: the physician as vintner, or the body as chemical apparatus. The ways in which these related analogies were contested by Charleton and Brown, and ultimately undermined the overarching comparison, points to how a concept cannot be easily distilled from a single metaphor or analogy as they rarely stand or fall on their own. Rather, they tend to be supported, extended or amplified through the dynamic interactions between other examples from across the text. Willis also faced some significant limitations in respect of his analogy with wine when it came to medical spirits. Besides notable polemics, this tension reflected some difficulties involved in the transference of explanatory models from their original context to new objects, coming with the loss of some internal coherence. For instance, Willis wanted to employ the mechanism of ferment in respect of both wine and the blood – it had the greatest explanatory power in the context of those discussions - but within the framework of this analogy, he also found it difficult to express how these events were of a different kind. This comes back to the notion that no single analogy or metaphor is supposed to fully encapsulate a conceptual model – it may provide a fundamental structure or foundation for that concept, but cannot, on close inspection, be made to express all the detailed elements of that model.

What these discussions denote, moreover, is that Willis's chemical analogies (the concepts, practices and objects that they drew upon) structured his anatomical, physiological and medical approaches. Willis's interpretations of the anatomical forms and structures that he would uncover were filtered through the lens of his existing chemical-physiological theories. They cannot be separated from how he came to conceive of the brain and nerves in his subsequent works. Willis's chemical analogies do real, structuring work in his anatomical and physiological investigations. The famous 'neurological' brain of Willis's anatomical masterpiece was not simply produced out of the apparently 'objective' practices of dissection and experimentation: it was also the outcome of the interpretative models that he had already developed in relation to his chemical theories and categories of explanation. His concept of the brain emerges from an overlapping tangle of influences, practices, concepts and metaphors. Willis's technical activities around distilling, evaporating and separating matter in his early career as an iatrochemist, for instance, informed his concept of pathological ferments; this likewise shaped how he came to interpret the structural function of the brain. These chemical

models were mapped onto the body first by the analogies in the text and then – in a physical sense – are imposed onto the body by the interpretative imposition of anatomist's scalpel. As Robert Frank argues, Lower's scalpel was 'directed' and informed by Willis's 'chemical agenda and schemas.'[107] This will be explored further in the next chapter.

Analogies and metaphors, then, enable knowledge to be transposed from one domain to another, to be mapped across disciplinary and professional boundaries - from the vintner's craft, to the anatomists dissecting table. Concepts stray across the disciplinary boundaries built around them; the analogies explored in this chapter help to stress this inter-connectedness of ideas and practices. Their function in this context, works against any attempt to assess Willis's contributions according to the criteria of one particular discipline and defy the neat picture of Willis as a neuro-anatomist in popular modern representations. The relationships mapped out here ought to caution, then, against stressing the independence of certain kinds of scientific practice or ways of knowing. A more nuanced understanding of the chemical discourse employed by Willis in his early career should act as an important means of complicating Willis's famous work on the brain as a product of 'neurology.'

[107] Frank, *Willis and his Circle,* p. 129.

Chapter Three

The Unfolded Brain: New Methodologies and the Rhetoric of Practice

Of all of his published works Willis is remembered, above all, for his *Cerebri anatome* (*Anatomy of the Brain*, 1664), in which he examined the anatomical structure of the brain and nerves.[1] Today, the work is widely regarded as a foundational text for neurology and a starting point for the modern neurosciences.[2] It is noted in particular for its discovery of new structures at the base of the brain and astute clinical observations on various pathological conditions.[3] As the foreword to the 1971 edition noted, it is said of Willis that he has 'written his name, if not upon our hearts, at least upon the bases of our brains.'[4] Reflecting Willis's important position within the medical profession, scholarship on *Anatomy* has tended to focus disproportionately upon the accuracy (or not) of Willis's observations, his use of new techniques and the novelty of his discoveries, particularly as they relate to current interests around the history of mental illness and the modern neurosciences.[5] The cost of this focus has been the neglect of Willis's broader theoretical work, especially his ideas on nervous physiology.[6]

Underlying these approaches is the notion that the history of anatomical "discovery" can be expressed as a story of technical or practical innovation. Willis's account, by this

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[1] Thomas Willis, 'Anatomy of the Brain', in *Remaining Medical Works,* translated by Samuel Pordage (London, 1681). All in text-citations will refer to this edition using the abbreviation 'AB.'

[2] Michael R. Trimble M. D., has recently remarked that *Cerebri anatome* is 'perhaps the most classic neurological text of all time': *The Intentional Brain: Motion, Emotion, and the Development of Modern Neuropsychiatry* (Baltimore: Johns Hopkins University Press, 2016), p. 51. For similar views see: Z. Molnar, 'Thomas Willis: Founder of Clinical Neuroscience', *Nature Reviews: Neuroscience*, 5 (Apr., 2004), pp. 329-335. Carl Zimmer refers to it as a 'defining moment' in neuroscience in his article, 'Beyond the Ivory Tower,' *Science,* 303 (Jan., 2004), pp. 42-44 (p. 43).

[3] Michael Trimble's *The Intentional Brain* (2016), for instance, focuses predominantly on Willis's study of mental illness (despite the modern connotations of this term) and his clinical observations, p. 53.

[4] Abraham Mizrahi, MD., forward to the 1971 reprint of the 1681 original by Thomas Willis, *Willis: the Anatomy of the Brain* (New York: USV Pharmaceutical Corp., 1971). On this legacy see: Noga Arikha, 'Form and Function in the Early Enlightenment', *Perspectives on Science,* 14.2 (2006), pp. 153-188 (p. 164).

[5] Michael J. Hawkins has discussed the disproportionate focus upon Willis's anatomical work as being driven by the concerns and interests of the modern brain sciences, *The Empire of Passions: Thomas Willis's anatomy of the Restoration Soul* (PhD Thesis: University of London, 2004), p. 11. More recently, Louis Caron has drawn attention to the same set of teleological difficulties in Willis scholarship: *The Philosophical Reception of Thomas Willis (1621-1675) with Particular Reference to John Locke (1632-1704)* (PhD Thesis: Kings College Cambridge, 2011), p. 11.

[6] Wes Wallace, for instance, describes Willis's anatomical descriptions of the nerves as an 'unequivocal doctrine,' whereas his physiological explanation of nervous functions were, in contrast, a 'series of metaphors': 'The Vibrating Nerve Impulse in Newton, Willis and Gassendi: First Steps in a Mechanical Theory of Communication,' *Brain and Cognition*, 51 (2003), pp. 66-94 (p. 77).

reading, is to be celebrated because it was the most accurate of its day and utilised new methodologies to observe the brain. As Nancy Siraisi has argued, historians since the nineteenth century have been 'drawn' to anatomical texts - over physiological accounts - because they appear to offer 'indisputable examples of genuine additions to knowledge achieved by means of observation and hands-on practical activity.'[7] Notably, Willis's anatomical observations have proved far less controversial among historians than the (physiological) uses to which he put them.[8] Above all, these positions fail to sufficiently attend to how, in producing knowledge, scientific practices replicate particular intellectual frameworks and that they do so by employing certain literary and rhetorical strategies.

This chapter broadly addresses a number of points intended to complicate these readings. It argues, first of all, that Willis's anatomical practices were inherently bound up with his chemico-physiological ideas concerning the nature of the corporeal soul – ideas which shaped both the development of his new method for dissecting the brain, and directed the interpretation of his findings.[9] When Willis suggested that to 'explicate' the uses of the brain was as hard a task as to 'paint the soul' he did so precisely because the two ends – anatomy and physiology - were conjoined endeavours, in his view.[10] In order to use the brain as a basis for speaking about the localised operations of the soul, as Willis intended, he first needed to present his readers with a new kind of anatomical object: one that was less fragile, wet and more reliably structured. As Walter Charleton noted, even the great anatomist Andreas Vesalius had found himself 'still ignorant of the principal seat of the soul,' owing to the brain's difficult and elusive anatomy.[11] Willis looked to overcome such obstacles by proposing an entirely new method for dissecting and observing the brain.

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[7] Nancy G. Siraisi, 'Early Anatomy in Comparative Perspective: Introduction', *The Journal of The History of Medicine and Allied Sciences*, 50 (January, 1995), pp. 3-10 (p. 9).

[8] Robert Frank Jr., 'Thomas Willis and His Circle: Brain and Mind in Seventeenth century Medicine,' in George S. Rousseau (ed.) *The Languages of Psyche: Mind and Body in Enlightenment Thought*, (Berkeley: University of California Press, 1990), p. 129.

[9] Robert Frank, 'Thomas Willis and His Circle,' p. 129.

[10] Adrian Johns argues that Willis's project was 'specific and unusual' in that it was anatomy carried out in order to demonstrate the parts and powers of the soul: 'The Physiology of Reading,' in *The Practice and Representation of Reading in England,* ed. by James Raven, Helen Small and Naomi Tadmor (Cambridge: Cambridge University Press, 2007), pp. 136-170 (p. 144). On the close inter-relations between anatomy and physiology in this period see: Andrew Cunningham, *The Anatomical Renaissance: The Resurrection of the Anatomical Projects of the Ancients* (Aldershot: Scholar Press, 1997), p. 208.

[11] Walter Charleton, *A Brief Discourse* (London: 1669), pp. 43-6. On the relationship between new anatomical learning and ideas about the soul in this period see: Richard Sugg, *The Smoke of the Soul: Medicine, Physiology and Religion in Early Modern England* (Houndsmills: Palgrave Macmillan, 2013), p. 299.

Willis's achievements in this area might appear to have had little to do with the work of metaphors and analogies. However, what unifies the discussions in this thesis as a whole applies here also: that to discuss only what Willis did without also considering how he was able to represent and make sense of those activities, through literary and linguistic strategies, is to misunderstand how knowledge is generated.[12] It was through his practical changes, and the authority claims he looked to build around them, that Willis was able to argue for (and validate) his new and alternative way of representing the brain – as a complex container for the soul. This ambition involved presenting the reader with very different representations of the brain from those of his predecessors: an object refashioned according to an alternate vision. These changes must be read not simply as a matter of technical progression but as part of a broader rhetorical strategy intended to invoke a new kind of solid and structured object, whilst drawing upon Baconian ideals of the 'natural' object.

Few studies have dedicated much time to Willis's new manner of dissecting the brain, with the exception of Robert L. Martensen and Louis Caron who have both made notable contributions here.[13] I take these important studies in a different direction by examining the literary and rhetorical character of Willis's claims to have achieved a more 'natural' presentation of the brain, rather than commenting on whether this was, in fact, the case. I argue, moreover, that his interventions were no less creative or interpretative than earlier methods but that they were intended to support a specific embodiment of objectivity in practice in order to support an entirely different conception of the brain. In keeping with Robert Frank's assessment of Willis's work, this chapter is therefore concerned less with the accuracy of his observations as with how Willis was able to

[12] Steven Shapin has notably argued that phenomena produced within the laboratory setting could only become classified as 'knowledge' or 'matters of fact' once they had first been *made* known through literary inscriptions and communication, which were fundamental to this process: Steven Shapin, 'Pump and Circumstance: Robert Boyle's Literary Technology', *Social Studies of Science,* 14.4 (Nov., 1984), pp. 481-520 (p. 484). The integral relationship between scientific knowledge and literary strategies has also been well addressed by Peter Dear (1985) and Bruno Latour (1986).

[13] Louis Caron, *The Philosophical Reception of Thomas Willis* (2011). Robert L. Martensen examines Willis's innovations chiefly as a means of contextualising the modern 'cerebral' account of personhood in his, *The Brain Takes Shape: An Early History* (Oxford: Oxford University Press, 2004). Trimble (2016) also mentions Willis's new method within the context of the development of the modern brain sciences, p. 51. As with the work by Martensen and Caron, this thesis is part of a growing field of scholars re-assessing Willis's contributions; I therefore trace out a similar story concerning Willis's innovations in brain dissection and his use of anatomy to talk about the mind, but do so in order to draw out different emphases, specifically, the rhetorical claims of Willis's practices.

represent the brain as a (re-formed) object of knowledge and the knowledge-claims he was able to construct around this new, material object.[14]

One thread within the body of scholarship around *Anatomy* that is particularly relevant here, touching as it does upon the relationship between writing and practice, is the debate over Willis's collaborations. Willis openly acknowledged collaboration with his colleague, Richard Lower, and the latter's skill in conducting the dissection process - as he also acknowledged his discussions of the findings with Christopher Wren and Thomas Millington. However, following its publication, *Anatomy* quickly became associated with charges that Willis's contributions had been chiefly literary and that he therefore took unwarranted credit for the substantially practical achievements of his collaborators.[15] As Robert Frank notes, Lower's practical skill was secondarily coupled with what he termed Willis's 'literary follow-through.'[16] While the two men certainly fulfilled different roles, these assessments risk assuming that the two activities (the dissection and the recording of its findings) were distinct rather than interrelated events; that the agreed methodology was somehow not, in and of itself, argumentative but only (latterly) shaped by the application of textual schemas and agendas. There can be no simple opposition of Lower's practical outcomes and Willis's textual ones: the visceral findings exposed by Lower's hand were only received as new 'facts' in conjunction with Willis's representational strategies. Moreover, the dissection method followed by Lower was itself bound up with Willis's particular way of thinking about the brain as a means to progress certain physiological arguments.

Flawed Methodologies

Following his appointment as Sedleian professor of Natural Philosophy at Oxford in 1660, Willis undertook an extensive programme of anatomical investigations into the

[14] Frank argues that we ought to consider how Willis constructed his model of the brain within his specific epistemological setting rather than presenting his work as a list of achievements that either succeed or failed in anticipating modern practices, *Willis and his Circle*, p. 110.
[15] Anthony Wood, *Athenae Oxonienses* (London: Printed for Tho. Bennet, 1691-2), vol 3. The idea that Willis took credit for Lower's work is now roundly dismissed. Willis openly acknowledged Lowers (and others) work in his preface - see: Frank Jr., *Harvey and the Oxford Physiologists: Scientific Ideas and Social Interaction* (Berkeley: California University Press, 1980), p. 128.
[16] Frank, *Harvey and the Oxford Physiologists,* p. 128.

structure of the brain and nerves in animals and humans.[17] As he noted in the preface to *Anatomy*,

> No day almost past over without some Anatomical administration; so that in a short space there was nothing of the Brain, and its Appendix within the Skull, that seemed not plainly detected, and intimately beheld by us (p.53).

Despite some notable early criticisms, the book was broadly well received by his contemporaries. Nicolas Steno, a prominent Danish anatomist and ardent critic of Willis, conceded in his Paris lecture of 1669 that 'the best figures of the brain up to the present are those presented to us by Willis,' though, he cautioned, they were 'not entirely free from error.'[18] The broad success of the work also owed credit to the richly detailed etchings of the brain provided by Christopher Wren, arguably more famous that the text which accompanied them.[19] Indicative of its success, *Anatomy* ran to nine separate editions in its first twenty years. Why, then, did Willis turn to the brain (so successfully) at this point in his career? As chapter two explored, by this point the brain had come to occupy a particularly important position within Willis's broader chemical and physiological explanations. In the 1650s, for instance, he had attributed hypochondria to a fault in the spleen but by 1661 he had relocated its cause to the brain.[20] This serves to highlight that Willis's research agenda was not simply about revealing the structure of the brain 'in its own right', but also to elaborate and underpin a set of pre-existing physiological ideas.

Moreover, there was a notable gap to be exploited here: despite advances made by Andreas Vesalius in the sixteenth century, anatomical knowledge of the brain had progressed very little since Galen.[21] As Willis complained,

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[17] On Willis's time at Oxford and position within the experimental community, see: Frank, (1990); J.T. Hughes, *Thomas Willis 1621-1675: His Life and Work* (Oxford: Rimes House, 2009).
[18] Nicolaus Steno, 'A Dissertation on the Anatomy of the Brain', translated by G. Douglas (London, 1743) reprinted in *Steno in Six Languages,* ed. by Ole J. Rafaelsen MD. (Copenhagen: Rhodos, 1986), p. 61.
[19] Kenneth Dewhurst notes (somewhat unfairly) that the work's success was 'undoubtedly' due to the technical skills of Christopher Wren: 'Willis and Steno', in *Steno and Brain Research in the Seventeenth century,* ed. by Gustav Scherz (London: Pergamon Press, 1965), p. 46. This stance might be explained in relation to the modern fixation on scientific images as the prime conveyors of objective information.
[20] Frank, *Harvey,* p. 122.
[21] As Scott Manning Stevens has commented, 'Vesalian anatomy had done much to demystify the hidden interior of the body…but the physiology of the brain remained obscure': 'Sacred Heart and Secular Brain', in *The Body in Parts: Fantasies of Corporeality in Early Modern Europe,* ed. by David Hillman and Carla Mazzio (Abingdon, Oxon: Routledge, 1997), pp. 263- 284 (p. 273).

> Among the various parts of an animated Body […] none is presumed to be easier or better known than the Brain; yet in the mean time, there is none less or more imperfectly understood (p.55)

Owing to years of clinical experience and numerous patient autopsies, Willis had also found himself confronted with the stark discrepancies between learned authorities on the brain – primarily Galen - and his own, first hand experiences.[22] Having 'wholly frustrated those illustrious Documents I had long since learned,' Willis thereby resolved to produce a reformed body of knowledge on this subject by committing himself

> […] not to pin my faith on the received Opinions of others, nor on the suspicions and guesses of my own mind, but for the future to believe Nature and ocular demonstrations: Therefore thenceforth I betook my self wholly to the study of Anatomy.' (AB, Preface)

This stance followed in the wake of a significant expansion of anatomical research in England during the seventeenth century, after human, rather than animal, dissection had been made legal by Henry VIII in 1541 – a move which encouraged new investigations into the body among members of the Royal Society.[23] Mirroring developments in Padua, English anatomists challenged Galenic anatomy by turning back to the body itself; the body, made naked from the gloss and commentary of ancient authorities, was to represent its own, renewed authority - much like the "uncorrupted" texts of the humanist enterprise.[24] It was to these developments that Willis's statements – and the authority they sought to suggest - were intended to appeal.

One of the more striking aspects of *Anatomy* was Willis's proposal of a new approach to dissecting and investigating the brain – a new 'anatomical administration', as he put it. Where modern day, non-invasive imaging technologies have vastly diminished questions

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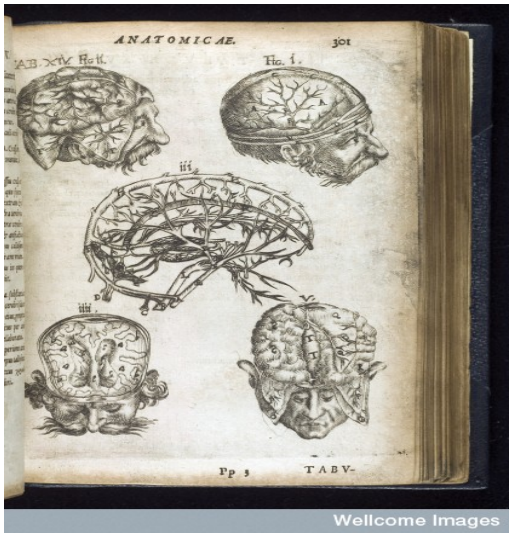
[22] Frank proposes that Willis's investigations were fuelled by a 'confrontation' between his years of clinical experience and the distinctly non-anatomical Aristotelian tradition that he was required to teach on, 'Willis and his Circle,' pp. 120-123.

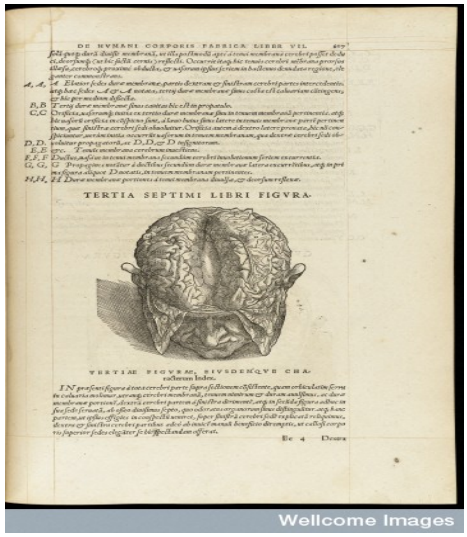
[23] From the thirteenth to the late fifteenth-century dissections on human cadavers were limited to Italy and southern France: Katherine Park, *Secrets of Women: Gender, Generation, and the Origins of Human Dissection* (Brooklyn, NY: Zone Books, 2006), p. 19.

[24] Matthew Landers argues that these developments 'produced many Vesalian texts in England,' meaning the English natural philosophers were 'inheritors' of the empirical anatomy of sixteenth-century Padua: 'Early Modern Dissection as a Model of Organisation', in *Anatomy and the Organisation of Knowledge, 1550-1850,* ed. by Matthew Landers and Brian Muñoz (London: Pickering and Chatto, 2012), p. 9. See also, Charles T. Wolfe and Ofer Gal, 'Embodied Empiricism,' in *The Body as Object and Instrument of Knowledge,* ed. by Wolfe and Gal (London: Springer, 2010), pp. 1-9 (p. 2).

of how to access the brain, this was a significant practical (and intellectual) problem facing early modern anatomists: how could reliable knowledge be produced from such a fragile and delicate object? Willis's answer involved seeking to overturn prevailing methods of dissection altogether, declaring that: 'for the anatomy of the brain to be rightly celebrated, I judge we ought not to proceed after the common way of dissection' (p.11). His arguments were met with some interest: John Ward, a medical student at Oxford, on receiving news from a friend, recorded in 1665 that 'Dr. Willis hath got a new way of opening ye Brains.'[25] *Anatomy* duly opens with an entire chapter devoted to setting out this new procedure. Having declared that the 'ocular demonstrations of nature' – direct observation of the body, in other words - would be the first and last authority in these matters, Willis's methodological account, which set out the manner of his observational practices, would be a vital foundation for his intellectual arguments.

The 'common method' that Willis sought to overturn was known as the in-situ method of dissection, as used by Galen, Vesalius and Steno. As the name suggests, this method involved dissecting the brain while still encased inside the skull. The procedure began by first removing the top part of the skull, then cutting and peeling back the covering membranes to reveal the cerebral hemispheres. The dissection progressed downwards from here, working towards the brain's central structures (the ventricles). The two figures below from Andreas Vesalius's *De humani corporis Fabrica* (1543) are typical examples of the brain represented according to this method.





Figures one & two: Andreas Vesalius, *De humani corporis fabrica*, 1543.

[25] Quoted by Robert Frank, 'The John Ward Diaries: Mirror of Seventeenth Century Science and Medicine,' *Journal of the History of Medicine,* (April, 1974), pp. 147-179 (p.165).

Notably, the brain represented in this manner remained an integral part of the cadaver – depicted by Vesalius with the face still clearly visible. The brain is not represented here as a fully independent object of inquiry - visually, physically or intellectually.[26] Though Steno and Willis disagreed on much concerning anatomy, they both agreed on one matter at least: that flawed and incomplete knowledge of the brain was in no small part due to the inadequacy of these common practices. Steno declared that 'the true manner of dissecting the brain is as little known as its substance.'[27] It was clear that these methods had done little to advance physiological explanations of brain function beyond (the increasingly discredited) Galenic account. [28] In seeking to displace Galenic theory, Willis began by attacking the very practices that had for so long supported and replicated those models.

Willis argued that the in-situ procedure was intellectually selective, that it focused only upon what was most immediately and readily exposed in the forepart of the brain, rather than attending to any 'complete' investigation of the object. He declared that 'all of it that appears, and is commonly described in the forepart or forehead, is beheld almost at a sight or two after some rude cutting up' (p.5). In addition to this rude cutting up, by commencing from above, the in-situ method also tended to privilege the central structures and ventricles in the brain at the material expense of its underlying structures. These underlying parts were exposed only as the end point of a dissection, which increased the likelihood of their total disintegration.[29] The in-situ methodology therefore assumed – and then imposed – a hierarchy onto the parts of the brain, as its work progressed towards a ventricular end point. This presumed order to dissection is

[26] Michael Trimble (2016) likewise notes that Willis and Lower's new method meant the brain 'became a visual object, an independent organ,' and that this enabled the application of new preservation methods, p. 51.

[27] Dewhurst, *Willis and Steno*, p. 47. Noga Arhika has also commented that although Steno argued for a 'higher standard of draughtsmanship,' he also accepted that 'the semi-fluid consistency of the brain tissue made accurate reproduction difficult': 'Form and Function in the Early Enlightenment,' *Perspectives on Science*, 14.2 (2006), p. 160.

[28] Scott Manning Stevens, 'Sacred Heart and Secular Brain', p. 273. Julias Rocca suggests that, in respect of the brain and nerves, Galen 'was not eclipsed until Thomas Willis': 'Anatomy,' in *The Cambridge Companion to Galen,* ed. by R. J. Hankinson (Cambridge: Cambridge University Press, 2008), pp. 242-262 (p. 257).

[29] The physician Mark Preul notes that both 'the Galenic and Vesalian method of examining the brain in situ from above allowed only limited examination of the basal structures': 'A History of Neuroscience from Galen to Gall', in *A History of Neurosurgery,* ed. by S. Greenblatt (Parkridge: American Association of Neurological Surgeons, 1997), pp. 99-130 (p. 106).

famously represented in Rembrandt's painting, *The Anatomy Lesson of Dr Joan Deyman* (1656).[30]

Figure three: Rembrandt Harmenszoon van Rijn, *The Anatomy Lesson of Dr Joan Deyman,* (1656)

It was a methodology that spoke, moreover, to the assumption that only specific structures within the brain (those privileged by the method itself) were functionally significant. Steno, like Willis, objected to the way in which such practices - taking advantage of the pliable material of the brain – were being used to support certain theories: 'anatomists having hitherto too readily formed systems…moulded these soft parts in the manner that was most agreeable to each.'[31]

It is the troubling materiality of the brain here, with its soft and pliable structure that underlines the perceived limitations of cerebral anatomy. This was compounded by the fact that it was also necessary to entirely dismantle the object in order to peer inside it. As Willis observed,

> We are not able to estimate the measure or to paint forth the pattern or draught of the frame […] unless the bulk or substance of the subject be first searched to the bottom, and its frame broken into pieces (p.55).

Having first dismantled the brain in order to gain access, the anatomist negated the guiding 'frame' or 'pattern' constituted by the spatial relations between parts; he could

[30] Jonathan Sawday has referred to this as a 'taken for granted' hierarchy in dissection, whereby cerebral matter was regarded as a 'prelude' to a set of more significant observations: *The Body Emblazoned: Dissection and the Human Body in Renaissance Culture* (London: Routledge, 1995), p. 156.
[31] Dewhurst, *Willis and Steno*, p. 59.

not rely on anything that he observed thereafter. In this passage, Willis deliberately evokes an image of a 'broken' and deconstructed object - a partial and fragmented set of observations – despite this being an integral component of anatomy. To 'anatomise' something is to take something apart in order to study its component parts. This passage nevertheless cleverly shows Willis's attempt to reframe his competitors' practices of dissection as inherently destructive and distorting activities; by suggesting that there must be some way of investigating the brain without 'breaking' it apart, he sets up a basis for validating his own alternate practices. Furthermore, while the idea of seeking a "complete" as opposed to a partial account of the object may appear to be self-evident from our own current perspectives, it actually reflected a specific intellectual change in this period. Where large parts of the brain had been disregarded as functionally irrelevant (especially the cerebral hemispheres), Willis's ideas concerning an integral correlation between form and function in anatomy led him to argue that any structure to be found in the brain suggested a specific function which the anatomist ought to examine. It was imperative, then, to pay attention to all – rather than some – of the brain's solid structures.[32]

What Willis properly refers to here is not so much the act of dissecting the brain – an activity he himself must engage in - but his predecessors' failure to attend to the spatial relations between structures and parts in the course of their procedures - a set of considerations that would be consistently stressed in Willis's own explanations. This situation was compounded by the related practice of representing the brain as transverse slices or sections – which further enhanced the prominence of the ventricles.[33] While Galen had sliced vertically, Vesalius had attempted to 'correct' this presentation with horizontal slices – with limited improvements.[34] Willis's criticisms here focused on the disregard this method showed for nature's sequencing of parts:

[32] On Willis's use of inference between anatomical form and physiological function see: William F. Bynum, 'The Anatomical Method, Natural Theology, and the Functions of the Brain', *Isis,* 64.4 (Dec.,1973), pp. 444-468 (p. 450); Martensen, *The Brain Takes Shape*, (2004), esp. pp. 75-81.

[33] Contemporary neuroscientist, Michael Macmillan observes that 'the technique of dissecting the brain in transverse sections reveal[s] the ventricles…more readily than other structures': 'Experimental and clinical studies of localisation before flourens,' *Journal of the History of the Neurosciences: Basic and Clinical Perspectives*, 4.3-4 (1995), pp. 139-154.

[34] On the various slicing methods described see: Martensen, *The Brain Takes Shape* (2004), p. 50; Greenblatt (ed.), *A History of Neurosurgery* (1997), p. 106.

> Hence it came to pass, that the old Anatomists in dissecting the Brain, not sufficiently attending what was placed first, what second, and what after that in the order of Nature, cut its Globe as it were into slices or parts (p. 5).

Slicing the brain constituted not only a violent but also subjective inversion. The analogy of a Globe rendered into slices, presents the reader with an incongruous image of unnatural partition; a direct inversion of natures own order. The slice converted three dimensions into two, representing a circle in place of a sphere, thereby excluding an entire set of spatial inter-relations (vertical or horizontal). The suggestion was that the sliced brain reflected only the creative interventions of the anatomist and not any quality belonging to the object itself. The results of these interventions were thus thought inherently unreliable and subjective. As Willis put it, dissections carried out in this manner saw 'Phenomena arising by chance,' such that 'by others from a dissection otherwise made, the parts and processes of it appear far different from the former' (p.5). His language here clearly drew upon the troubling implication that, hidden within the deconstruction of any object, lurked the prospect of erroneous 'reassembly' – taking anatomy away from the ideal of reading nature without representation. His fellow anatomists were, argued Willis, complacent in the value of their own schemas; they needed rather to defer to and follow nature's own design.

This situation was compounded by the material complexities of the brain, which Willis conceived of as a web of inter-related vessels and structures. He observed that, because the brain was so 'rolled' together no one part could be separated without also tearing and distorting some other part attached or intertwined with it: 'as often as the substance or bulk of the Brain so conglobated or rolled together is cut […] the portions of divers parts cleaving together, are carried away with them' (p.55). These representations – of a rolled or 'conglobated', compacted, sphere - were used here to foreground Willis's proposal of an alternative method of dissection, to which I will turn shortly. Again, Willis's concern to represent these specific features of the brain was not the simple outcome of greater accuracy; these were features of the brain that had previously been disregarded by his predecessors as sites of no intellectual significance, but which were now being used as a basis for an entirely different model of brain function. Speaking after Willis had published his findings, Steno seemed to agree, commenting that 'I need not mention the method of cutting into slices, because it is owned by everybody that

nothing can be learned that way.'[35] He concluded that the method produced only uncertainty, even on the definition of what a ventricle actually represented, it being 'a very equivocal term.'[36] Here Steno suggests – and Willis implies – that the problem of equivocal or disputed terms in natural philosophy could be tied into issues around practice: if one could claim to have followed an objective set of practices, then the outcome could not be viewed as equivocal. The names ascribed to these objects would be similarly reformed by such measures.

Unfolding the brain

In answer to these substantial issues, Willis proposed to turn the 'common method' on its head: instead of cutting away at the brain inside the skull, the anatomist would first remove it entirely from the skull, intact, before turning it upside down to observe its underlying structures.[37] He argued that, before any act of cutting, the brain ought to be first fully removed from the skull, its membranes 'wholly loosened,' after which 'the several parts ought to be turned over and stretched forth into their proper dimensions' (p.55). Everything was to be observed and noted prior to any act of cutting. He concluded that, 'with these things being first done, we will more largely deliver the Description of the Brain' (p.6). What Willis proposed here amounted to more than a technical change in procedure, but an argument for a new way of looking at the brain, as an independent, self-contained object comprising a series of inter-connected parts. Willis was not, however, the first to have examined the brain by this method. Costanzo Varolio, Vesalius's successor at Padua, had employed the method during the 1540s.[38] However, it was Willis who, through the broad success of his publication, brought it to notice. A number of Willis's Oxford contemporaries credited him, and not Varolio, with the innovation.[39] In Willis's hands, the methodological change was taken as yielding genuine advances in knowledge of the brain. Robert Plot, professor of chemistry at Oxford, noted in 1677 that 'Dr Willis's Method of dissecting the Brain…is new, and

[35] N. Steno, 'Anatomy of the brain,' as quoted by Dewhurst, *Willis and Steno*, p. 43.
[36] *Ibid*, p. 65.
[37] Highlighting how Willis is often assessed according to how he informs current day practices, Kenneth Dewhurst notes that what Willis described here is the method used by pathologists today, p. 47.
[38] M. Preul, 'A History of Neuroscience from Galen to Gall,' p. 106.
[39] As Dewhurst points out, it 'was, in fact, the same method adopted by Varolio, although an Oxford contemporary thought that it was original,' p. 47. On Willis's improvement of the understanding of underlying structures such as the cerebellum see: Martensen, *The Brain Takes Shape*, p. 50; Nathan Flis, 'Drawing, Etching, and Experiment in Christopher Wren's Figure of the Brain', *Interdisciplinary Science Reviews*, 37. 2 (June, 2012), pp. 145-60 (p. 147).

most exact, that there is scarce any one Part in it, but what has receiv'd considerable Advancements.'[40] Arguably, what is significant here is how Willis's account of the procedure proved to be *persuasive* in its capacity to support a set of alternative physiological explanations. Ultimately, the two men used the new technique to make very different claims: Willis, that the anatomy of the brain could be used to make important claims about its operations; Varolio, by contrast, argued that one could say next to nothing about the brain by examining its substance.

The new approach had a number of significant consequences. In the first instance, the freed brain created an entirely new set of perspectives by allowing the observer to vary and alternate their perspective. As Willis observed, the brain became mobile and, for the first time, entirely visible: 'the whole frame or substance of the Brain and its Appendix may be somewhat elevated, and moved here and there, be everywhere conspicuous, and at length taken from the skull' (p. 8). In this, Willis appealed to contemporary developments around the tool of perspective, as a means of more accurately representing the natural world in art; as with the camera obscura or the microscope, this was another means by which observation - the testimony of the eye -was being augmented and replicated more accurately.[41] Willis was not the first to suggest that the body, if it were to be observed as a truly 'natural' object, needed to be viewed from multiple angles. In 1487 Leonardo Da Vinci described to his reader that his 'plan of the human body' would be 'unfolded to you just as though you had the natural man before you,' by 'examining from different aspects, from below, from above and from the sides.'[42] Willis's claims to have represented the 'proper dimensions' of the brain were embedded in the same sort of validating claims attached to these observational practices – premised upon the primacy of direct observation and an attendance to perspectival matters.

Observed in this new manner, the brain presented as a very different kind of object. Willis noted that the freed brain now appeared to him as a 'curious quilted ball,' however, he also noted that this spherical shape was itself only a temporary consequence of the

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[40] Robert Plot, *The Natural History of Oxford-shire* (Oxford University Press: Sheldonian, 1677), p. 301.
[41] On perspectival innovations in Dutch art during the Renaissance see: Svetlana Alpers, *The Art of Describing: Dutch Art in the Seventeenth Century* (Chicago: University of Chicago Press, 1983). On the influence of new technologies in representing the brain during this period, albeit from a quite teleological perspective see also: Daniel D. Cavalcanti, M.D. et al., 'Anatomy, Technology, Art, and Culture: Toward a Realistic Perspective of the Brain,' *Neurosurgery Focus,* 27.3 (September, 2009), pp. 1-22 (p. 11).
[42] E. MacCurdy, *The Notebooks of Leonardo da Vinci* (New York: George Braziller, 1956), quoted in Daniel Cavalcanti, 'Anatomy, Technology, Art, and Culture,' p. 11.

shape of the skull-container and the membrane rather than a structural feature of the brain itself. The brain only appears like 'a curious quilted ball' because of a membrane that 'knits together' its parts, when this is removed its parts 'fall open' and are found 'lax and hanging loose' (p.59). The 'unfolded' brain, within this presentation, works merely to expose the brain's own structural dimensions, rather than those imposed upon it. Here Willis expressed an important and novel emphasis on the material substance of the brain. Only those parts that conformed to his reading of this definition of 'structure' were deemed worthy of investigation. This did not include the ventricles. By having removed the brain from the skull, Willis had observed that the ventricles were not an inherent, structural feature of the material object, but a consequence of its relation to the skull - a mere accident of its arrangement: they 'go into one empty space or mere vacuity, resulting from the complication of the Brain' (p.12). This pointed to an important shift of emphasis by Willis away from the empty spaces of the brain to its solid, structural form.[43]

Nothing more clearly demonstrated the interpretative influence of rival dissection methodologies: transverse slices had revealed the ventricles to be central and of 'obvious' significance whereas unfolding the brain revealed precisely the opposite. Displaying a use of form to consider function, Willis later remarked that the ventricles' role 'seems to be only secondary, and as it were by chance' (p.20). It made little sense, for Willis, that nature would have made a provision of complex structures in the brain only to situate the fundamental operations of animal government in its 'empty' cavities. Only complex, material constructions spoke to the purpose of design; and only God's design could be made to speak to the body's hidden functions. As William Bynum points out, 'that the structures of the brain are intimately related to the functions of that organ is a proposition underlying all of Willis's works on the nervous system.'[44] Accordingly, the ventricles were instead likened to passive waste receptacles, akin to 'jakes or sinks.' As the next chapter explores, the passivity of these images comes in marked contrast to Willis's representations of the cerebral structures.

[43] George S. Rousseau has talked about Willis's shift to a focus on the solid substance of the brain a paradigm shift: *Nervous Acts: Essays on Literature, Culture, and Sensibility* (Basingstoke: Palgrave Macmillan, 2004), p. 360. William F. Bynum also stresses this new focus by Willis on the solid structures of the brain see: 'The Anatomical Method,' pp. 444-468.
[44] Bynum, 'Anatomical Method,' p. 450.

The freed brain also became an upturned one, creating a new set of alternative observations and therefore new intellectual possibilities. As we can see in Wren's famous etchings for *Anatomy* (Figure Four), the brain is represented both as an independent object, pictured apart from the cadaver, and with its underlying structures prominently on display.[45]

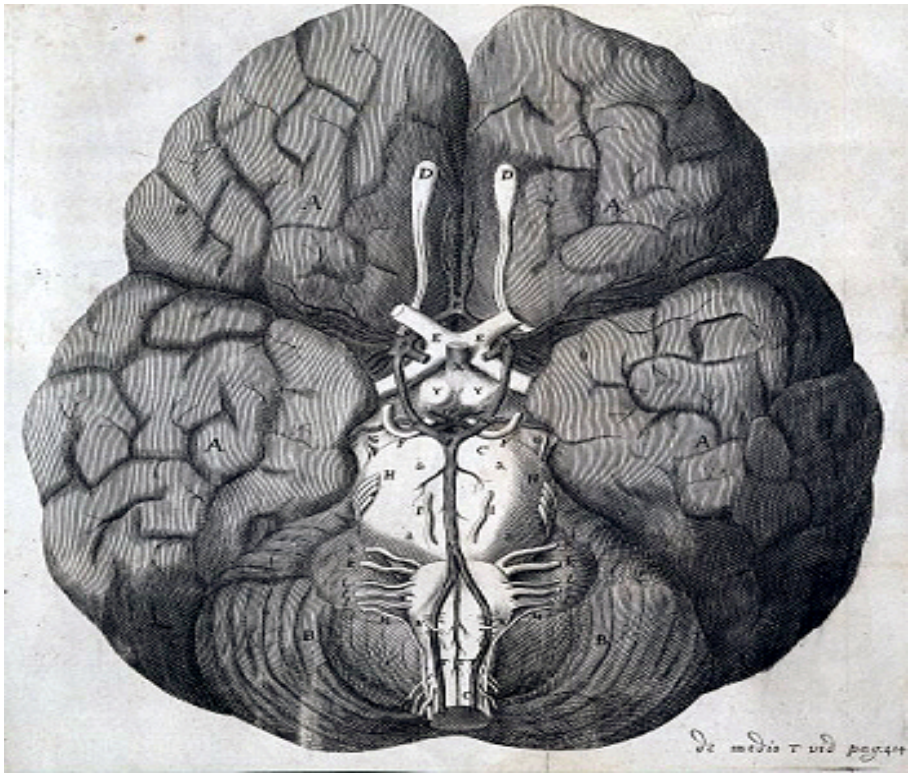

Figure Four: Christopher Wren for Thomas Willis, *Cerebri anatome* (1664)

In place of the ventricles, Willis's focus now rested on the 'most intricate frame and various recesses' at the base of the brain, which, he noted, had been 'less accurately discerned and investigated' by his predecessors (p.6). One of the more significant changes attached to this approach concerned the nature of Willis's physical engagement with the brain. Holding the brain removed from the skull created a vastly different experience in this regard: it could be held in the hands and gently prised apart or turned over, rather than being excavated or dismantled. Importantly, these changes allowed Willis to reframe his own actions in terms of *explicating* the brain, meaning 'to unfold.' This term originates from the Latin *ex* (out) and *plicare* (to fold), which became explicate

[45] This way of representing the brain - independently and from beneath - became standardised through the broad replication of Wren's famous etchings. A useful illustration of the image's wider visibility can be seen in William Hogarth's painting *Credulity, Superstition and fanaticism: A Medley* (1762). The work features a human brain in the lower right corner, positioned to expose its underlying parts.

(unfold) by the 16th century. Echoing da Vinci's earlier example, Willis's use of the verb in this context could carry the double meaning of both physically opening up the brain and at the same time "unfolding" hidden knowledge before the reader. As Willis described the process,

> Wherefore a true and genuine description of the Brain might be shewed before its substance and continuity is dissolved, before all things its whole frame or substance ought to be explicated (p.6).

With the brain cut away from its appendages (the oblong marrow and the cerebellum), Willis observed how it could now 'be wholly lifted up, turned forward, and unfolded into a plain […] stretched out into a broad floor,' such that it might 'be seen and handled' (p.61). [46] The use of the verb to unfold ('explicate') is interesting here in that it foregrounds a linguistic emphasis by Willis upon the passive nature of his own activities throughout his account. The brain, held in the hands of the anatomist, could be carefully prised 'open' by rolling, loosening and stretching it apart; Willis recalled how these actions allowed the brain's interior recesses to simply 'lye yet more clearly open' – his own physical interventions vastly diminished. None of these are actions that suggest a substantial re-making of the object, but which simply make it more visible by opening out its existing parts and projecting them onto a flat surface – a 'broad floor.' The brain is being revealed before the anatomist and, at the same time, to the reader's gaze: they are both "witnesses" to the fact. Willis's reference to the dimensions of the brain being flattened, 'projected onto a plain,' invoked the same imaging technologies being demonstrated on the white wall of the *camera obscura*. These images were taken as reliable representations of the world, even though they were an inverted image of the real thing.

The 'unfolded' brain was, above all, presented by Willis as being a more naturalistic representation of the brain, in that it was unmediated by the methodological impositions of his rivals. Not only were new structures being revealed, but those that were already known could also now be conveyed in their 'proper' - and by extension, their 'natural' - dimensions.[47] He suggests, for instance, that once the membranes have been loosened,

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[46] In Latin, 'ac in planum explicari poterit,'*Cerebri anatome* (London, 1664), p. 22.

[47] On representing nature in this period as 'unadornded' and 'naked' objects, rather than as vehicles of symbolic meaning see: William Ashworth, 'Natural History and the Emblematic World View,' in *Reappraisals of the Scientific Revolution,* ed. by David C. Lindberg and Robert S. Westman (Cambridge: Cambridge University Press, 1990), pp. 303- 332.

'the several parts ought to be turned over and stretched forth into their proper dimensions' (p.6). Throughout the work, Willis refers to parts being 'freed' (rather than torn) from other parts so that they might 'easily appear' to the eyes – rather, that is, than being presented to the reader by the anatomist, which implies an active or artificial arrangement. The oblong marrow, for example, is merely 'loosened from its cohesion', before being bent forth and lifted up (p.11). These acts of elevating, turning, and unfolding granted Willis the ability to vary and alter his perspective on various parts of the brain, all without fundamentally changing how they fitted together. His was a set of actions that would reveal the natural form of the object, rather than remaking it in a new image. This account was intended to stand in sharp contrast to (Willis's presentation of) the wilful destruction entailed in his rival's activities.

Arguably, Willis's framing of his methodology was an effort to obscure the inherently creative and intellectual work of dissection. His language of 'unfolding' the brain promoted the idea that such actions were part of a self-evident process of 'opening' of the brain. This was intended to make Willis's role marginal in order to diminish any mark of his own creative input: freeing, unfolding and exposing parts are passive acts. The fact that membranes had to be removed and ligaments 'cut a little' to do so is intentionally minimised by this narrative. Moreover, 'turning over', 'stretching forth' and encouraging the brain into its 'proper dimensions' were all premised upon a change in our perspective of the object. Holding a brain removed from the skull, being able to turn it 'upside down' and manipulate its structures therefore creates a vastly different engagement with the brain as a material object – but overall, as an act of observation. These outcomes were derived both from a practical innovation (affording Willis new investigative possibilities) united with a sophisticated literary strategy.[48] Where Louis Caron has discussed Willis's new method of dissection as allowing him to 'observe with more clarity the natural features of the organ,' I would argue that his presentation of this particular method was intended to create the impression of a more 'natural' object according to the specific values of the period. [49]

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[48] On the literary strategies involved in the experimental program and their involvement with practice, see: Shapin and Schaffer, *Leviathan and the Air-Pump* (Princeton: Princeton University Press, 1985), p. 63. For Boyle's considerations on the essay genre and the role of witnessing see also: Scott Black, 'Boyle's Essay: Genre and the Making of Early Modern Knowledge', in *Making Knowledge in Early Modern Europe: Practices, Objects and Texts, 1400-1800,* ed. by P. Smith and B. Schmidt (London: University of Chicago Press, 2007), pp. 178-195.
[48] Robert Boyle, *Certain physiological essays* (1669), p. 13.
[49] Caron, *Philosophical Reception,* p. 14.

The authority that Willis claimed on behalf of this reformed methodology was intended to appeal to the rhetorical principles – and generic conventions - of the experimental philosophy. For instance, Willis had outlined the procedure in broadly sequential detail, indicating the assumption that his reader could replicate the event for themselves if they wished; he stressed his regular use of the microscope – experimentally augmented vision - and the presence of multiple participant observers from among the leading natural philosophers of the day.[50] In his account of the procedure itself, he stressed that the 'the disposition or order' of all the brain's parts was to be preserved in the precise sequence in which they 'appear before the eyes' – that new authority (pp.11, 12). Parts 'appear to the eyes' and are 'followed', rather than being demonstrated by the method. This all served to indicate Willis's commitment to new standards of objectivity – through direct observation - as a mode of praxis.[51] As Lorraine Daston and Peter Galison have argued, concepts of objectivity do not accord to a set of historically transcendent and self-evident principles but are bound up in historical and cultural conditions.[52] In this period, it could be defined, along humanist lines, as a turning away from textual learning to focus on the raw material of 'things' in the natural world, as explored via the evidence of sensory perception and the experimental method.[53]

Willis's arguments here were also part of a much broader project during the period, as Steven Shapin has put it, aimed at reforming 'the apparatus of representation'.[54] Willis's methodological claims were also about appearing to have established a new and valid mode of representing the natural world 'as it is'. In this, Willis drew on related notions of the 'natural' object, stripped of learning, and utilised new technologies of observation (the microscope) and ideas of perspective. Indicative of these themes, Willis opened by stating his rejection of the 'vain figments' of learning and the 'received opinions of

[50] On the role of public observation and authority-making claims in this period see: Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump* (1985).
[51] On notions of objectivity – rather than the pursuit of a fixed 'truth' – as a means of reformulating the natural philosophical project in this period, see: Stephen Gaukroger, 'The Autonomy of Natural Philosophy: From Truth to Impartiality,' in *The Science of Nature in the Seventeenth Century: Patterns of Change in Early Modern Natural Philosophy*, ed. by Peter R. Anstey and John A. Schuster (Dordrecht, NE: Springer, 2005), pp. 131-165 (pp. 159-60).
[52] For the argument that objectivity is a concept that is culturally and historically contingent, see: Lorraine Daston and Peter Galison, *Objectivity* (Brooklyn: Zone Books, 2007).
[53] Francis Bacon proposed a new basis for natural philosophy premised on the 'foundation of experience' and direct observation of nature in his *Advancement of Learning* (1605) and *Novum Organum* (1620), p. 76. See also: Peter Harrison, *The Bible, Protestantism, and the Rise of Natural Science* (Cambridge: Cambridge University Press, 2001).
[54] Shapin, 'Pump and Circumstance,' p. 481.

others' to rely solely upon the proof of 'Nature and ocular demonstrations' (*preface*). In a particularly vivid image, Willis reinforced his point by recalling that whole 'catacombs' of heads had been 'slain' to achieve this goal: his acts of observation were to be many and varied.

This was a set of ideas that also drew on a specific Vesalian inheritance within anatomy. In the 1540s Andreas Vesalius had argued that anatomical learning ought to be premised upon the direct observation of the body and visual demonstrations alone, as opposed to the received opinion of doctrine.[55] As Andrew Cunningham writes, with Vesalius, 'the body is not being tested against a text, nor is a text tested against the body', rather, the body stands as its own (visual) authority.[56] The Cambridge physiologist, Walter Charleton, noted in his anatomy lectures of 1683, 'in things Anatomic, the Eye is a better Instructor than the ear.'[57] The resultant, rediscovered body would stand to reform the errors and vanity contained in words and learning.[58] The body, of course, still had to be narrated by the text, it could never be truly 'naked'. New and alien forms needed to be made intelligible and meaningful, through metaphor and analogy. Vesalius had himself complained that demonstrators were generally 'so ignorant of language that they are unable to explain their dissections.'[59] The issue, then, was not one of banishing words from the body, but the need to reform that relationship: words needed to be fitted to the body, not the other way around. The language with which Willis presented his own methodology referenced these Vesalian notions of a direct and unmediated encounter with the body, whilst continuing to rely upon vivid and rich analogical devices to ensure create a coherent and meaningful representation of the body.

Interestingly, as with the themes explored in chapter one, Willis's literary strategy in this matter harked back to the Royal Society's concern with a 'plain style' in natural

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[55] Andreas Vesalius, 'Preface,' *De Fabrica Corporis Humani* (1543), p. 3; translated by B. Farrington and printed in *Proceedings of the Royal Society of Medicine*, 1 (July, 1932), pp. 40-48 (p. 43).
[56] Andrew Cunningham, *The Anatomical Renaissance: The Resurrection of the Anatomical Projects of the Ancients* (Aldershot: Scolar Press, 1997), p. 207.
[57] Charleton, *Enquiries into human nature* (1680), p. 42. As Alpers notes, recording visual observations, in written or pictorial form, was to be the basis for the new Baconian knowledge: (1983), p.73.
[58] Cunningham, *The Anatomical Renaissance*, esp. pp. 88-142. The research interests of the members of the Royal Society reflected this renewed interest in the body, on this see: Charles and Ofer (eds.), *The Body as Object and Instrument of Knowledge,* p. 2. See also David Harley, 'Political Post-Mortems and Morbid Anatomy in Seventeenth century England', *The Society for the Social History of Medicine*, (Jan., 1994), pp. 1-28.
[59] Vesalius, 'Preface', *Fabrica,* p. 43.

philosophy, which was itself a deliberately construed literary strategy of the 'non-style.'[60] As Willis records, when the brain is removed from the skull and its membrane cut, it is thereby 'left naked, uncloathed' (p.60). While this is a reference to the literal work of peeling back the membrane to reveal the cerebral matter underneath, it is also strikingly similar to the language which surrounded the reform agenda in the natural sciences: objects were to be divested of the layers of scholastic gloss and literary embellishment that had formerly 'cloathed' them by being presented directly before the senses. The revelations promised by the unfolded and opened brain – marked out as a specific break with the observational experiences of his predecessors – spoke directly to this sense of an entirely new and (textually, intellectually) 'naked' object. These ideas referenced parallel efforts to reform knowledge by addressing the relationship between words and things, informed the rhetorical claims of the empirical sciences.[61]

Despite this rhetorical work, Willis's actions were necessarily still creative interventions that altered the form of the object: just as the act of removing it from the skull necessarily altered its form, unfolding the brain into a flat 'plain' also represented a change in the brain's 'natural' dimensions comparable to the practice of transverse sectioning: both created flat surfaces out of a spherical object. Despite his rhetoric to the contrary, Willis also necessarily sliced the brain; he could not avoid doing so if he wanted to observe sections under the microscope. He did so in conjunction with the application of new preservation technologies, which artificially preserved specimens for a much longer period. Willis had also been forced to concede that the great 'bulk' of the cerebral matter remained a significant 'hindrance' to a close examination of the basal structures and would therefore need to be removed before the former could be fully examined. The brain would, eventually, have to be excavated and dismantled. Willis's account (and Wren's accompanying images) were, furthermore, based upon composite rather than direct representations - an amalgamation of comparative anatomies. This work relied upon the core assumption, held by Willis, of a 'remarkable analogy between Man and four-footed beasts' (p.56). His study of the brain was therefore already being 'mediated' by these broader practices and by his intellectual commitment to the notion that structural features – shared between human and animal brains – could speak directly to

[60] Michael McKeon, *The Origins of the English Novel 1600-1740* (Baltimore, London: Johns Hopkins University Press, 1987), p. 105.
[61] Devon Hodges argues that Vesalius aimed to present the body to the eyes of his students 'unencumbered by representation' and to 'present the unadorned truth to the eyes of his readers,' in *Renaissance Fictions of Anatomy* (Amherst: The University of Massachusetts Press, 1985), p. 3.

matters of function.

Most striking of all is the quiet admission, nestled towards the end of the chapter, which reveals that the unfolded brain described by Willis – on which so much of his observations depend - is in fact a substitute: only a sheep's brain, and not human one, could be projected in the manner he described on account of the sheer bulk of the human cerebrum, which meant it could not be 'so easily and thoroughly inverted' (p.61). The human brain could be 'bent back' to allow examination of its interior, but a sheep's brain could be entirely 'spread plain.' Willis's investigation of the 'unfolded' brain was therefore dependent upon a set of transposed observations, conducted on the basis of a stable analogy between the structures in man and four-footed beasts. None of this is particularly well signposted in the text; Willis was distinctly vague about *which* brain he was unfolding. This was enabled by the fact that his argument rested not so much on the individual 'facts' of the object itself as in the claims being made about the kind of object it represented: the brain was a substantially solid, complex, structural object.

A bowl of curds: contesting analogies

Whether an anatomist chose to unfold or slice the brain, they confronted the same set of challenges when it came to investigating its fragile, gelatinous material. Upon removal from the skull, the brain immediately begins to relinquish its form and rapidly disintegrates. As Steno had complained, the brain possessed a near fluid-like consistency such that its fibres 'can hardly be touched without breaking.'[62] The further one delved into its depths, the more its structures melted away. Willis pointed to this when he talked about the need to 'explicate' the brain before all its continuity and substance were 'dissolved' (p.6). These material features did not simply represent a practical obstacle; they also created the unsettling impression that the brain itself had no substantial form, besides that which its container (or the anatomist) imposed upon it. As a result, Steno suggested that nothing reliable could be said about the brain: as he vividly remarked, 'when you would look into its inner substance you are utterly in the dark.'[63] This left the

[62] Nicolaus Steno, 'A Dissertation on the Anatomy of the Brain', translated by G. Douglas (London, 1743) reprinted in Ole J. Rafaelsen MD., *Steno in Six Languages* (Copenhagen; Rhodos, 1986), p. 59. On the unsettling prospect of delving into the elusive depths of the early modern body, Sawday (1995) comments that 'The body's interior architecture concealed dizzying depths and capacities… in which the imagination could lose itself,' p. 16.
[63] *Ibid,* p. 16.

subject open to speculation and invention: 'we know so little of the true structure […] that a Man of tolerable Genius may say about it, whatever he pleases.'[64] This was a stinging criticism levelled against those anatomists – most notably Willis - who would presume to build physiological theories upon what could only be accepted as a flawed anatomy of the brain.[65]

Figurative representations of the brain as a gelatinous, fluid mass reinforced these assessments and supported the arguments of figures such as Steno who sought to reject Willis's notion of the brain as a container for the soul.[66] Willis's task, therefore, was both a technical challenge – finding new technologies to circumvent these difficulties – and a matter of creating a new discourse around the brain, challenging prevailing representational strategies. In his efforts to rehabilitate the brain as a reliable material and thereby, intellectual, object Willis evoked a new kind of object through images of a 'structural' and solid object, one displaying a variety of intricate textures and forms intended to supplant the fluid-brain evoked by his rivals.

On the matter of the practical change, Willis adopted a pioneering (if rudimentary) preservation technique for 'fixing' the brain in alcohol, as used by Robert Boyle who noted that the 'spirit of wine' left a 'clear prospect of the bodies immers'd in it.'[67] The use of alcohol infusions had a dramatic impact: the brain could be studied for a matter of days, rather than hours, conferring obvious practical advantages onto Willis over his predecessors.[68] It was also useful in preserving thin slices of brain tissue for close examination under the microscope.[69] This technique was amended through a new technique *chirurgia infusoria*, developed by Willis's colleagues Christopher Wren and Dr Richard Lower, which involved intravenous infusions of alcohol and coloured dyes being

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64 *Ibid.* For a discussion on Steno's views regarding the limits of anatomical inquiry see: Kenneth Dewhurst, *Willis and Steno*, p. 46.
65 Dewhurst, p. 46.
66 On those objecting to materialist notions of the soul, including on the grounds of the brain's physical inability to give rise to such events, see: John Henry, 'A Cambridge Platonist Materialism: Henry More and the Concept of Soul,' *Journal of the Warburg and Courtauld Institute,* 49 (1986), pp. 172-95.
67 Quoted by Carl Zimmer, *Soul Made Flesh: The Discovery of the Brain - and How It Changes the World* (London: William Heinemann, 2004), p. 166. Zimmer notes that soaking the material in alcohol helped to fix the shape of specimens, which could then be more easily cut and sliced; this provided days, rather than hours of observation time, p. 176.
68 On the new method of fixing the brain see: Sugg, *Smoke of the Soul,* p. 303; Cavalcanti, 'Anatomy, Technology, Art, and Culture,' p. 17.
69 Bradley C. Lega, 'An Essay Concerning Human Understanding: How the *Cerebri Anatome* of Thomas Willis Influenced John Locke,' *Neurosurgery*, 58.3 (2005), pp. 567-576 (p. 570).

injected into arterial vessels.[70] It is often presumed that Willis's access to these new techniques supplies us with an obvious explanation for the greater accuracy noted in his depiction of the basal structures and vascular system, as compared to Vesalius before him, for instance.[71] However, this is more than a story of technical achievement.

Willis's interest in, and subsequent focus upon, the substantial material form of the brain was made possible by the advent of new technologies, but these events on their own do not explain his motivations. Rather, we must acknowledge that Willis's *practical* focus on the intricate structures of the brain was broadly informed – and made meaningful – on account of his pre-existing physiological ideas. The new method was conceived as part of a wider effort to validate an alternative set of ideas about the nature of the corporeal soul, which he conceived in terms of animal spirits moving within the parts and channels of the brain's interior spaces.[72] Accordingly, Willis used his new dissection techniques to present the anatomical brain as characterised by solid, complex material structures – the 'channels' and 'chambers' of the soul. These intellectual theories were realised – in the material of the body - through the application of new technologies. Despite the broad appeal to a more naturalistic presentation of the brain, what Willis created here was an alternative way of seeing the brain; one which was no less the product of the anatomist's own specific emphases and physical interventions.

These practical changes – and the arguments that were built around them – were importantly bound up in Willis's use of language. He needed not only to stabilise the brain in a material sense, but also to suggest how this change could reveal an entirely distinct kind of object. This involved contesting popular representations of the brain as a wet and even repulsive object - the gelatinous mass evoked in Steno's remarks. The English philosopher, Henry More famously likened the cerebral hemispheres to a 'bowl of curds' and the human intestines.[73] This ignoble intestinal analogy was both effective and ancient, having also been employed by Vesalius to describe the convoluted presentation of the cerebral hemispheres. The analogy was notably persistent: in 1684,

[70] On Wren's development and use of this injection technology see: Sarah De Rijcke, *Regarding the Brain: Practices of Objectivity in Cerebral Imaging, Seventeenth Century to Present* (PhD thesis: University of Groningen, 2010), pp. 34-5; Nathan Flis, 'Drawing, Etching and Experiment,' p. 155.
[71] Dewhurst, p. 46.
[72] Adrian Johns makes a similar argument, stressing that the 'practical novelty' of Willis's method lent 'legitimacy' to his claims about the soul: 'The Physiology of Reading,' p. 145.
[73] More's idea of the brain was of a 'watery, structureless substance', see: Carl Zimmer, 'Introduction: Bowl of Curds,' in *Soul Made Flesh,* pp. 3-9.

for instance, Raymond de Vieussens maintained that of all the parts of the body the brain was most like the intestines.[74] Analogies between parts of the body are a somewhat self-referencing system – they do not extend or amplify beyond a shared domain (the body), as a comparison with a complex machine or celestial body might. Both the bowl of curds and intestines ultimately stressed the same point: that the brain was, despite its raised position, still a component of a corrupted, fleshy vessel. It certainly wasn't a site fit to house the higher operations of the soul. Walter Charleton publically rejected Willis's proposals noting that the 'wet' consistency of the brain made it a difficult notion to accept:

> […] truly if any man shall seriously, and without prejudice consider the great bulk, cold temperament, various parts, fabrick and texture of the Brain; he will at length find but little reason to believe, that Nature hath framed it chiefly for a Laboratory of Spirits […] can a part so dense, so cold, so clammy, and to like a bogg, as the Brain seems to be, be thought an instrument fit for sublimation or rectification of a spirituose substance? [75]

The imagery evoked by Charleton, of the 'cold' and 'clammy' environment of the brain, evoked the fluid imbalances characteristic of traditional humoral physiology. Health was determined by a precarious balance between the four humors; by inciting an image of a predominately cold and wet brain, Charleton marked it out as an unlikely seat for a spirituous and active soul.[76] In this passage, Charleton looked to undermine Willis's specifically chemico-corpusuclar theory of the soul by suggesting that the subtle matter of spirits could not be sublimed or circulated within such an environment. The laboratory analogy, site of experimental learning drawn upon so heavily in Willis's earlier writing around the brain, is mocked and ultimately displaced here by the image of the bog - a visceral and dark setting. What we see here is how debates about the material qualities of the brain's anatomy acted as proxy arguments for rival conceptions of the soul (and its relationship to the body). How the brain was to be framed – a laboratory or

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[74] Ludger Schwarte, 'The Anatomy of the Brain as Instrumentalization of Reason,' in *Instruments in Art and Science: On the Architectonics of Cultural Boundaries in the 17th Century,* ed. by Helmar Schramm, Ludger Schwarte and Jan Lazardzig, vol. 2 (Berlin, New York: Walter de Gruyter, 2008), pp. 176-200 (p. 183).

[75] Walter Charleton, 'Enquiries into human nature,' in *Anatomic prælections in the new theatre of the Royal College of Physicians in London,* (London: Printed by M. White, for Robert Boulter, 1680), VI, p. 175.

[76] Martensen, pp. 12-13. See also John Sutton's work on cultural representations of Englishmen's brains as excessively moist and inconstant as a reflection of their environment: 'Spongy Brains and Material Memories,' in *Environment and Embodiment in Early Modern England,* ed. by Mary Floyd-Wilson and Garrett A. Sullivan Jr. (Handmills, Basingstoke: Palgrave Macmillan, 2007), pp. 14-15.

a bog – carried high stakes indeed. It was important, then, for Willis to reframe this discourse. As he noted, the removal of the brain from the skull was itself intended to allow him a greater examination of 'its make or fabric, and the disposition of order of all its parts [...]' (p.60). Removing the membrane also showed that the 'substance of the brain itself' was distinct from that of its appendix, the cerebellum, with the latter displaying a striking 'striated' texture (p.60). Rather than an amorphous mass, the brain is here composed of various discrete parts, materials and textures – images that moved the reader far beyond the intangible, unfixed form suggested by the image of a bog or curds. This was a vital foundation for Willis to have established, which would be used to support his alternative physiological model of the mind.[77] In this, Willis did much more than simply improve upon the accuracy of the brain's anatomy; as Anthony Clarke, along with many others, has stated, Willis is to be credited with having introduced a 'new way of seeing the brain.'[78]

Cerebral Topographies: Mapping the Brain

One particular set of images that unites the themes discussed so far in this chapter is Willis's extended use of topographical analogies; this drew upon both his prevailing rhetoric of naturalism while also emphasising how the complex, structural features of the brain might be seen as indicators of brain function. Where images of curds, intestines and bogs had couched the brain in a veil of opaqueness – a challenging and unworthy subject – Willis instead conjured an image of the brain as a detailed, terrestrial landscape to be explored and traversed, presented 'in the mode of an atlas.'[79] Like the world, the brain was richly inscribed with different forms and textures; his analogies thus conjured up images of river systems, valleys, or ploughed and furrowed fields. As Willis described it, 'the substance of the brain is seen to be plowed, or laid as it were with furrows, out of which arise banks or ridges of broken crevices' (p.92). These images helped to stress the textured quality of the cerebral landscape as well as its structural complexities. In the cerebral hemispheres – so long associated with the intestinal mass - its convoluted folds were instead likened to 'a plot of ground, planted everywhere with nooks and corners' (p.92). Although the two images did much the same work, in that they visually conveyed

[77] Rousseau suggests that this was a vital innovation by Willis in his *Nervous Acts* (2004), p. 168.
[78] Edwin Clarke and Kenneth Dewhurst (eds.), *An Illustrated History of Brain Function: Imaging the Brain from Antiquity* (Norman Publishing, US: 2nd edition, 1995), p. 77.
[79] Flis, 'Drawing, Etching and Experiment,' p. 146.

the random folds which characterised the cerebrum, they also imported a very different set of associations. A ploughed field is in fact a cultivated feature of the landscape; it is a productive space. God, of course, as the 'first workman', had himself created these formations in the body precisely so that they might serve a valuable function. With his prior assumptions about the noble work of the brain, Willis certainly believed that these functions were to extend beyond the expulsion of waste products.

These topographical scenes were also notably familiar and accessible. People could not peer inside their own bodies to study the intestines, but most would be able to see a plot of ground first hand or even tend to it themselves. These were images that divested his anatomical account of the darker, visceral connotations of the body and supplanted this with the rich discourse of geography.[80] In co-opting the language of topography, Willis appropriated a collection of intellectual tools and textual signifiers used to organise and make sense of the space around us – tools which he transposed from the landscape of the new world to the new territory of the body. For instance, Willis describes how

> The anterior branches of the Carotides […] creeping upwards like a bounding River, distinguishes either Hemisphere of the Brain as it were into two Provinces (p.10).

The brain was a structure comprised of discrete but interconnected regions or territories. As with the terrestrial globe, these features could also be used to denote inter-connected or communicating geo-political entities, a model which would have implications for Willis's explanations of the operations of animal spirits between the two 'hemispheres'. In another example, the nerves were described as gaining a 'larger province' in the mouth and face (p.12). Importantly, these were not spatial markers imposed by the anatomist's knife, but naturally occurring characteristics of the cerebral-landscape; like the explorer, Willis presents the anatomist's role as being to report, not remake, what he observed. Borrowing from geographical discourse was, on the one hand, a reference to the naturalism bound up in Willis's broader narrative of the 'unfolded' (as opposed to the sliced) brain; it also represented a useful and specific analogue for the body. Provinces,

[80] On the violence implicit in early modern anatomy see Sawday (1995), p. 1. On learned physicians wariness of being associated with the rough and violent work of common autopsy in this period see: Roy Porter, 'Death and the Doctors,' in *In Sickness and in Health: the British experience, 1650-1850,* ed. by Porter and Parker (London: Blackwell, 2005), pp. 245-57. This argument is repeated by Harley, 'Political Post-Mortems and Morbid Anatomy,' (1994), p. 21.

regions, hemispheres were all representations of how "things" were positioned in space relative to each other – a task shared by the cartographer and the anatomist alike.[81] As recognisable signifiers of units of space in the world, these images helped to suggest a tamed and disciplined anatomy, helping to dispel the lurking prospect of visceral or fluid chaos.

Willis's language therefore evoked parallels between contemporary projects to 'map' the (rediscovered) body and the new world; both involved traversing new landscapes and both represented acts of discovery. Willis did not just describe the brain in the mode of an atlas, but also framed his observational experiences of the brain in terms of explorer-discovery narratives. [82] The representational task faced by the anatomist, as they progressed deeper into hidden and alien terrain, was certainly open to a comparison with parallel efforts to map the edges of the atlas. As Jonathan Sawday notes, 'the body was a territory, an (as yet) undiscovered country', the exploration of which seemed 'analogous' to the experiences of the voyagers writing about the discovery of news lands.[83] This mode of representing the body was by no means new to Willis: the body had long been evoked through a variety of spatial metaphors, while the narration of its form in terms of traversing a physical topography was a well-established trope in anatomical poetry. Prominent examples from this period include Phineas Fletcher's *Purple Island* (1633) and John Donne's first *Anniversary* poem 'Anatomy of the World' (1611). While not original, Willis certainly used topographical analogies to particularly vivid and original effect in articulating his 'new' vision of the anatomical brain.

The elevated (rather than excavated) brain also meant that the brain's features could be traced out in new and more flexible ways. As he noted, the carotid arteries were 'more clearly beheld if the Brain be lifted up', before instructing the reader to bend and tilt the brain in order to continue following the path of the optic nerves (p.8). These actions read

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[81] Sawday, *Body Emblazoned,* p. 86.

[82] Representations of the anatomical body frequently borrowed from cartographic practices. On this see: Sara Kowalski, 'Severed Limbs and Dissected Bodies: Early Modern Discourses of Anatomy, Cartography, and Corporeal Fragmentation in the Age of Discovery', *Graduate Journal of Visual and Material Culture*, 4 (2011), pp. 1-20 (p. 7, 14). Valerie Traub also discusses how the mid-seventeenth century saw a 'synthesis of anatomical and cartographic practices' that created a 'global body': 'Mapping the Global Body,' in *Early Modern Visual Culture: Representation, Race, and Empire in Renaissance England*, ed. by P. Erickson and H. Clark (Philadelphia: University of Pennsylvania Press, 2000), pp. 44-97.

[83] Sawday, p. 23. As Alan Salter has explored, a 'language of popular empiricism' brought these discourses on the natural world and the body together under an 'empirical narrative framework of discovery': 'Early Modern Empiricism and the Discourse of the Senses', in Wolfe and Gal (eds.) *The Body as Object*, pp. 59-75 (pp. 59-60).

as if they continued on from the passive acts of unfolding with which the process commences: Willis, like the explorer, follows and traces out pathways, tilting and bending the brain as he goes. As I've touched upon already, Willis was especially concerned to emphasise his attendance to the natural sequence and order of parts within the brain. Notably, even when Willis refers to his own acts of cutting (and he must), these actions are almost always conditioned by this surrounding narrative of sequential progress through a geographical landscape. This was an important contrast for Willis to establish - between an observational experience that was guided by nature's own design against one that was imposed, fragmented and broken.[84] Here, Willis in effect mediated the loss of (an artificially imposed) order to the brain by deferring – as the explorer might - to the order presented before him by nature.

In addition to these images, Willis also drew on a host of organic, vegetative analogies, especially in attempting to represent the networked complexities of the vascular structures. The nerves penetrated the brain, for instance, like 'young branches of Vines' - a familiar sight in the garden - as they 'branch' out and 'impart roots' (p.8, 10). The arteries similarly rose up on either side of the brain to encompass and bind the sphere or globe of the brain together: sending 'forth shoots and little branches on every side' they 'intimately bind about the utmost compass of its Sphere' (p.10). These structures formed a particular visual challenge. Like creeping vines, they displayed

> […] several tails or little feet compacted together, all of which, although distinct one from another, are endued with figures diversly expanded…thrust everywhere into the same Globe (p.5).

The image resonated, for Willis, with the spectre of the 'labyrinth' only he was now tasked with mapping its contours onto the flat of the page. One of the ways in which Willis developed and disciplined the potential chaos lurking within this imagery of creeping vines and shoots was through the supplementary (and notably artificial) image of a net, a constructed or man-made object. He describes how,

[84] Kowalski also argues that, through certain figurative representations of the brain, Willis attempted to construe a notion of his dissected brain as an object that could still be 'trusted' to reveal its natural form: 'Severed Limbs', p. 14.

> […] the subject may be seen covered with the infolding Vessels, as it were with a net admirably variegated or flourished, and its sight or aspect shews like the picture of a fruit bearing wood (p.10).

The inclusion of the image of the net helps to tame the initial prospect of the mass of tails and feet by drawing our attention to the replicating, visual pattern created by the net. As with a net, the vessels created inter-related, replicating units of space extended over a large area (though not in a regular fashion). While he could not describe in exact detail every 'unit' of this net he could, through the comparison, impart a (borrowed) structural logic. Both the net employed by fishermen and the vessels of the brain were structured in such a way as to distribute evenly, over a large surface area. As a constructed object used in industry, it was an image that also helped to infer a notable artifice in the vascular structures and nerves: these images moved the reader away from the initially chaotic prospect of feet and tails to an image of purposeful and rational design. As William Bynum notes, the notion of providential artifice as something revealed in the design of the body was a key factor in Willis's use of anatomical form to speak about physiological function.[85]

The pattern represented by the net was nevertheless significantly complex – defying direct visual representation. The 'wonderful net' or *rete mirabile* was, for instance, depicted in diagrammatic form as a unit of cross-hatched space in Vesalius's illustrations of the brain.[86] A more accessible and indeed, naturalistic, picture of the same networked effect is instead supplied by the image of a 'fruit bearing wood.' The wood created an image of branches heavy with appendages, forming a complex visual matrix of divaricated forms and distributed fruits. This was a far more accessible representation of structural complexities that could not otherwise be described directly and of Willis's broader argument that these vessels served for the even distribution of blood across the brain. Once again, these images served to emphasise the naturalness of the object Willis presents to the reader.

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[85] On the assumption of design, and therefore a designer, in the correlation of form with function in early modern anatomy see: Bynum, 'The Anatomical Method,' (1973), p. 445.

[86] On this and the broader history of representing the *rete mirabile* see: Sebastian Pranghofer, "It could be Seen more Clearly in Unreasonable Animals than in Humans": The Representation of the Rete Mirabile in Early Modern Anatomy,' *Medical History,* 53 (2009), pp. 561-586 (p. 566). See also, Richard Sugg, *Smoke of the Soul,* p. 284.

The image of the 'fruit bearing wood' was not, however, a simple visual analogy for the 'natural' object presenting before Willis's eyes; rather, it was a picture generated specifically by his use of intravenous imaging techniques.[87] As he describes it,

> […] the picture of a fruit-bearing wood, the Idea of which, the Vessels of the Brain more aptly represent, and are themselves seen better and more distinctly, if you first squirt into the Carotidick Artery some black liquor' (p.10).

By adapting the intravenous infusions pioneered by Wren and Lower to inject coloured dyes into the cerebral arteries, Willis created an augmented sight in the brain which both enhanced the visual presentation of the vessels and also made them better conform to the analogy he had proposed.[88] These practices visually – and intellectually - enhanced those structures that were most important to Willis while at the same time diminishing those that weren't. Notably, what Willis reproduced here was the experimental replication of blood-flow - the inanimate object is by such means reanimated, providing a simulation of its function in life. Again, Willis's practices worked here to reinforce his particular way of seeing the organ as one primarily intended to support physiological operations. Here, the vessels are not visualised in their own right but highlighted as formations that could be made to speak to the nature of the spirituous activities which occurred within them.

Willis used this imagery of the rich, cerebral 'landscape' to foreground important functional claims. His analogy between arteries and rivers, for instance, helped the reader imagine both their visual appearance (as networked structures) and their role in channelling and directing the flow of blood about the brain. Willis's interest in the movement of blood and nervous juices through these complex structures further consolidated his rejection of the vague circulation models denoted by the ventricular theories, derived from Galen. The meandering and crooked nature of these vessels moreover, especially at the base of the brain, further suggested the provision of flood defences. Willis interpreted these features by drawing on existing ideas about the differences between human and animal physiology noting, for example, that in humans the carotid artery enters the brain as an 'undivided channel' and rarely sent out small

[87] On technology and visualisation see Flis, p. 146.
[88] Lega, 'How the Cerebri Anatome of Thomas Willis Influenced John Locke,' pp. 567-576.

'shoots,' because, he reasoned, humans needed a free and full supply of blood for the enactment of the 'generous Affections' of the sensitive soul (p.29). To which end,

> […] it is behoveful for its River not to run into narrow and manifoldly divided Rivulets, which would scarce drive a Mill, but always with a broad and open chanel, such as might bear a Ship under Sail (p.86)

On the one hand, Willis recorded his direct observation that the carotid in humans is less divaricated (or networked) than in animal brains; at the same time he also connected this observation, through the analogy with the mill and ships under sail, to his interpretation that human brains were anatomically designed to support greater affective capacities. His anatomical findings reproduced and confirmed a working model, rather than being a simple matter of empirical discovery. Having noted the need for an unhindered supply of blood to the brain, Willis also looked to demonstrate a corresponding provision of defensive structures, suggesting that the 'meandering' and 'crooked' ascent of the carotid artery, like a 'river' carving its way through a valley, would moderate this plentiful flow of blood into the brain. As he noted, by this 'imbowing' the blood was 'carried about by a longer compass, (that the Torrent of the Blood, before it comes to the border of the Brain, might flow slowly and pleasantly with a broken force)' (p.48).

This too was a reading of the brain which Willis looked to demonstrate through his experiments with coloured dyes: 'the liquor being plentifully injected, could not so suddenly pass through the very small Vessels covering the Brain' which prevented the brain from being subject to the 'violent impulse of the liquor' (p.30). Notably, the results of this experiment did not stand on their own: rather, the observable outcomes were made sense of by reference to the distinctions encapsulated in the contrast established between the open channel and the crooked 'imbowing' of the arterial rivers. From narrow rivulets to broad channels, these analogies – used in conjunction with new imaging techniques - were used to propose significant physiological models of human and animal brain functions, thereby moving well beyond the traditionally agreed parameters of anatomy.[89]

[89] Caron, p. 24.

These discussions were, in turn, used to support a quite different kind of metaphor: that of the brain as an apparatus of chemical distillation, used by Willis in his *Diatribae Duae* (1659) and then repeated in *Anatomy*. As he observed, the blood vessels, arranged 'like leaves of a wood', worked to instil animal spirits into the brain 'as it were [by] a Chymical Artifice' (p.48). The vascular pathways further reminded Willis of 'little serpentine channels hanging to an alembic' – the glass flask used in the distillation process. Particular attention was paid, here, to the work of the arteries in establishing the conditions required for distillation to take place inside the brain. He observes, for instance, the 'notable provision' of 'imbowings and branching' of the arteries that hinders the approach of the blood ensuring that, 'concerning the matter to be distilled…great care is taken both that choice of matter may be had, and that only a due proportion of it be exposed to distillation' (p.54). Here, Willis took the findings of his experiment – which showed a slowing down the influx of blood - as a feature designed to support the process of distilling and refining the spirits delivered to the brain.

These anatomical findings were therefore being interpreted through – and used to reinforce – pre-existing intellectual models conceived by Willis, shaped by his earlier chemical practices. Images of rivers, crevices and branches helped to map a set of chemical ideas onto an anatomical (and thus more empirical) setting. This complicates any sense in which Willis used his analogies to simply illustrate the anatomy of the brain he saw before him. Furthermore, these examples show how topographical imagery could also intersect with and help to extend a chemical metaphor. This highlights both that his anatomical findings were mediated by his physiological and chemical theories, but also that a given set of analogies or metaphors do not necessarily operate in isolation within a text. They can be used to extend and develop an apparently unrelated set of images.

Interestingly, the topographical and vegetative imagery of these examples was not applied uniformly to the entire brain but featured most prominently in his discussions of the brain's cerebral hemispheres (its 'grey' matter) and major arterial networks. Once the brain had been 'opened' up to expose the so-called 'white' interior structures, the typographical imagery largely gives way to a far more architectural and mechanistic set of analogies (p.12). The outcomes of these contrasting image-sets are explored in the next chapter. The point I wish to emphasise here is that topographical analogies served a specific function at a certain point in these explanations. They were also part of a

broader contrast, noted by Willis, between grey and white material structures in the brain – visually embodied in two vastly different sets of analogies. Overall, topographical images helped to establish the brain as a complex, interconnected body of parts: spatially organised (as hemispheres and provinces) and bound together as one 'globe'. They also provided a platform for considering functional implications through references to flood defences and river-flow management. Willis was less concerned here to discuss the specific, localised operations of the soul inside the brain than he was interested in establishing a larger physiological framework against which to frame those events. The success of Willis's broader argument – that the brain could indeed house the physiological operations of the soul – was, for example, importantly grounded in his observations that the brain received a plentiful provision of blood and spirits from the body and that it could also manage and refine the ingress of that matter. These were arguments that were inextricably linked to the creativity and effectiveness of his analogical strategies.

Conclusion

Willis promoted to his reader the idea of a direct and unmediated encounter with the brain as a 'natural' object, chiefly by describing an unfolded rather than a dissected brain – a claim he substantiated and developed through naturalistic imagery and topographical analogies. Despite all of his narrative work Willis still, at some stage, cut or broke parts of the brain in order to peer inside; his claim to expose the all the brain's hidden recesses to view clearly required a much greater level of physical intervention than merely stretching, lifting or unfolding. However, what Willis's narrative achieved more broadly was to push this conflict to the margins. Arguably, his framing of his methodology around a language of naturalism and the passive acts of freeing, unfolding and exposing the brain was an attempt to diminish the creative impositions of dissection, to erase (as far as possible) his own active presence. It was also a means by which to claim a specific kind of authority – signified through reformed observational practices – with which to support his later arguments around the soul.

Within more traditional scholarship around Willis, it has been proposed that his physiological ideas mark a deviation from an otherwise meticulously empirical investigation into the brain and nerves. This suggests that his descriptions of anatomical

structures were objective and free from the literary excesses of his functional explanations. This reading fails to take account of the rhetorical arguments bound up within Willis's account of his own practices and the specific kind of objectivity he strove to adopt in order to validate his physiological arguments concerning the soul. Moreover, the nature of his findings - their significance and meaning – was fundamentally mediated through his use of particular literary strategies of representation. Willis's arguments relied in no small part upon the effectiveness of his images of the brain as a new kind of object, moving from an amorphous mass to a complex 'globe' marked out by discrete 'provinces' and channels. The outcomes of his *Anatomy* thus relied upon a set of contested analogies of the brain, rather than being produced by a straightforward technological development or neutral observational experience.

The key point here has been to challenge approaches that treat anatomical discovery as independent of the literary representations that surround those events: Willis's claims to objectivity were based as much on his practices as the rhetorical claims he was able to construct around those acts. There is no possibility of an anatomical account bound only by the work of describing the body 'as it is'. For Willis, the work of describing the brain was simultaneously a project to map out the hidden places of the soul and to suggest something about its activities. Here, Willis's metaphors and analogies of the brain were not merely illustrative guides but arguments for a particular vision of the soul. His descriptions of the 'unfolded' – or explicated - brain allowed him to emphasise the importance of the structure and sequence of the brain and its underlying structures; these were the sites and structures within which his explanations of the soul's operations within the body would be situated. This is not to undermine Willis's contributions to anatomical knowledge, but to emphasise how, through the work of analogy and metaphor in science, knowledge is produced out of the dynamic intersections between language, culture and practice. The issues raised here remind us of the need to consider the intrinsic relationship between practice and rhetoric in the history of science; there is no simple dichotomy between scientific knowledge and literary strategies.

Lastly, the correlation Willis drew between limited physical intervention in the body and claims of a more objective or accurate account is perhaps evident in our use of modern imaging techniques – to the extent that there is increasingly no need to actually dissect a brain in order to study how it works. These modern techniques reproduce a certain

emphasis on the movement of blood through structures of the brain, rather than being concerned with structure in its own right. This is not to say that such practices are a direct inheritance from Willis; but to suggest that ways of looking at the brain are always shaped and limited by the availability of technologies and the metaphors and linguistic structures available to make sense of them. There is no self-evident representation of the brain to be found, only historically specific ones; this is true of Vesalius's sliced brain as much as it is of Willis's 'unfolded' brain and the modern MRI scan.

Chapter four

The Cloistered Brain and the Clockwork Cerebellum

In 1653 the Cambridge Platonist Henry More remarked that the 'Brain, with all its Caverns is but one great Nerve;' a hollow, conduit structure.[1] It was, for More, also an unstructured and disturbingly moist object, which he chose to compare to a 'cake of sewet' and a 'bowl of curds.' It was thus too 'laxe' to house something as noble as the soul.[2] Where More had seen only caverns and curds, Willis instead emphasised a complex, solid and structural representation of the brain. He described an intricate architectural setting replete with cloisters, cells and chambers. Importantly, reflected in these contrasting representations of the brain's internal spaces, were two vastly different models of the soul. While Willis's account was in no small part the outcome of new techniques for physically investigating the brain, it was also bound up in the ways in which he was able to conceive of the brain through the lens of a particular physiological theory of the soul.

Reflecting on the next stage of his anatomical investigation, Willis wrote that having 'thus far beheld the Coverings of the Brain,' a consideration of the 'Fabrick and true Hypotype or Character of the Brain and its Appendix, together with the action and use of all the parts' should follow.[3] What was notable about his approach here was the particular emphasis on the structure and fabric of the brain itself, alongside a broad disregard for its cavities or ventricles – previously significant locations for models of brain function. Moreover, beyond simply describing the physical form of the brain, Willis explicitly sought to use his anatomical account to provide a more solid foundation for a detailed physiological model of brain function. He is often heralded as being the first to establish the brain (and the nerves which served it) as the exclusive seat of the sensitive soul in the body; the ways in which he chose to represent his anatomical findings was an important

[1] Henry More, *The Immortality of the Soul* (London, 1659), p. 130. John Henry, 'A Cambridge Platonist's Materialism: Henry More and the Concept of Soul,' *Journal of the Warburg and Courtauld Institutes*, 49 (1986), pp. 172-95.
[2] More retained his conviction even after Willis's much celebrated anatomical research had been widely disseminated after 1664 showing it to be a solid, structural object, *Immortality,* p. 106.
[3] Thomas Willis, 'Anatomy of the Brain', in *Remaining Medical Works*, translated by Samuel Pordage (London, 1681), p. 90. All in-text citations will refer to this edition using the abbreviation 'AB.'

part of this intellectual contribution.[4] Willis's arguments, for instance, were broadly premised upon a correlation between (anatomical) form and (physiological) function: the more complex the anatomical formations he observed, the more complex the functions he was able to ascribe to them.[5]

The question of how the anatomical structure of the brain could be used to reveal the (invisible) workings of the soul sat at the centre of Willis's anatomical work.[6] Though this constituted (for a number of Willis's detractors) a dangerously speculative leap from what was known to what could not be, Willis's application of anatomical learning in order to consider the nature, powers and arrangement of the soul fitted into a long established tradition of using the providential design of the body to make teleological arguments concerning the soul in natural philosophical works.[7] A notable example is in the work of the influential sixteenth century Wittenberg anatomist Phillip Melanchthon, whose popular and widespread *Commentarius de anima,* published in 1540, became one of the most widely printed commentaries on Aristotle's *De anima* in the period.[8] His work is significant here in that it incorporated aspects of Galenic anatomical learning into a

[4] As George Rousseau has argued, it is less the (much celebrated) 'accuracy' of his anatomical descriptions than his important ideas about the brain as the *exclusive* seat of the corporeal or sensitive soul, which marked out his work as paradigmatic: George Rousseau, *Nervous Acts: Essays on Literature, Culture and Sensibility* (Basingstoke: Palgrave Macmillan, 2004), p. 168.

[5] That Willis's anatomical method was premised upon the inferences between anatomical form and physiological function has been well established by William F. Bynum, 'The Anatomical Method, Natural Theology, and the Functions of the Brain', *Isis,* 64.4 (Dec., 1973), pp. 444-468 (p. 450); Robert Martensen, *The Brain Takes Shape: An Early History* (Oxford; Oxford University Press, 2004), esp. pp. 75-81; Adrian Johns, 'The Physiology of Reading and the Anatomy of Enthusiasm,' in *Religio Medici: Medicine and Religion in Seventeenth century England,* ed. by O. P. Grell and A. Cunningham (Aldershot: 1996), pp. 136-170 (p. 144).

[6] Adrian Johns argues that Willis's project was, on this basis, 'specific' and unusual: 'The Physiology of Reading,' p. 144. Michael Hawkins also argues that Willis only described anatomical form to effect an explanation of the passions of the soul, *'The Empire of the Passions: Thomas Willis's anatomy of the Restoration soul'* (PhD thesis: Imperial College, 2004), p. 196. Louis Caron similarly proposes that this use of anatomy to support a discourse on the soul pushed at the accepted boundaries between anatomy, physiology and theology in this period: *The Philosophical Reception of Thomas Willis (1621-1675) with Particular Reference to John Locke (1632-1704),* (PhD Thesis: Kings College Cambridge, 2011), p. 24. However, Hawkins and Caron's positions overstate the case: Willis's works were part of a much longer tradition of using anatomy to investigate the soul, as seen in the works of Phillip Melanchthon and the Wittenberg anatomists. On this, see: Sachiko Kusukawa, *The Transformation of Natural Philosophy: the case of Phillip Melanchthon* (New York: CUP, 2006) and Vivian Nutton, 'Wittenberg anatomy', in *Medicine and the Reformation,* ed. by Peter Grell Ole (London: Psychology Press, 1993).

[7] As Vivian Nutton has argued, it was 'commonplace' to find expressions of teleological argument in anatomy: God left his 'footprints' in the body, as in nature, as 'evidence for man to contemplate.' This was especially evident in Wittenberg anatomy, where such arguments offered a response to the chance model of epicurean atomism: Nutton, 'Wittenberg anatomy', (1993), pp. 11-32 (pp. 18-20). On Nicolas Steno's attacks on Willis's use of anatomical knowledge see: Kenneth Dewhurst, 'Willis and Steno', in Gustav Scherz (ed.) *Steno and Brain Research in the Seventeenth century,* (London: Pergamon Press, 1965), p. 46.

[8] Sachiko Kusukawa, *The Transformation of Natural Philosophy*, (2006), p. 84.

Christian (largely Lutheran) reading of Aristotle's treatment of the soul.[9] Notably, Galenic anatomy had itself sought to align a tripartite schema of the faculties of the soul with particular parts and functions of the body: the incomparable artifice of the body reflected the hand of the creator, rather than chance occurrence, and this design necessarily spoke to the nature or arrangement of the soul it was designed to contain. Willis would himself apply a tripartite model of the soul to represent the arrangement of its faculties within body, but with a focus on the specific micro-structures and textures of the brain itself – rather than the traditional three venters of the Galenic body - as the souls exclusive 'seat' in the body.

To have the soul sit at the centre of a medical investigation of the body of this kind was also reflective of the traditional education physicians such as Willis received at Oxford during this period, which maintained a long and widespread tradition of inquiry into the soul in its natural philosophy curriculum, focusing on explication of Aristotle's *De anima.* Physicians of the learned medical tradition all used the philosophical teachings of the undergraduate arts course - shaped by Aristotelian treatments of the soul - as a starting point for their own medical investigations.[10] While commentaries on Aristotle were in a decline over the course of the seventeenth century, the soul nevertheless still formed 'the culmination of a course in natural philosophy' – and thus medical training - in this period.[11] Willis's education was no exception to this; we need only look to the title of his *De Anima Brutorum* to see how he positioned himself in reference to Aristotle's *De Anima.*

The point to be noted here is that Willis's use of cerebral anatomy to think, in teleological terms, about the intended arrangement, powers and faculties of the soul was not in itself radical. Both Melanchthon and Willis after him drew on a long tradition of teleological thinking within anatomical leaning, notably expressed by Vesalius, whereby dissection could be justified on the basis of its capacity to reveal the imprint of divine craftsmanship, every part having been designed and arranged for a particular function.[12] This elevated knowledge of the body alongside that of the soul. Willis's descriptions of

[9] As Kusukawa argues, Melanchthon's *Commentarius* ought to be read as a work on 'human anatomy *and* the rational soul,' though historians routinely overlook the significance of the anatomical component, p. 101.
[10] Ian Maclean, *Logic, Signs and Nature in the Renaissance: The Case of Learned Medicine (Ideas in Context)* (Cambridge: Cambridge University Press, 2007).
[11] As Richard Serjeantson has argued, though Aristotle ceased to 'sit at the centre of the web of investigations into the soul, the *de anima* tradition was transformed rather than straightforwardly rejected,' 'The Soul', *The Oxford Handbook of Philosophy in Early Modern Europe,* ed. by Desmond M. Clarke and Catherine Wilson (Oxford: OUP, 2011), pp. 119-141 (pp. 120-121).
[12] On this, see: Nutton, 'Wittenberg anatomy', *Medicine and the Reformation,* (1993), pp. 18-20.

the cerebral anatomy he investigated are, therefore, an important and even integral component of his broader arguments about the soul. Willis's arguments that specific structures in the brain could be used to express a (quite expanded) range of functions and activities for the animal spirits nevertheless probed new and potentially contentious ground; how he chose to represent the details of his anatomy of the brain is therefore important when examining his defence of a new physiological model of the soul.

What is of interest here, specifically, is how Willis marshalled his specific analogical and metaphorical representations of brain-structure to buttress his use of inferences from the body in order to make claims about the soul. The anatomical 'facts' he described here were not merely the result of empirical 'discovery'– their significance as sites of knowledge and as a particular kind of evidence (as objects that spoke to a concept of the soul) are established through creative, intellectual activities – including literary strategy. Even as Willis grappled with the visceral forms displayed on the dissecting table before him, it was his conception of the body as a vessel for a particular kind of material soul that gave meaning and form to those observations. The soul is necessarily the object of his *Anatomy*.

The themes that I seek to pick up on here have been variously touched upon in scholarship from the late 1980s onwards, in particular by Robert L. Martensen (2004) and Michael Hawkins (2003). Hawkins argues, for instance, that 'it is difficult to understand his [Willis's] theories fully without an appreciation of how he believed that anatomical knowledge of the structure of the brain and nerves revealed their hidden physiological and pathological aspects.'[13] As Roy Porter and others have also shown, Willis's concept of the soul was 'not aloof but *plugged* into the bodily economy' – an economy which, according to Willis, was importantly tied into anatomical form.[14] Willis's concept of the soul must therefore be understood also in relation to his representations of the body's structural form.[15] More recently, Louis Caron has stressed the significance of Willis's marshalling of anatomical facts in support of his 'ideological commitments'

[13] Michael Hawkins, *The Empire of the Passions,* p. 196. See also: Robert L. Martensen, 'When the Brain came out of the Skull', in *A Short History of Neurology: The British Contribution 1660-1910,* ed. by F. Clifford Rose (Oxford: Butterworth Heinemann, 1999), pp. 19-35.
[14] Roy Porter, *Flesh in the Age of Reason* (London: Penguin Books, 2003), p. 59.
[15] Ludger Schwarte argues that Willis derived 'the internal architecture of the rational soul from the anatomy of the brain and nervous system': 'The Anatomy of the Brain as Instrumentalization of Reason,' in *Instruments in Art and Science: On the Architectonics of Cultural Boundaries in the 17th Century,* ed. by Helmar Schramm, Ludger Schwarte and Jan Lazardzig, vol. 2 (Berlin, New York: Walter de Gruyter, 2008), pp. 176-200 (p. 189).

concerning the mind, noting that in this pursuit was 'doing something unprecedented.'[16] However, as I have noted above, this position overstates the radical nature of Willis's use of the body to discourse on the soul, which reflected a long-standing tradition within natural philosophy.[17] I also seek to shift the emphasis here by proposing that Willis's anatomical 'facts' were not in themselves self-evidently available or independently deployed in this endeavour: these facts were *created* and made possible by the theory of mind that Willis held.

I seek to build upon this body of work by being more explicit about the significance of literary strategies in the formation and argumentation of these ideas. Willis had already expressed a quite detailed physiological model of the body in his *De Fermentionae* and in his Oxford lectures of 1661, well before he began dissecting the brain.[18] His notions about the nature of spirits and souls looped back and disciplined the ways in which he then saw and read the body before him; these relationships are bound up in the figurative language used to describe the body. In this I build on work by Ann Jessie Van Sant, who has argued that the 'physical and non-physical "spaces" of Willis's brain were 'extensively *related* by the figurative language used to describe them.'[19] That is to say, the specific structures Willis described were made, through certain figurative devices, to speak to his ideas of what was occurring within those functional spaces.

Though aspects of Willis's theory of the soul are necessarily discussed here - as a structuring framework to his anatomical descriptions - Willis's specific ideas around the powers and pathologies of the soul, as well as the wider religious implications, will be examined in considerably more detail in the following (and final) chapter of this thesis. Lastly, in dealing with Willis's literary representations of the brain's structural economy, I also refer back to the physical and technical practices Willis employed, as I considered in the previous chapter. These practices, as I have argued, privileged observations of the brain's *structural* qualities over and above other considerations. In this way literary and technical practices are brought together.

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[16] Caron, *Philosophical Reception,* p. 22, 25.
[17] Kusukawa, *Transformation of Natural Philosophy*, p. 84, pp. 99-101; Nutton, 'Wittenberg anatomy,' p. 20.
[18] Louis Caron also makes the point that Willis had in place a well structured physiological account of the soul by the time he came to write his *Anatomy*, see: *Philosophical Reception,* p. 61. See also: Caron, 'Thomas Willis, the Restoration and the First Works of Neurology,' *Medical History,* 59.4 (2015), pp. 525-553 (p. 541).
[19] Ann Jessie van Sant, *Eighteenth-Century Sensibility and the Novel: The Senses in Social Context* (Cambridge: Cambridge University Press, 1993), p. 63.

Anatomy and the soul: the 'empty trunke'

I have suggested that, in seeking the soul, Willis began with the body - but how did he make this leap, from dissecting the body to representing the soul? And on what grounds did he defend this particular approach? Despite the rise of mechanical and materialist philosophies in the period, prevailing medico-philosophical and literary conceptions of the body continued to be structured by notions of spirits and souls.[20] To investigate the body was to say something about the soul that inhabited and gave meaning to it; they were, to an extent, inseparable endeavours in this period.[21] As Willis noted of the task he had set himself: 'Wherefore to explicate the uses of the Brain, seems as difficult a task as to paint the Soul' (AB, Preface). This task was, of course, one and the same thing for Willis: he described the intricate parts of the brain *in order* to reveal the secret hiding places and pathways inhabited by the soul (AB, p.92).[22]

The brain, for Willis, was first and foremost a container for the animal spirits. The spirits were, as he put it, the primary or 'immediate instruments' of the soul and as such were extended to all parts of the body: 'spirits are the Authors of the Animal Function, and do constitute the *Hypostasis* of the Soul it Self' (AB, p.18-19). The spirits were produced in the brain from the vital spirits of the blood and performed all the tasks of government and sensation by receiving and carrying impressions of the objects of sense between body and brain, travelling through the nerves. Anatomy would lead on to knowledge of the soul's actions in the body by providing a (visible) framework within which to frame and situate these various activities of the animal oeconomy. As he sets out,

> after the figures, sites, processes of the whole and singular parts should be considered […] some truth might at length be drawn forth concerning the exercise, defects, and irregularities of the Animal Government. (AB, Preface)

[20] As Simon Schaffer argues, 'if a mechanical philosophy was to be possible, the minimum condition was the establishment of a proper space for spirit' (in the body). Spirits and souls were both the 'source' and 'target' of these anatomical-physiological enterprises: 'Godly Men and Mechanical Philosophies,' *Science in Context,* 1 (1987), pp. 55-85 (p. 57).

[21] On early modern physiology and anatomy see: Andrew Cunningham, 'The Pen and the Sword: Recovering the Disciplinary Identity of Physiology and Anatomy before 1800. I. Old Physiology - The Pen,' *Studies in History and Philosophy of Biological and Biomedical Sciences*, 33 (2002), pp. 631-665.

[22] Hawkins argues that Willis doesn't study the body 'for its own sake' but as a means to illustrate his theory of the passions of the soul, *The Empire of the Passions,* p. 194.

Despite Willis's apparent optimism, this equation (uniting form, *place* and function in the brain) was neither a given nor without controversy. Where the invisible actions of the soul had once been the preserve of theologians, natural philosophers – drawing on a long Aristotelian tradition of investigating the soul - now developed their discussions of the soul along increasingly corporeal lines, employing atomistic and quasi-mechanical explanations to consider the nature of animal spirits. However, despite the confidence of these new sciences, it was still unclear as to why the bodies of the deceased should have revealed anything about the mechanism of life. This situation was further complicated by the fact that Willis's own theory of the soul granted to its corporeal part (the animal spirits) a certain vital agency, rather than a purely mechanical action; it was even less clear, then, how the physical structure of the body might be made to speak to the nature and actions of that soul.[23]

We get some sense of the opinions against which Willis set himself from the work of the English poet, Edward Calver, who in 1643 - while Willis was still undertaking his medical training at Oxford - published the *Divine Passions,* in which he mused (with some suspicion) upon the role of the anatomist-physician.[24] Calver was a parliamentarian sympathiser who would later write poetry on the 'reconstitution of the body politic' following the English civil war. In this piece, he appears to first muse on its destruction, through the same metaphor of the body.[25] As Jonathan Sawday has convincingly argued, anatomy and poetry shared overlapping frames of reference in this period, so it is not incongruous to find a poet pondering the tensions of the body-soul relationship in these terms.[26] Calver vividly cast the anatomist's endeavour as a violent and crude deconstruction of godly design – a tearing down of the 'walls' comprising the body-edifice - and an ultimately flawed undertaking:

> Man peradventure, like a butcher may,
> Unmake those walls which thou hast made of clay,
> Rip up mans body, open every part,
> Take out his entrails, looke into his heart,

[23] I explore Willis's notion of spirituous agency in chapter five of this thesis.
[24] Edward Calver, *Divine Passions* (London: printed for Richard Harper, 1643).
[25] The Oxford Dictionary of National Biography refers to Calver's poetry as a 'meagre talent,' about which little is known: Nigel Smith, 'Calver, Edward (*bap.* 1598?),'
Oxford Dictionary of National Biography, Oxford University Press (2004) <http://0-www.oxforddnb.com.catalogue.libraries.london.ac.uk/view/article/4408> [accessed 23 Sept 2016]
[26] Jonathan Sawday, *The Body Emblazoned: Dissection and the Human Body in Renaissance Culture* (London: Routledge, 1995).

Note every artrie, conduit pipe, and veine,
And pry into the chamber of the brain.[27]

Calver questioned what form of enlightenment these destructive efforts would bring the presumptuous, *prying* anatomist, asking 'what can man in this description read' when having 'unlocked the doore of some rich cabinet [...] Doth finde it empty, all its jewels gone.' The body, as a 'cabinet' for the soul, once opened by the 'key' of death finds itself transformed:

Mans body straight becomes a trunke bereft
Of all its matchlesse treasure, empty left.[28]

The ornate body-cabinet is instantly reduced to a crude, empty 'trunke' - an early modern term for a dead body or a one without a head, bereft of a soul.[29] All that remained for the anatomist to admire, then, was 'the curious art about the little frame' of the one-time cabinet, the former dwelling places of the soul. As Calver notes, drawing on a Cartesian metaphor of the body-machine, it was the (now absent) soul that had given the physical features of the body significance in the first place: it was the soul that 'sets every wheel a working in the frame.'[30] The structure of the anatomical body, the poem argues, provided very little by way of insight into its own operations. Notably, both the cabinet and the trunke are, when compared to the metaphor of the body-machine, passive objects; the cabinet (once opened) is a display piece for the (passive) anatomist-observer; the trunke, a mere, and now redundant, storage vessel. Calver's objections here provide a useful context for thinking about the perceived limitations of anatomy; it also speaks to the kind of argumentative work required of Willis's account as the poem, in particular, undercuts the premise that anatomy could be used to talk about the soul.

Interestingly, while the body is crudely dismantled, the anatomist's actions in respect of the brain are of a different order: prying into secret chambers, they sought knowledge they were not necessarily entitled to. In the 1660s the influential anatomist, and vocal critic of Willis, Nicolas Steno took up these same concerns, complaining of the arrogance

[27] Calver, *Divine Passions,* p. 96.
[28] Calver, p. 96.
[29] "trunk, n." *Oxford English Dictionary Online*. Oxford University Press, December 2014. Web. 10 February 2015.
[30] Calver, p. 96.

of the anatomist who looked to discuss the invisible matters of the soul through the body.[31] Both Vesalius and Steno after him stuck firm to the notion that anatomy was only to be concerned with describing form and structure - the 'fabric' of the body - rather than to speculate on (physiological) function, which necessarily relied upon the related concept of animal spirits or *pneuma*.[32] As invisible atoms, these bodies could not be directly described or their actions explained according to the demands of experimental or empirical philosophies. Similarly, the Cambridge Platonist Walter Charleton expressed uncertainty over the 'invisible' motions of the spirits and rejected Willis's explicitly physiological (rather than preternatural) approach to the soul. [33] Employing much of the same imagery used in Calver's poetry, Willis sought to make the opposite argument about the brain: that the lifeless structure of this organ *could* tell him something meaningful about the function of the soul.

A shadowy form

One of the ways in which Willis addressed these tensions was to suggest that the spaces created inside the brain formed an inverted or negative image of the sensitive soul. He described how the first operation of the soul was to 'frame the Body as it were its domicil or little House.' The soul 'frames the Body, is Co-extended with it, and fitted exactly, as to a little Box or Sheath.'[34] In so doing, it rendered the body fitted to its uses and was therefore 'intimately united to the Body' as its active 'form' (SB, p.6-7). The sheath in particular develops an image of the brain as a container designed to conform to the shape of its object – just as the sheath is fitted exactly to the dagger. To study the form of the container is to denote something about which it is designed to contain; like a plaster cast, its hollow spaces revealed an image of an absent entity. The soul, thin and

[31] Nicolaus Steno 'A Dissertation on the Anatomy of the Brain', translated by G. Douglas (London, 1743); reprinted in *Steno in Six Languages,* ed. by Ole J. Rafaelsen (Copenhagen: Rhodos, 1986). For a discussion on Steno's views about the limits of anatomical inquiry, see: Kenneth Dewhurst, 'Willis and Steno', in *Steno and Brain Research in the Seventeenth century,* ed. by Gustav Scherz (London: Pergamon Press, 1965), p. 46.
[32] Julius Rocca, 'Anatomy,' in *The Cambridge Companion to Galen,* ed. by R. J. Hankinson (Cambridge: Cambridge University Press, 2008), pp. 242-262 (p. 247).
[33] Walter Charleton, *Enquiries into human nature in VI. Anatomic prælections in the new theatre of the Royal College of Physicians in London* (London: Printed by M. White, for Robert Boulter,1680), p. 13, 170. On Charleton's objections to Willis's physiological theory of the soul, see: Michael Hawkins, "A Great and Difficult Thing": Understanding and Explaining the Human Machine in Restoration England', in *Bodies/Machines,* ed. by Iwan Morus (Oxford: Berg Publishers, 2002), pp. 15–38.
[34] Thomas Willis, *De anima brutorum* (1672), translated into English by Samuel Pordage in *Two Discourses on The Soul of Brutes* (London, 1683), p. 6. All in text citations will refer to this edition using the abbreviation 'SB.'

corporeal, extended to all parts of the body, therefore formed what Willis evocatively described as the 'Spectre, or the shadowy hag of the Body' (SB, p.6).

Where the body was conceptualised as a sheath, box or chest this placed the image of the body front and centre (with the shape of the soul implied); Willis ends up with an (indirect) image of the soul itself, lifted from the body. Though he had acknowledged that 'we can discern nothing with our eyes, handle with our hands, of these things that are done within the secret Conclave or Closset of the Brain,' what he achieves with the images above is to propose an alternative mode of 'sight' where the soul is observable as an inverted image of the bodies negative space (SB, p.27). As he writes, if the 'whole sensitive soul' is to be *viewed* […] we must altogether represent the same Figure and Dimension, and the whole Head with its System and Appendix; so that as we may behold all these parts, shadowed in the same Image' (SB, p.24). While these passages are taken from Willis's later publication of 1672, *The Soul of Brutes,* I use them here in order to illustrate the intellectual assumptions that were being implicitly relied upon in *Anatomy*. Moreover, these passages provide some sense of the physiological outcomes that *Anatomy* was intended to help fulfil: as Willis stated, 'for the Crown of the Work, a certain Theory of the Soul' should be added to the 'naked Anatomical Observations' (AB, p.192).

A key principle at work in these discussions was the notion that, as nature does nothing in vain, the brain's structural form was the necessary product of providential design. This form must, then, be taken as speaking to the brain's intended role or purpose. As something presumed to have been designed to house the soul, Willis approached the brain as being fitted to the specific needs and requirements of that soul. As Galen had also stated in his *De Usu Partium*, 'in every case the body is adapted to the character and faculty of the soul.'[35] This was a sequence of reasoning which allowed the anatomist to propose that they could grasp the functions of the body by deconstructing and understanding the artifice of its design. Indeed, the anatomist traced out the parts of the body in order to reveal its divine artifice. As Devon Hodges effectively put it: 'anatomical truth was not based simply on observation and enumeration of parts of a dissected body;

[35] Galen, *Galen on the usefulness of parts of the body,* translated by Margaret Tallmadge May (Ithaca: Cornell University Press, 1968), I, p. 68.

an anatomist also claimed the ability to see how each part of the body revealed the divine purpose of its creation."[36]

The architectural body: vaults and chambers

Of course, any analogy taken in isolation reveals certain explanatory limits. Both the sheath and little box analogies were able to say very little about how the soul actually occupied or moved within what was (for a sheath or box) a largely undifferentiated interior space. These objects did not express how a body of active, self-moving atoms might have arranged themselves so as to be so intimately conjoined with the hard shell of the container. To support his presentation of the brain as an internally complex structure, Willis developed his discussion by drawing on a set of widely used architectural metaphors of the body. The body could thus be conceived of as an edifice, built from component parts fitted together, and with the implication of multiple spatial partitions - rooms, chambers, cells and so on.

Not all parts of the brain were subject to this metaphorical treatment, however. Willis often drew a distinction between the 'dual substances' of the brain: the ashy-grey cortical matter and the white medullary parts.[37] The medullary substance formed the underlying or interior structures of the brain (the cerebrum) and its appendix, and was prominently represented in terms of architectural structures. The cortical substance, in contrast, was a soft and spongy material, which formed the brain's exterior shell, commonly thought to resemble the intestines. Willis had, unlike his contemporaries, made efforts to ascribe greater structural (and thereby functional) significance to this cortical mass - casting its folds and crevices in terms of a distillatory role, rather than an amorphous 'bowl of curds.' He nevertheless maintained that it was the medullary structures that constituted the *proper* places of the soul and the seat of animal government. The 'brownish' and soft cortical matter, he observed, ought to be removed by 'gently scraping with the point of a Pen-knife' in order to 'better expose' the white medullary structures lying underneath (SB, p.25). While descriptions of the spirit's passage into the brain had evoked images of

[36] Devon Hodges, *Renaissance Fictions of Anatomy* (Amherst: The University of Massachusetts Press, 1985), p. 3.

[37] There was already a general distinction being made in anatomy textbooks between the 'soft' grey matter and 'solid' white matter, but these were vague at best and didn't extend to specific physiological explanations. For example see: Helkiah Crooke, *Mikrokosmographia* (London: printed for William Laggard, 1615), p. 455.

fluids moved (or distilled) through topographical features, the medullary parts conjured up a noble, architectural setting. As Willis remarked, his *Anatomy* examined not only the 'outward Courts and Porches of this Fabrick, as it were of a certain Kingly Palace, but also its intimate Recesses and private Chambers' – the medullary spaces (AB, p.192). As Willis noted, the medullary substance being 'harder than any other portion of the brain,' was seen to be 'chambering or arching the brain' creating various 'vaults' for the spirits to inhabit (AB, p.93). These 'marrowy' chambers – and their related structures - were designed, Willis argued, to support and organise the localised operations of the sensitive faculties, as the rest of this section will explore.

Images of vaults and arches were often used to describe the callous body in particular. The largest of the white structures, the callous body refers to a flat band of nerves, nestled at the centre of the brain, which unites the two cerebral hemispheres. Its curved shape created the impression of a vaulted or arched ceiling covering the interior cavity space of the brain. Vesalius had also described it as 'resembling a vault (fornix) or arched roof,' upon which the structural integrity of the brain depended.[38] Upon entering the brain, the spirits were first brought to this chamber: 'they are brought at last into the *Callous Body,* as into a spacious field; where, as in a free and open place, these spirits being newly produced, are expatiated or issue forth (AB, p.93). This was a spatially demarcated process of transformation for the animal spirits: emerging from labyrinthine folds of the cortex, characterised as crevices and branches, the spirits now circulated freely within an open, communal and urban arena. In this, they moved into a far more determinable space.

Vaulted and arched ceilings, or palatial porches, were of course features of buildings – not bodies. Architecture was a prominent and widely employed metaphor for the body in this period, both within anatomical texts and literature, but especially in relation to accounts of dissection.[39] As Ludger Schwarte has argued, for Willis and his contemporaries, 'the assumption of a brain architecture ("fabrica cerebri") is much more than an analogy' – indeed, it was a metaphor, guiding how the body was to be investigated and understood.[40] It expressed notions around the constructed nature of the

[38] Vesalius, *Fabrica* (1543), quoted in Peter Mitchell, *The Purple Island and Anatomy in Early Seventeenth century Literature, Philosophy, and Theology* (Madison, NJ: Fairleigh Dickinson University Press, 2007), p. 81.
[39] P. Mitchell, *The Purple Island,* p. 81; David Cowling, *Building the Text: Architecture as Metaphor in Late Medieval and Early Modern France* (Oxford: Clarendon Press, 1998); Sawday, *The Body Emblazoned,* (1995).
[40] Ludger Schwarte, *Instrumentalisation of Reason,* p. 187.

body and established it as something which could be explored and examined as an artificial edifice – in the sense of it being reducible to a set of component parts which could be made to speak to its design.[41] The brain and body really were materially fashioned and *constructed*; in which sense, the body was both like and unlike all artificial bodies in the world – from other animals to clocks to buildings. The anatomist could therefore investigate the fabric of the body as the features of a building might be surveyed - in order to understand how its composite parts related to the structure of the whole. Vesalius, in Book I of his *Fabrica,* mused that 'what walls and beams provide in houses, poles in tents, and keels and ribs in ships, the substance of bones provides in the fabric of man.'[42] In a later example by Samuel Collins, *System of Anatomy* (1685), he stated that the aim of anatomy was to 'give a pleasant prospect of the elegant building of Man's body […] of the several apartments […] and the rich household stuff and fine furniture contained in them.[43]

The human body was at once a source and object of the architectural metaphor. In an example from 1624, Henry Wotton described how the ledges of a building were 'interlayed like *Bones*,' in his *Elements of Architecture.*[44] Gothic architecture from the eleventh century, in turn created 'rib-vaulted' ceilings, highlighting the interplay between the body and architecture. These were, of course, an interconnected set of discourses; human construction sought to reflect the fundamental principles of geometry and proportion, as expressed in God's own creations in nature, the body being the chief example of divine artifice. Architectural theory was a particularly useful proxy for thinking about how physical structures were arranged in space, which was precisely what the practice of anatomy sought to relate.[45] Anatomy, echoing architectural theory, concerned itself with underlying structures, depth and volume, rather than surface qualities.[46] As Walter Charleton observed in his *Enquiries into Human Nature* (1680), the anatomist considered and interpreted the structure of the body as one would study and admire a work of architecture: in respect of the brain, for instance, he appreciated 'the pillars that support it, the arch'd roof that covers and defends it, the fret-work of the

[41] On the early modern use of the term artifice in relation to the body see: Robert L. Martensen, *The Brain Takes Shape. An Early History* (Oxford: Oxford University Press, 2004), p. 83.
[42] Quoted by David Cowling, *Building the Text,* p. 111.
[43] Samuel Collins, *A Systeme of Anatomy,* 2 vols. (London, 1685), *I.* p. i.
[44] Henry Wotton, 'The Elements of Architecture' (orig. pub. 1624), *A collection of lives, letters, poems* (London: T. Roycroft, 1672), p. 29.
[45] Sawday, *Body Emblazoned,* p. 136.
[46] Harry F. Mallgrave, *The Architects Brain: Neuroscience, Creativity, and Architecture* (West Sussex: Blackwell Publishing, 2010), p. 11.

Ceiling […] the four vaulted cells.'[47] The body was, at the same time, a source of architectural knowledge: Vitruvius's geometry, for example, stressed the proportional relations of body as a basis for architectural theory - we might think about how a 'foot' is a unit of measurement here.[48] The architectural metaphor therefore referenced the perceived relationship that existed between human and natural artifice, being that the former aimed to replicate the principles operating in nature as far as possible.

This conceptual framework extended between anatomical and literary treatments of the body.[49] In popular poetry we find numerous examples of the body-interior represented as a building that could then be figuratively traversed by the anatomist-explorer. Two of the most famous examples are Edmund Spencer's extended allegory in book two of the *Fairie Queene,* 'The House of Alma', and Phineas Fletcher's epic poem the *Purple Island,* where man's body was represented as an island to be traversed and explored. Fletcher, for instance, wrote that 'Mans Bodie's like a house: his greater bones/ Are the main timber; and the lesser ones/ Are smaller splints […] his heart/ Is the great chamber, full of curious art.'[50] John Donne's *Poems* similarly described travelling through the 'vaults', 'ladders and cellars' of the body-interior.

The spaces of a building also say something about the kinds of activities they are intended to be used for; in this instance, vaulted rooms suggested a familiar (that is, human) set of behaviours or activities for the spirits. Grand chambers, vaulted ceilings and the lofty porches of a kingly palace were all elevated spaces and signifiers of human activity - rather than spaces designed for passive or domestic storage.[51] Once the spirits entered into the callous body, they were ready to take up the task of government. Whereas For Donne, the mind was an obscure, 'infinite Hive of honey' and an 'insatiable whirlpool,' and the brain therefore cast as little more than a fluid receptacle, for Willis, the mind was to be located and traced out through a complex set of architectural spaces.[52] Notably, though Vesalius had made reference to 'vaulted ceilings' in the brain,

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[47] Walter Charleton, *Enquires into Human Nature* (London, 1680), 'Preface.'
[48] Sawday, p. 76. Mallgrave also notes that Alberti likewise proposed that the geometric rules of perspective were 'corporeally embodied in human form,' *The Architects Brain* (2010), p. 11.
[49] As Mitchell argues, these anatomical and literary representations shared 'conceptual content,' *The Purple Island,* p. 81.
[50] Phineas Fletcher, *The purple island, or, The isle of man* (Cambridge: the printers to the Universitie of Cambridge, 1633), p. 13.
[51] As Sawday notes, Donne's imagery here is associated with domestic or 'low culture,' as opposed to Willis's altogether more elevated images of kingly palaces, cloisters and cells, p. 19.
[52] *Ibid*, p. 18.

and Calver to its empty 'chambers', Willis sought to trace out a far more complex interior space, replete with discrete cells and cloisters.

Emporiums and Marts

Though Willis had already explained how the callous body structured the interior cavity like a vaulted ceiling, providing space for the spirits to meet and circulate, he also looked to expand on its proposed physiological function by introducing another set of images. Employing a socio-economic unit of space – the public market – he proposed that the callous body was also a site where the spirits could publicly come together and perform tasks as agents of the animal oeconomy. Willis described how the spirits emerged out of the 'several winding Crevices' to

> […] meet together, and remain as in a publick *Emporium* or Mart; from whence, as occasion serves, they are raised up, and drawn forth for the uses of every Faculty (AB, p.93)

An emporium or 'mart' described a centrally located trading location. The analogy also spoke to brain as a broader geo-political microcosm: London, for example, was described in 1657 as the 'chief Emporium of Great Britain,' signifying its political and economic centrality. In a later publication, London was also referred to as 'a Mart of Nations, it being the great Emporium or Mart-Town.'[53] The callous body is therefore being situated here as a central locus of the wider body-oeconomy: the primary 'mart' in the 'chief kingdom' of the body.[54] The exchange of goods and services represented by the analogy made sense of Willis's physiological notion that this was a space in which all the spirits would wait to be selected and drawn forth by the animal faculties. These spaces were a recognisable and familiar part of the fabric of urban life; the reader could easily imagine the kinds of activity occurring here - meetings, trade, and commerce.

The image of the public market moved the reader away from purely architectural structures to think about dynamic spaces in which the spirits *acted* within the 'economy' of the animal government. These anthropomorphised spirits now occupied a civic space

[53] Samuel Rolle, *Londons resurrection, or, The rebuilding of London* (London: printed by Tho. Pankhurst, 1668), p. 79.
[54] James Howell, *Londinopolis* (London: printed by Thomas Dring, 1657).

– as suggested by their activities of 'meeting' together, mingling and being 'at leisure'. This is as opposed to being passively stored as material bodies within a container or receptacle (such as a vault). As Willis stated, while the spirits were (chemically) 'procreated' in the cortical matter, in the medullary parts (such as in the callous body) they laboured in their proper 'shop' or 'work-house' (AB, p.95). Though Willis had conveyed a sense of scale and volume with his images of vaults and chambers, he required the analogy of the shop or 'mart' to underline his conception of these interior structures as the *functional* spaces of the soul and, in turn, to expand on his rendering of the body as a geo-political entity - the brain being a 'kingly palace' or a chief 'kingdom' where the sensitive faculties where to be seated. It was also a space where the animal spirits had been brought, like goods, into their 'principal shop' for 'purchase' by the faculties; this sense of passivity is qualified though by the image of the workhouse and the broader uses of personification in relation to the spirits.

Images of urban or architectural spaces also further underlined Willis's physiological argument that the spirits were substantially and qualitatively transformed when they entered into the medullary structures of the brain. This was an argument he had previously made in relation to the chemical processes of distillation: a material change now embodied by the kinds of space the spirits have come to inhabit. Only at this point, and not before, could the animal spirits embody the sensitive faculties of the soul. It was fitting, then, that these 'transformed' spirits should perform their tasks within an identifiably human set of spaces. Interestingly, the mart-emporium was an uncommon analogy in anatomical or medical texts. This is perhaps because, unlike vaults and arches, it pushed at the agreed (if not practised) conventions around the use of analogy as a purely illustrative aide by speaking more to the (inherently speculative) *activities* of the spirits, rather than the brains observable and material form. It nevertheless served a useful function here in extending the discussion into the realm of a socio-economic model.

Locating the faculties

According to Willis's theory, while the spirits circulated and waited in this 'chamber' or 'emporium', they properly performed their tasks (of animal government) by moving through specific, discrete locations in the brain. This rooting of specific mental functions

to certain parts of the brain is what is meant when historians refer to Willis's localisation model – although this is itself a modern term. Before I explore some of the images used in connection with these structures, it is useful to summarise Willis's approach to, and the historical context around, models of localised brain function. Today, the modern neurosciences place considerable emphasis on being able to pinpoint specific brain functions within the neural-structures of the brain, even locating memory at the subcellular level.[55] Localisation theories are therefore viewed from present perspectives as being significant to historical studies of the brain. It is a theory largely traced to the neurology of the nineteenth century, though it has a much older history going back to Galen. The faculties had traditionally been located in one of three ventricular cavities within the brain. The ventricles, according to Galen, were receptacles for psychic *pnuema* –what Willis would later refer to as the 'animal spirits' - which performed all the vital and sensory functions of the body.[56] Later Christian scholars modelled the cell-doctrine along the same lines as Galen's model, locating the faculties inside three (or alternatively, in Avicenna's non-Christian model, five) communicating cavities or 'cells' in the brain. The anterior cell (which housed the *sensus communis* or 'common sense') was where sense impressions were first delivered to the imagination; the middle cell was the seat of reason; and the posterior cell the home of memory. Though the physiological mechanism behind this model was accounted for in very general terms, the cells came to be seen as dynamic, communicating structures.[57]

With the rising influence of new experimental physiologists in the sixteenth and seventeenth centuries, the cell doctrine – along with Galenic doctrine more widely – became the subject of sustained critique. The broad spatial organisation of the faculties denoted in these models nevertheless remained remarkably stable. As Thomas Vaughan in his *A Brief Natural History* (1669) wrote, 'It is a common received Opinion in Philosophy that the principal faculties of the Soul […] are distinguished by three several Cells or Ventricles in the Brain.'[58] Unsatisfied with the notion of the spirits being

[55] The modern notion of the biological cell – as a basic component of all organisms – traces its roots to the uptake of microscope technologies and to the terminology used by Robert Hooke in his *Micrographia* (1665), although 'cell theory' doesn't emerge until some time later. On this see: Paolo Mazzarello, 'A unifying concept: the history of cell theory,' *Nature Cell Biology*, 1.1 (1999), pp. 13-15. On the modern concept of the cell as having a form of 'memory' see: Martin Schwaerzel et al., 'Extinction Antagonizes Olfactory Memory at the Subcellular Level,' *Neuron,* 35.5 (August, 2002), pp. 951-960.
[56] Galen actually located the faculties within the substance of the brain (not its empty cavities), though he didn't offer specific details on this: Julius Rocca, 'Anatomy,' p. 247.
[57] Cowling, *Building the Text,* p. 112.
[58] Thomas Vaughan, *A Brief Natural History* (London, 1669), p. 76.

circulated in some vague capacity inside a brain-cavity, Willis and his contemporaries sought to investigate (what they considered to be) the precise physiological mechanisms that lay behind these mental phenomena.

Willis's primary contribution here was in having decisively shifted focus away from the ventricular cavities to consider how the spirits moved through the complex, physical structures of the brain in the performance of their functions.[59] Robert Hooke, in contrast, had not been concerned with precisely *where* the soul was located, only stating that it was to be found 'somewhere in the Brain of a man.'[60] Willis, on the other hand, sought to ascribe the functions of the soul to discrete structures and parts in the brain, with a particular focus on its solid substances.[61] In his model, sensation (or the 'phantasie') was found in the corpus striata, Imagination in the corpus callosum, and memory in the cortical spires of the 'barkie' exterior of the brain. According to Willis, when a sensible impression was carried to the brain – by a mechanism analogously represented 'as an undulation or waving of waters' - it first reached the callous body where 'a perception or inward sense of the sensation' arose. Following this, the impression passed through the callous body towards its forepart where the imagination was located; finally, progressing further, the impression struck 'against the Cortex of the Brain, as its utmost banks,' and created an impression of the object in memory. This same motion was 'afterwards reflected or bent back,' to affect a memory of the thing felt (AB, p.96). As Louis Caron has argued, the spatial nature of this physiological model required the spirits to pass through certain structures in sequence; an act of imagination had to occur prior to memory, and remembering had to involve the imagination.[62] Here, Willis marked out a far greater emphasis on the spatial dimensions of phenomena of the mind – and their relationship to the material structure of the brain itself. Having been one of the first to routinely use a microscope, Willis was able to trace out in

[59] Willis was determined to undermine ventricular theories of brain function. On this see: Martensen, *The Brain Takes Shape,* p. 83

[60] Douwe Draaisma, 'Hooke on Memory and the Memory of Hooke,' in *Robert Hooke: Tercentennial Studies*, ed. by Michael Cooper and Michael Hunter (Aldershot: Ashgate, 2006), pp. 111-122.

[61] On Willis's localization theory see: George Rousseau (1976); Adrian Johns (1996); L. Caron, (2011), p. 60-1; Ann Thomson, *Bodies of Thought: Science, Religion, and the Soul in the Early Enlightenment* (Oxford: Oxford University Press, 2008), p. 83. Kenneth Dewhurst likewise acknowledged Willis for his 'pioneering' localisation model, 'Thomas Willis and the Foundations of British Neurology,' in *Historical Aspects of the Neurosciences,* ed. by F.C. Rose and W.F. Bynum (New York: Raven Press, 1982), pp. 327-346 (p. 336-7).

[62] Louis Caron argues that Willis 'pushed beyond' an account of the animal spirits that was 'essential and highly generalised,' in order to consider precisely how they moved through specific spaces to account for the various mental functions, *First Works of Neurology,* p. 544.

unprecedented levels of intricacy structures that would provide him with the physical basis for an alternative rendering of the doctrine of localisation.

Cells and cloisters

The new cerebral anatomy revealed to Willis by his dissections, appeared to be as visually complex as the soul's functions were thought by him to be diverse or manifold. Though he had described the faculties using relatively broad schematics - memory and imagination constituted as a motion from centre to periphery - Willis extended his discussion by also stressing the role of a partitioned set of bounded spaces. Evoking images of much smaller structures such as cells, cloisters, pores, orbs and tracts, Willis further enhanced the structural and textural complexity of his account. As Willis described, having being drawn forth from the callous body, the spirits did 'depart of themselves' and enter into various 'diverting places,' where they were kept 'as it were in distinct Cloisters or Cells to be drawn forth for the manifold Exercises of the animal Function' (AB, p.95). In contrast to the communal mingling of the market place, or the 'undulating waves' of memory-imagination sequences, these spaces inferred a quieter, more secluded or private character upon the activities of the spirits. Here, the spirits would arrange themselves into specific orders and sequences, protected from interference within the cloistered cells of the brain. Here, the emphasis on communal (physiological) mechanisms shifted to matters of order, seclusion, storage or safekeeping.

The use of the cloister analogy in this context specifically suggested an enclosed, private space or a 'place of religious seclusion'; it came from the Latin *claustrum* meaning to lock in an enclosed place or *claudere,* 'to close.'[63] One could be 'cloistered' away in a small space, for example, in 1663 Thomas Southland posed the question, 'Do you think I can cloister up myself, Be kept coop't, like a Chicken in a Pen.'[64] Equally, a cloister could be used to suggest a network of interlinked spaces, such as a covered walkway inside a covenant, which could also be used to support the overall impression of a network of judiciously divided spaces within an overarching architectural building – a sense extended through the related use of images of cells and spires.

[63] "cloister, n." *OED Online*. Oxford University Press, December 2014. Web. 10 February 2015.
[64] Thomas Southland, *Love a la mode* (London: printed for John Daniel, 1663).

As with the cloister, in the seventeenth century the term 'cell' (or its Latin equivalent, 'cella' or 'celula') was commonly used to describe a small or confined dwelling space, usually a monk's cell.[65] These were small, private units of discrete and bounded space. Robert Hooke is considered to have been the first to use the term 'cell' to signify a *structural* unit comprising organic bodies in his study of the structure of cork in 1661.[66] In respect of the human body, cells had featured in much older models of the brain. In the middle ages, the term cell was commonly used to refer to one of three communicating cavities or ventricles in the brain, in which the animal faculties were located; though this was less a specific, structural designation than it was a spatial schema for organising the primary faculties across general regions of the brain. Alexander Ross in 1652 wrote, for instance, that the 'common sense, the imagination, the discursive, and memorative qualities […] have their distinct cels,' while not referring to any specific anatomical structures.[67] Van Helmont, who was influential in Willis's chemical work, used the term 'least cell' to refer to the brain's ventricles.[68] Increasingly, over the course of the seventeenth century, the cell took on a much more overtly physiological emphasis in models of brain function. For instance, James Howell wrote in his *A Dialog between the soul and bodie* (1651) that the exhalations of his spiritual affections caused the blood to 'boyl' and rise up to 'fill all the cells of my brain to contemplate his goodness.'[69]

Willis's specific contribution to the history of the cell is linked to this physiological context and his ideas about the possibility of ascribing specific functions of the brain to discrete structures within its substance. When Willis talked about cells inside the brain he did so in reference to a complex network of interlinked bounded spaces, wherein the spirits (carrying the imprint of thoughts and memory) would be organised and stored without interference from one another. As he described, 'in such, distinct Cells, and parted one from another […] the divers Species and Ideas of things are kept apart' (AB, p.92).[70] These 'cells' were not like those of the older schematic models of the brain; instead of housing vaguely localised faculties of the brain, they formed a complex matrix

[65] Cowling, *Building the Text*, p. 112.
[66] Hooke used the term specifically in reference to the properties of cork, and not in the sense of a monk's cell. Robert Hooke, *Micrographia* (London, 1665), 'Observation XVIII.'
[67] Alexander Ross, *Arcana microcosmi, or, The hid secrets of man's body discovered* (London: printed by Tho. Newcomb, 1652), p. 59.
[68] Van Helmont, *Ortus medicinae,* English translation by John Chandler (London, 1664), p.156
[69] James Howell, *A Dialog between the soul and bodie* (London, 1651), p. 45.

[70] These memory-cells are actually *inside* the folds of the cerebral gyrations; this is separate to the cerebral 'crevices' described by Willis in relation to the spirits distillation into the brain, which describes the spaces in-between these folds.

of structures which supported the specific – and myriad - activities of the animal spirits. In Willis's model, then, we see 'cells' becoming both specific, physical structures of the body and at the same time much more smaller units of space.

The notion that cells were the smallest units within much larger and complex superstructures (as in a network) had been expressed earlier by Robert Hooke in 1661, who observed that the micro-structures of cork resembled a 'Cavern, Bubble, or Cell […] distinctly separate from any of the rest'.[71] He used both 'pore' and 'cell' to describe how cork was comprised of 'a great many little Boxes,' within which air was 'perfectly' enclosed, hence the buoyancy of cork.[72] For Hooke, the cell analogy was used here to indicate a judiciously divided, bounded and discrete set of spaces within a much larger and complex structure. The prolific writer of natural philosophy, Margaret Cavendish, Duchess of Newcastle-upon-tyne, also notably expressed this sense of 'networked' cells within the context of the brain in a poem from 1653. Comparing the compartments of the brain to a beehive, she wrote

The Head of Man just like a Hive is made,
The Braine, like as the Combes exactly laid.
Where every thought just like a Bee doth dwell,
Each by it selfe within a parted Cell.[73]

The poem continues to by making bees analogous to individual thoughts, which mingle in a swarm or 'take flight' in various directions, hence the need to order them and keep them bounded in cells. These examples are close to the sense in which Willis had also employed the term in respect of the brain, in that the emphasis rests on how cells were designed to protect thoughts by keeping them apart and distinct.

Willis's premise that the actions of the animal spirits produced all the complex effects of the animal faculties relied, in part, on the implications of this particular reading of cerebral anatomy - as something furnished with discrete, yet interconnecting cells. The provision of partitioned and bounded structures was a significant support to Willis's broader physiological model, which supposed that the corporeal soul performed its vital

[71] Robert Hooke, *Micrographia*, p. 116.
[72] *Ibid.*
[73] Margaret Cavendish, 'Similizing the Head of Man to a Hive of Bees', *Poems* (London, 1653), p. 149.

and sensitive actions on the basis of matter 'rightly disposed.'[74] As John P. Wright has already argued, like Gassendi, Willis ascribed 'life to atoms structured in a certain way.'[75] That is to say, in order to assign ever more complex functions to the corporeal soul, some assurances were needed to suggest how the spirits could go about their operations without cross-interference and the chaos of mingling forms. As Willis stressed throughout *Anatomy,* he conceived of a need for a certain imposition of order (however precariously maintained) to be applied to the spirits in the brain - a requirement supported by their arrangement within chambers, cloisters and now cells. The spirits, he argued, 'ought, for the various Faculties of the Soul, to be composed into various series, and divers orders and dispositions, therefore ought to be moved within perculiar orbs and tracts' (AB, p.96-7). For the acts of imagination and memory especially, the spirits were to be moved 'within certain and distinct limited or bounded places,' to serve as a protection against the prospect of intermingling. Even within the apparently open and 'spacious field' of the callous body, the spirits were not simply left to 'lye disorderly or lossely,' but were organised and arranged by 'being limited with certain Bounds and Cloysters' (SB, p.25). Bounded cells take on a new significance here – as a physical foundation for this physiological model.

Willis was also able to indefinitely extend the spaces provided here through imagery of *replicating* units and cells. As he later described, these spaces formed a 'most ample and highly intricate Labyrinth of Cloysters […] all of them distinct, and designed to certain offices' (SB, p.23). Areas with many cell divisions could be said to correspond to the soul's capacity to enact complex, distinct activities – and thus give rise to correspondingly complex mental phenomena. The order suggested in discrete, bounded spaces is maintained without sacrificing complexity, the space being replete with internal divisions.

Willis's approach in highlighting and detailing these complex structural features echoed the Baconian view of the body, which, as Sawday has noted, represented the most complex spatial organisation in the universe, composed of 'passages and pores…cavities,

[74] John Wright, 'Locke, Willis, and the Seventeenth century Epicurean Soul,' in *Atoms,* Pneuma, *and Tranquillity: Epicurean and Stoic Themes in European Thought,* ed. by M. J. Osler (Cambridge: Cambridge University Press, 1991), pp. 239-258 (p. 246).
[75] As John Wright has argued, 'Willis concludes that there is no reason to think that matter, as it is put together in a living body, cannot produce even the most complex actions of animals,' 'Locke, Willis and the Epicurean Soul,' p. 250.

nests and receptacles'.[76] Of course, Willis applied this same notion of structural complexity in a very specific way to his new anatomy of the brain, in order to make original claims about its *functional* attributes (moving away from passive cavities and receptacles). With Willis's account, complex operations were being inferred from (and projected back onto) complex spaces in the brain. This points to an important principle at work in Willis's work – being a correlation between complex form and correspondingly complex functions.[77] The physical separation created by these bounded cells allowed Willis to multiply the individual functions and operations being undertaken by the sensitive soul at any one point. This was required in order to demonstrate how the physical spaces of the brain could be said to accommodate the manifold acts of the higher faculties. Willis was laying the anatomical foundations for his theory that the sensitive soul possessed far greater powers than were traditionally allotted to it. Willis employed the visible complexities of cerebral anatomy as a proxy body of evidence for the (invisible) physiological operations of the soul. The more complex the structure, the greater the functional complexity that could be ascribed to it.

Willis was evidently keen to stress that the freedom of movement denoted in his image of the 'mart' and emporium did not equate to chaos - to a swarming mass of spirits. Certainly, prevailing physiological theories of the mind evoked such fears in the period, with the prospect of swarming, swirling spirituous bodies. Margaret Cavendish wrote, for instance, about the 'confusion' of Epicurean atoms which produced 'strange and monstrous figures' and 'blinded the perception' of the mind.[78] In 1661, Joseph Glanvill questioned whether cells were in fact adequate to ensure order in this setting, thereby seeking to challenge Willis's theory of the soul as a material agent located within the brain. As he argued in his *Scepsis Scientifica; Or, the Vanity of Dogmatizing*, Glanvill asked how it was that the bustling animal spirits carrying the individual objects of memory, which were 'ever and anon justled,' could 'so orderly keep their Cells without any alteration of their site or posture.'[79] Clearly, the cell – as a structural unit of the brain – was closely informed during this period by debates around the possibilities or not of localised, physiological explanations of brain function. Though Willis's model would

[76] Sawday, p. 94.
[77] Robert Frank Jr., 'Thomas Willis and His Circle: Brain and Mind in Seventeenth century Medicine,' in *The Languages of Psyche: Mind and Body in Enlightenment Thought,* ed. by George S. Rousseau (Berkeley: University of California Press, 1990), p. 132; William F. Bynum, 'The Anatomical Method,' p. 450.
[78] Margaret Cavendish, *The description of a new world* (London: printed for A. Maxwell, 1668).
[79] Joseph Glanvill, *Scepsis Scientifica; Or, the Vanity of Dogmatizing* (London, 1661), p. 36.

need to extend someway beyond anatomical explanations if he was to elaborate on mental phenomena at the level of spirituous activity, the point to be made here is that his interpretation of brain-spaces were not guided by simple empirical goals, but by broader theoretical arguments.

The provision of discrete cells was also a feature of the brain that Willis drew upon to outline a distinction between animal and human faculties. He noted that the cerebral gyrations, with their 'manifold convolutions', created 'Cells or Store-houses severally placed' where the 'species of sensible things' were to be kept in safety and seclusion (AB, p.92). Though the brain's 'cloysters' were interwoven or 'variously implicating one another,' he maintained that in these *cells*, the spirits (carrying the objects of sense or memory) would remain entirely 'distinct'. Animals, however, had much smaller and less complex cerebral gyrations, on account of which Willis argued that they had a limited capacity to remember things and only recalled things of a similar type - precisely because they lacked the bounded cells which would have enabled them to keep thoughts separate and distinct. As he writes, 'for that in such, distinct Cells, and parted one from another, are wanting, in which the divers Species and Ideas of things are kept apart' (AB, p.92). In fishes, for instance, the cerebral 'gyrations' were 'plain and even,' they therefore acted largely on the basis on 'natural instinct' rather than active memory-recall (AB, p.92). Willis employs comparative anatomy here to reinforce his reading of the function of the cerebral gyrations as pertaining to memory, a faculty in which humans notably excelled beyond the capacity of animals. These 'bounded places' are also taken as materially supporting his notion that the spirits movements would often be 'iterated or repeated through the same tracts or paths', such as when we call on a particular memory (AB, p.92).

However, did these images of small, bounded cells not also promote a restrictive environment? With the proliferation of spatial partitions in the brain, the individual spaces in which the spirits were to act became increasingly smaller (even if there were more of them). As Margaret Cavendish wrote in 1653, a cell was lowly and restrictive, a place to kept locked up in: 'I live in a low Thatcht House, Rommes small, my Cell/ Not big enough for Prides great Heart to dwell.'[80] Francis Bacon had himself used 'cell' as a metaphor to link a notion of being physically constrained with intellectual constraints:

[80] Cavendish, 'Of Poverty', *Poems,* p. 95.

the 'schoolmen,' he noted, with their 'wits being shut up in the cells of a few authors…as their persons were shut up in the cells of monasteries and colleges' had produced little learning about the physical world beyond their books.[81] In a spiritual setting, however, the monk's cell might have been physically limited but would have inversely supported focused spiritual reflection (upon which it set no such limits). Despite the ambiguities entailed in the associations of the cell, as Willis sought to promote a quasi-materialist model of the mind he would have needed to defend it against the notion that the soul's proposed materiality could have set a physical-spatial limit to the varied powers and actions of the animal faculties.[82]

While compact cells and cloisters may have worked against what Willis saw as the natural tendency of the animal spirits to unfettered expansion in Willis's explanations, they did not necessarily restrict their activities (AB, p.96). The generally agreed view that the spirits were exceedingly subtle bodies also helped to alleviate the potential for tension here. As Willis noted, the spirits were sufficiently subtle (indeed, the most subtle bodies found in the natural world) that they 'require no manifest cavity' for 'their expansion,' and could expand perfectly well in very dense substances (i.e. the nerves) (AB, p.127).[83] They were, of course, able to move within or through a complex, permeable matrix. In this interconnected web of structures, the spirits movements *between* various cells or chambers were being similarly localised to the solid structures of the brain, rather than being a swirling mass of mixed bodies. As Robert Frank argues, Willis's model proposes an image of 'spiritous particles residing in a differentiated neural matrix.'[84]

The spirits did not need expansive cavities; what they actually required were boundaries, a means of being ordered and separated from other bustling spirits. The spirits, he noted, 'being very subtil, and apt to fly away, require not such large and open spaces, rather than

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[81] Francis Bacon, *The Advancement of Learning* (1605), in *Francis Bacon: The Major Works,* ed. by Brian Vickers (Oxford: Oxford University Press, 1996), I, pp. 27-28.

[82] Anatomists in this period would have been aware of the dangers of reducing the soul's faculties down to material structures of the brain, on this see: John Henry, 'The Matter of Souls, Medical Theory and Theology in Seventeenth century England', in *The Medical Revolution of the Seventeenth century*, ed. by Roger French and Andrew Wear (Cambridge: Cambridge University Press, 1989), pp. 87-113. Willis's model did, in fact, set limits on the powers of the sensitive soul by insisting on the superior role of the Rational soul, but he nevertheless significantly expanded on the corporeal soul's powers (in the brain) by the standards of prevailing models – as the next chapter will explore in greater detail.

[83] Willis used these ideas to argue that the spirits were able to move within the (dense, but permeable) structure of the nerves, even though no cavity could be discerned through the microscope. See Martensen (2004) on these themes, p. 85.

[84] Frank, 'Willis and His Circle,' p. 133.

the more narrow passages and little pores, such as are made in the substance of the Brain' (AB, p.96). As volatile bodies prone to expansion and evaporation, the spirits relied for the performance of their activities on these cells, pores and passages. As Willis noted, 'for the various Faculties of the Soul, to be composed into various series, and divers orders and dispositions, therefore ought to be moved within peculiar orbs and tracts' (AB, p.97). These structures replicated inwards to form a network of spaces, on a labyrinthine scale, which were both complete and interrelated (in the sense of judiciously divided, so that each element has its distinct place), and self-contained sphere of activity.[85] What Willis appears to be referencing here, with the emphasis on a 'peculiar orb', is this sense of a discrete, spatially demarcated zone of action. The spirits, tasked with undertaking specific roles for the animal faculties, acted within their given orbs – rather than communally (or randomly), in an undifferentiated cavity. The emphasis here is on the ordering work of space, not its expansiveness. We return here to the associations between cells and cloisters and notions of secrecy or privacy: carrying the individual impressions of thoughts and memory, the spirits needed to be protected from intermingling. Notably, Willis's reading of brain structure depended upon – and always refers back to – his pre-existing physiological conception of the spirits and his intellectual commitment against ventricular circulation models.

It could be suggested that there is some tension here between preceding images of sweeping, fluid wave-mechanisms and Willis's intention to describe the spirits as being ordered and quietly arranged within cells and cloisters. Fluid-mechanisms do not neatly map onto the architectural setting or onto notions of neatly ordered and partitioned spaces. They refer to different measures of scale as well as modes of action. These analogies do not, however, need to be consistent to be coherent: wave mechanisms conveyed how the spirits were *moved* through a broad expanse of space, while cloisters and cells suggested how, at a more detailed level, the spirits performed their various allotted tasks in the midst of these larger movements throughout the brain-space. Read at different stages of the narrative, both examples served the reader in understanding different aspects of a complex conceptual model.

[85] William West, *Theatres and Encyclopaedias in Early Modern Europe* (Cambridge: Cambridge University Press, 2002), p. 18. Jonathan Sawday has also discussed Francis Bacon's descriptions of the body as a series of pores and cavities, which Willis echoes in his rendering of the cerebral landscape: *Body Emblazoned*, p. 94.

Finally, it is also interesting to consider how Willis used the term 'cell' with an awareness of its *analogical* function; the structures he observed within the brain *resembled* the cells observed in bee-hives or the dwelling places of monks but, as the dwelling place of the soul, were a unique category of space. Today, the cell is a foundational concept within the biological sciences, referring to the most basic unit of living organisms - both at a structural and functional level. It is so successful that it has largely ceased to function as a metaphor at all.[86] In a distant echo of Willis and Hooke's emphasis on the cell as a psychical unit in the architecture of bodies, its role is today expressed through the metaphor of the 'building block of life' – one that carries the 'code' of DNA within its nucleus. In the context of modern biology, however, cells also are not passive containing structures, but active producers; for instance, they replicate and reproduce DNA. Moreover, since the 1980s the cell has undergone further changes and attracted new metaphors; as cell biologist David Baltimore commented in 1984, 'biologists needed to find the cell's brain' – meaning its nucleus.[87] Older biological analogies of the cell as a 'factory' were to give way to a more complex entity, with its actions governed by a nucleus and various chemical proteins. It is a metaphor that has not simply been 'inherited', but adapted to new discoveries and concepts within modern science.

The brain and cerebellum: a comparative anatomy

The spaces inside the brain (by which Willis meant the cerebrum) were notably distinct from its appendix, the cerebellum. Descriptions of cells and cloisters were only applicable to the brain; the cerebellum presented a very different landscape.[88] The brain was believed by Willis to have been designed to house the animal faculties of sensation, memory and imagination. As such, its structural provisions, or the spaces created within the brain, were required to support a free and indeterminate motion among the spirits so as to avoid limiting their ability to form a variety of impressions in response to sense objects or the appetite – neither of which were routine or predictable. As Willis described, 'for the various and manifold actings of the superior Faculties,' the cerebral gyrations were 'garnished with an uncertain, and as it were fortuitous series, that the exercises of the animal Function might be free and changeable, and not a determined to

[86] On the variable uses of 'cell' in modern biology see: Evelyn Fox Keller, *Refiguring Life: Metaphors of Twentieth-century Biology* (New York: Columbia University Press, 1995), p. 36.
[87] David Baltimore's views on the cell are discussed by Evelyn Fox Keller, *Refiguring Life,* p. 27.
[88] Where Willis referred to the 'brain' he used this as shorthand for the cerebrum, which encompassed the cerebral hemispheres and the core 'white' structures of the brain.

one (AB, p.92). Willis's particular reading of these anatomical features therefore reflected a spatial dimension to the presumed scope and diversity of human mental phenomena. The brain supported free movement while still maintaining the necessary partitions required for complex operations to occur unhampered. The spirits penetrated through pores, expanded inside orbs or carved out deep tracts in the brain's soft tissue – but they performed their offices within the cells or cloisters of the cerebrum and they did so freely.

This varied cerebral-topography was established in stark contrast to the form, texture and role of the cerebellum. Importantly, Willis drew here on the important trope of the body-machine. The cerebellum was a much smaller structure tucked underneath the brain (as it was arranged in the skull) but was connected to it via the oblong marrow – a structure furnished, Willis observed, with 'porticoes' and 'highways' to facilitate the passage of spirits between each part. A largely neglected structure, the cerebellum (or 'little brain') had generally been cast as a storehouse repository for memory impressions.[89] Though Vesalius had improved upon its description, even he had declined to ascribe to it a specific physiological function.[90] Willis blamed this general state of ignorance on his predecessor's specific neglect of the fabric and substance of the brain, commenting: 'as to the office or use of the Cerebel in general nothing of it occurs, spoken by the Ancients, worthy of its fabric, or agreeable to its structure' (AB, p.111). It was upon precisely these two aspects – substance and structure – that Willis looked to construct an alternative theory of the cerebellum. Of course, as a structure tucked underneath the brain, the cerebellum had been made more visible - as an intellectual and physical site of knowledge - by Willis's new dissection methods.

Like Clockwork

Firstly, by noting that the cerebellum was proximate to but much smaller than the brain, Willis deduced that it served an important - yet ultimately secondary - role in animal government. He characterised this relationship through a socio-political analogy, as

[89] Drawing on the work of Galen, Nemesius (390) described how 'if it is the cerebellum that is damaged, only loss of memory follows,' *On the Nature of Man,* English trans. (1955), p. 341; cited by Stanley Finger, *The Origins of Neuroscience: A History of Explorations into Brain Function* (Oxford: Oxford University Press, 1994), p. 18.

[90] Mark C. Preul, 'A History of Neuroscience from Galen to Gall,' in *A History of Neurosurgery in its Scientific and Professional Contexts,* ed. by S. H. Greenblatt (Parkridge, IL: The American Association of Neurological Surgeons, 1997), pp. 99- 130 (p. 106).

resembling that between a city-state and its 'province' or an arm of local government. Situated between the brain and the praecordia (heart and chest), the cerebellum was a form of boundary gatekeeper, the first body to greet the spirits rising up from the body seeking entry into the brain-city. Local government marked a significantly heightened status for the cerebellum, which had hitherto been cast as a passive repository. Willis had even granted to the cerebellum - this newly crowned 'second' seat of government - its own body of animal spirits, set apart from those in the brain: 'the Cerebel is a peculiar Fountain of the animal spirits designed for some works, and wholly distinct from the Brain' (AB, p. 111). This constituted, in effect, a further sub-division (or localisation) of the sensitive soul. Together, they formed what Willis termed the 'double fountain' of the sensitive soul.

The cerebellum was primarily cast by Willis as the body that produced the routine and reflexive responses required to satisfy the vital needs of the body – such as respiration or the pulse. This role was represented by Willis through the metaphor of the clock:

> For indeed those in the Cerebel, as it were in a certain artificial Machine or Clock, seem orderly disposed after that manner within certain little places and boundaries, that they may flow out orderly of their own accord on series after another without any driver, which may govern or moderate their motions. (AB, p. 111)

The clock metaphor was a popular trope in this period, especially among mechanical philosophers such as Descartes, but also among corpuscular philosophers such as Robert Boyle. It is often discussed in relation to the emergence of the 'modern sciences' for its role in representing an emerging mechanical world-view - an explanation of nature that stressed its order and regulation.[91] It was used, primarily, to express the notion that nature operated according to mechanism, which allowed it to function independently of an immediate agent, by virtue of the contrivance of their parts. These parts were set in motion by God, the original 'watchmaker'. As Boyle noted, The world was 'like a rare Clock, such as may be that at Strasbourg […] the Engine being once set a Moving, all things proceed according to the Artificers first design.'[92] Following a teleological argument, complex designs were taken as implying an intelligent designer.

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[91] John Henry, *The Scientific Revolution and the Origins of Modern Science* (Houndmills: Palgrave Macmillan, 2008), p. 106.
[92] Robert Boyle, *The Works of Robert Boyle*, ed. by Michael Hunter and Edward B. Davis, 14 vols. (London: Pickering and Chatto, 1999), vol. 10, p. 448.

These ideas directly informed themes in Willis's model of the cerebellum. As Willis writes in the Epistle Dedicatory to *Anatomy,* the name of natural philosophy is 'abused' by those who study the 'wheels, curious frame […] small pins, and all the make and provision of a Clock,' and yet does not 'acknowledge the Artist, to whose Labour and Wit he owes all those things.' While we may not ever fully comprehend the intricacies of God's design, the philosopher could grasp certain dynamic principles at work within nature and represent those in human artificial designs – as represented by the clock.[93] The metaphor related to anatomy in that it supposed that the body, being similarly *constructed*, could like the clock be deconstructed and separated into its various parts in order to comprehend the logic of its design.

Clocks are an interesting example of the relationship between technological practices and the availability of certain metaphors across disciplinary discourses. Clocks emerged in the fourteenth-century as mechanical marvels of the astrological sphere, but none had a natural oscillator until the seventeenth century, when Galileo designed the pendulum. The first design of these self-regulating clocks went into production in 1657 – just before Willis's *Anatomy* was written.[94] Just as clocks created a range of new possibilities for the regulation of social life in the seventeenth century, here too they provided a new way in which to read the body in terms of a set of self-regulatory mechanisms - providing a new lens through which to interpret the work of the body and the significance of its artifice. [95]

In a physiological context, the clock related to the Cartesian metaphor of the body-machine. Descartes had conceived of all natural bodies as automata in his *Treatise on Man*, where he argued that humans were complex machines driven by the physical force of the passions, which put the various parts of the body into motion. All actions of the body were ultimately the outcome of the arrangement of these parts.[96] As with architectural theory, the machine analogy was especially useful for expressing how complex

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[93] Amos Funkenstein, *Theology and the scientific imagination from the Middle Ages to the Seventeenth Century* (Chichester: Princeton University Press, 1989), p. 323.
[94] Jim Bennett, 'Clock and Chronometer', in *The Oxford Companion to the History of Modern Science,* ed. by John L. Heilbron (Oxford: Oxford University Press, 2003), pp. 158-161 (p. 159).
[95] This analogy features most famously in William Paley's *Natural Theology or Evidences of the Existence and Attributes of the Deity* (1802). On this see: John Hedley Brooke, *Science and Religion; Some Historical Perspectives* (Cambridge: Cambridge University Press, 1991), p. 196.
[96] *The Philosophical Writings of Rene Descartes,* ed. by John Cottingham, Robert Stoothoff and Dugald Murdoch (Cambridge: Cambridge University Press, 1985), I, p. 108. Although Descartes' *L'Homme* refers instead to the human body as an automata, a hydraulic imitation moved by water pipes and air, to express the physiology of the nerves. On this see: Dennis Des Chene, *Spirits and Clocks: Machine and Organism in Descartes* (Ithaca: Cornell University Press, 2001), p. 29.

component parts (of a body) fitted together and related to the whole. Robert Hooke used a particularly extended clock-metaphor in his study of nature under the microscope, *Micrographia,* published in 1665 to express how a fault in any one of these parts could have larger effects in the organism/machine. In a discussion on the decomposition of organic matter Hooke drew upon the idea of a broken clock. Opening with an explicit concession to the reader's comprehension, he began:

> To explain my meaning a little better by a gross Similitude. Suppose a curious piece of Clock-work, that had several motions and contrivances in it, which, when in order, would all have mov'd in their design'd methods and Periods.[97]

He goes on to suppose that if this clock were to be broken, with 'several parts of it being dislocated', as the other parts 'also have dependence upon them […] so the whole instrument becomes unserviceable, and not fit for any use.'[98] As he further illustrates, if the vegetable 'machine' has any one part corrupted by mould, the whole body produces effects other than that which it was designed for - everything is corrupted. Notably, the machine-metaphor applied to any natural body (vegetable or animal) as both were examples of divine artifice or construction. The owner of the broken clock, 'ignorant of the Watch-makers Art, wonders what is betid his Clock' and is forced to conclude some intervention by the 'Artist' as he has no other means to explain how these effects are wrought; but the clock is stopped by its own mechanical fault. This thread of reasoning served a particularly useful medical analogy, in the sense that the physician looked to identify faults in the body-machine, rather than supernatural causes such as the intervention of demons or evil spirits.

The mere fact of structural complexity did not however, suggest (in and of itself) that the cerebellum was an object available to be read through the metaphor of a machine; or else the cerebrum – a far more complex structure – would also be open to the same comparison. For Willis, it was the conjunction of structural complexity *and* regular or replicating forms that suggested to him the mechanical nature of the cerebellum and the comparison with the clock. Underpinning the mechanical analogy was a compared anatomy between the brain and cerebellum, through which Willis attempted to correlate observable structural and textural differences with distinct functional roles. It was by

[97] Hooke, *Micrographia,* p. 133.
[98] *Ibid*, p. 133.

setting up a stark contrast between two distinct types of space that Willis argued for the distinctiveness of their roles. As he observed, the cerebellum was characterised by a regular and striated form which stood in contrast to the irregular, meandering formations of the cerebral:

> Wherefore whilst the Brain is garnished as it were with uncertain Meanders and crankling turnings and windings about, the compass of this is furnished with folds and lappets disposed in an orderly series. (AB, p.110)

These 'lappets' and 'folds' were, Willis noted, 'ordained with a certain and determinate series, and almost after a like manner in all' (AB, p.110). A lappet commonly referred to an overlapping fold or pleat in a men's shirt and had elsewhere been used to describe folds in the liver, though Willis was the first to adopt this analogy in relation to the brain.[99] These features could not have been more different to the cerebrum's 'uncertain manner', with its creeping and winding formations, characterised through topographical or vegetative imagery. Willis repeatedly stressed the proportional and repetitive pattern of the shapes he observed in the cerebellum, which he also compared to concentric rings or circles:

> Its folds are disposed in a certain orderly series; for the exterior frame of it seems to consist of thin lappets, or little rings or circles, being contiguous and infolded…with a parallel site or situation. (AB, p.67)

In contrast to rolling and meandering crevices, we find geometric shapes and neat folds arranged in a continuous and parallel order. These images - of repeated folds, lappets and circles - created a far more comprehensible and manageable picture for the observer (in this instance, the reader) than crevices and branches. They suggested the cerebellum's openness to being 'mapped' or subject to the rules of geometry – though they did not necessarily imply a lack of structural intricacy. This comparison, between the striated or convoluted bodies, was actually Galenic - though Willis's work represented a greater degree of anatomical detail and an innovation in terms of the functional explanations he looked to make on the basis of those distinctions. While folds and lappets were, like cells and cloisters, demarcations of spatial partitioning, they were specifically interpreted as having imposed a uniform or determinate order upon the spirits. Where as the

[99] "lappet, n." *OED Online*. Oxford University Press, September 2016. Web. 25 September 2016.

variegated spaces of the cerebrum had required the spirits to actively navigate them, rather than being passively shunted about as per a hydraulic machine, in the cerebellum, the effect of its spatial design was entirely mechanistic.

The main distinction between brain and cerebellum therefore described a tension between free and uniform, or regimented motions of the spirits. Notably, the animal spirits in both brain and cerebellum were materially of the same kind, each having been 'procreated' by the same cortical-distillation process – any distinction in their roles and activities had, therefore, to be ascribed to their particular environments and the structures they inhabited. The distinctive patterns or behaviours physically adopted by the spirits corresponded to their habitation, and produced different functional roles. Willis took the spaces in the brain as supporting the far more variable requirements of the voluntary affections, in that they were not spatially proscriptive or uniform. The spirits here flowed 'neither by such a continual course without intermission […] nor are sustained by a perpetual provision […] but both the loss of them, and their reflection, are uncertain, unequal, and variously interrupted' (AB, p.415). These processes were necessarily characterised as unpredictable and irregular to account for (or avoid setting distinct limitations on) the actions performed by the mental faculties. As Willis would later affirm, within each cell or chamber of the brain, the spirits could enact an 'infinite Variety of Actions and Passions' and were allowed 'Stretchings forth of a divers sort' for the 'divers uses of the Animal Faculties' (SB, p.25, p.22).

The structuring of the cerebellum, in contrast to the brain, was used by Willis to suggest a correspondingly ordered and uniform arrangement of the spirits, so that it was able to perform its 'solemn acts' by a 'customary', 'perpetual' and 'equal efflux' of spirits. In these cerebellar spaces the spirits were 'expanded according to the Rule and Method naturally impressed on them.' As Willis noted, the 'radiation of the Spirits from the Cerebel doth flow after another manner than the other from the Brain' (AB, p.114). Willis elaborated on these distinctions by proposing his theory that the spirits housed within each part attended to two distinct aspects of the nervous system: the voluntary and involuntary nervous responses. The brain housed the higher faculties of memory, imagination and the phantasy (perception or judgement), which - under the conscious oversight of the will and the rational soul - produced the 'voluntary affections' (our conscious acts and movements). The cerebellum, on the other hand, was granted a lower

order of functions: the 'involuntary affections,' which included respiration, the pulse, and reflexive motor responses. As Willis wrote,

> The office of the Cerebel is to procreate animal spirits apart from the spirits begotten in the Brain, and to dispense them into the Nerves, the Executors of the involuntary Actions and Passions.' (AB, p.114)

Notably, the reflexive, autonomic nature of the motions of the spirits was enabled (that is to say, inferred from) the structural features of the cerebellum. The uniformity observed in the cerebellum was used to materially underline Willis's ideas around the routine and reflexive nature of the involuntary passions. He proposed that the cerebellar spirits responded to the basic, vital functions of the body 'silently' and by an independent capacity, which did not involve conscious perception in the brain (unless such mechanisms were to become corrupted by a pathology or fault). The cerebellum's operations could occur automatically, that is without the involvement of perception and will, precisely because it had been constructed according to the logic of a machine. In this sense, Willis correlated the cerebellum with the cerebrum of lower beasts, which were also structured in a 'plain and even' order – leaving them able to respond only to basic stimuli and recognise certain natural objects on the basis of autonomic (that is, non-reasoned) responses. The cerebellum, then, is a 'lesser' brain.

This separation of roles was essential: the autonomy of the involuntary function allowed for the vital operations (such as respiration) to continue uninterrupted, such as when we are asleep. At the same time, the spirits of the involuntary system were offered some (limited) degree of protection from the passions afflicting the brain by being housed in a separate, if proximate, body.[100] Willis's explanations of sleep also relied upon cerebellar independence in that they freed up the spirits of the brain to rest. The spirits of cerebellum were not inclined to rest as their work was said to be less arduous and even easy – dispensed as they were by the ordering work of the cerebellum (SB, p.87). Sleep was, Willis described, essentially the 'shutting up' of the external senses while the involuntary actions continued to operate autonomously.

[100] The cerebellum was the first part of the brain to receive impressions carried by the spirits from the body, but only vehement affections (caused by objects promising good or evil) where strong enough to continue onwards to the brain. Likewise, strong affections conceived in the brain, by dint of their proximity and a 'shared walkway', could affect spirits residing in the cerebellum. This helped to explain the accompanying physical effects of some more forceful passions (i.e. increased heart rate during fear). These bodies therefore shared certain affects of the passions, but only in the more violent cases.

This model, which localised the voluntary and involuntary systems to two discrete bodies, was credited to Willis in particular. As Robert Plot, professor of Chemistry at Oxford, wrote of Willis in his 'Natural history' of 1677, 'his placing of the Spirits to serve to voluntary actions in the Cerebrum, and those that serve Involuntary in the Cerebellum, is a noble and useful discovery.'[101] Importantly, Willis's innovation did not come about simply because he had improved on the 'accuracy' of the anatomical account. Rather, it was based upon how he mobilised certain aspects of that account to make important claims about the nature of the corporeal soul and its core functions. Specifically, he used the form and texture of these bodies to infer distinct kinds of activity and movements of the spirits.

The chief argument underlying these descriptions was that the cerebellum served a more complex function than was generally accorded to it. As Willis bemoaned, 'Others place the Memory in this part, supposing the cerebellum to be as it were a Chest or Box […] but it is far more probable that this faculty resides in the cortical spires' (AB, p.111). To have accepted the cerebellum as a mere storage vessel for memory would have been to frame it similarly to the ventricles - as a vague, undifferentiated cavity space. Willis was inclined to disregard such explanations, using images of folds, circles and lappets to argue against prevailing readings of the cerebellar function by creating an internally complex structure. These features were evidence, he felt, of it having been providentially fashioned for a correspondingly complex (if regulated) set of operations.[102] Taken together, these spaces complicated the interior of the brain, with each set of spaces inferring a complex set of functions uniquely attributable to that part.

The limits of mechanism

Humans weren't just *like* other machines; according to the Cartesian model, they were themselves fully functioning automata. Automata – self moving, mechanical simulations of animals or humans - had existed since ancient times and, as Jessica Riskin has noted, primarily functioned as an amusing 'dramatization of a philosophical problems' – being

[101] Robert Plot, *Natural History* (London, 1677), p. 302.
[102] On Willis's correlation of complex form and function, see: William Bynum, 'The Anatomical Method,' p. 450.

whether animals and humans operated mechanically.[103] Though Willis certainly drew upon mechanistic categories of explanation where they were useful to him, he set a number of significant limits to the mechanical aspects of his explanations. The clock-metaphor, for instance, is limited to only one aspect of the nervous economy, rather than being applied to the body as a whole. Moreover, the cerebellar function was based both on the mechanical provisions of the cerebellum and on a certain natural 'instinct' possessed by the spirits themselves. Ultimately, the more complex outcomes of machines (and mental phenomena) required the interventions of a 'driver' (such as the rational soul). Whilst the clock image represented an expanding confidence among the new sciences in their ability to deconstruct and understand the inner workings of the body, Willis's account of the brain (as opposed to the cerebellum) worked against mechanical explanations. Here, Willis's discussions were somewhat limited by a sense of uncertainty: the cerebrum's physical complexities and contusions covered the spirits moving there under a veil of opaqueness (secluded in chambers and cells): their motions could not be predicted or mapped out according to the spaces they inhabited. His evocation of the cerebral space therefore evoked a notion of spirituous agency: it was a space that above all required navigation. The spirits were not mechanically shunted about or disposed into action by their container; indeed, they could actively overrun it and carve out new tracts for themselves, as the next chapter will explore in more detail.

The cerebellum provided no such observational tension with its straightforward folds, lappets and orderly series. Its anatomical artifice was easily mapped onto an available technology through the metaphor of the clock. The cerebellum, like a machine, was reduced and exposed as the mere sum of its parts and processes – any mystery undone. Looking specifically at the British context here, John Henry has argued that the clock metaphor was received with 'reserve and ambivalence' in contrast to the continent – which speaks to the English reticence over mechanical philosophies on the whole.[104] Interestingly, Henry shows that the metaphor stood for 'regimentation' and even 'mindless compulsion' in this setting – two features that align with and inform Willis's model of the cerebellum, as distinct from the (superior) brain.[105] The clock image, of

[103] Jessica Riskin, 'The Defecating Duck, Or, the Ambiguous Origins of Artificial Life,' *Critical Inquiry,* 29.4 (2003), pp. 599-633 (p. 601).
[104] On the 'local contexts' of mechanical philosophy's reception, see: Simon Schaffer, 'Godly Men and mechanical Philosophers: Souls and Spirits in Restoration Natural Philosophy,' *Science in Context,* 1 (1987), pp. 55-85 (p. 55).
[105] Henry, *Scientific Revolution,* p. 106.

course, only applied to the involuntary part of the sensitive soul and not the 'superior legion' of the animal spirits, which remained free to move and to be directed by the rational soul. This speaks to Willis's grand balancing act, incorporating some of the most influential aspects of materialism and atomism, while marking out a protected space for the (Anglican) soul against those forces.[106] What Willis achieved here, above all, was to have drawn a firm distinction between the clockwork cerebellum and the cloistered brain – the latter being a private and sacred space, left alone from the encroachment of mechanism relegated to the cerebellum.

As the image of the labyrinth had been used to suggest, though it was equally as *constructed* as the cerebellum, the space of the brain spoke more to the (incomparable) artifice of the creator – to some category of design that went beyond what man could feasibly replicate and went beyond the limits of what could be explained by mechanism alone. This was not to suggest, of course, that Willis could not expose and relate the anatomical structure of the cerebrum – but that it was of a level of complexity that placed certain details beyond reach (i.e. precisely what it is that happened inside the privacy of the 'cloister' or the lofty 'spires' of memory). This reflected Willis's notion that the cerebrum housed the highest of the sensitive faculties; a liminal phenomenon, that reached out from the body towards our spiritual selves.

An interesting comparison can also be drawn from the different knowledge-producing practices implied by images of cells, chambers and cloisters and the clock. A machine is taken apart to understand how it works; cloisters and chambers are lived in, or peered into. The clock suggests an act of deconstruction by the anatomist, whereas architecture does not – we don't need to take a building apart to note its features; instead we observe it, move through its spaces. Looking back to Calver's poem, there is a sense here in which the 'prying' and crude anatomist is pushed into the background when Willis talks about the secluded, spiritual spaces of the cerebrum. Lastly, coming back to the role of language, Willis's concept of the cerebellum, and likewise the cerebrum, were necessarily constructed through analogical reasoning. Willis had himself stated that this new role for the cerebellum – housing the involuntary function - had been arrived at via a 'certain thread' of analogical reasoning, 'to which afterwards happened an Anatomical inspection, which plainly confirmed me in this opinion' (AB, p.111). The cerebellum's role was

[106] On Willis's relationship with Anglicanism see: Robert Martensen, "Habit of Reason': Anatomy and Anglicanism in Restoration England,' *Bulletin of the History of Medicine,* xvi (1992), pp. 511-535.

established only in *comparison* to the brain and expressed through the contrasts noted between a clock and a public market, a kingly palace or a city-state. These images, in turn, informed and directed the anatomical findings, as Richard Lower's letters to Boyle on the research prepared for *Anatomy* made clear. Lower observed that Willis had 'several times' demonstrated to him, using the physical anatomy of the body, 'his opinion of the use of cerebel for involuntary motion.'[107] As his analogies were being demonstrated against the evidence of the body, so they in turn defined how that evidence was being read and understood. [108] Taken together, these spaces complicated the interior of the brain and showed how it could be said to support the equally complex functions of soul.

Conclusion

In drawing attention to the brain's intricate and bounded spaces, Willis shaped a particular narrative of brain function as something which occurred as a series of discrete, localised physiological operations inside the brain, rather than as broad sweeping motions inside ventricular cavities. Though he had referred to anatomy as an 'inelegant foundation', it clearly provided him with a means by which to infer key physiological mechanisms by providing a spatial matrix in which to plot their secret affairs (AB, p.192). Explanations of cognition and the vital functions of the body could – and were - being built around descriptions of the ways in which animal spirits moved through the various structures of the brain; a model that Willis developed with a leading focus on the solid substances of the brain itself.[109]

This is all very far away from the 'opaque veil' which two of Willis's contemporaries, Nicolas Steno and Walter Charleton, had felt to be shrouding the brain's interior operations. It also rather inverts the significance of Calver's 'empty trunke'. Even with the soul materially absent, the body-trunke, reimagined as a complex series of chambers, cells and cloisters or a clock, retained its significance post-mortem because of its embodiment of divine artifice - a container fashioned in the image of the soul it had been designed to house. The subtle shifts in emphasis between the cloisters of the brain, and

[107] Letter from Lower to Boyle, 18 Jan (1661) [/2], p. 462; quoted by Robert Frank Jr., 'Thomas Willis and His Circle', p. 128.
[108] Frank has argued that Willis's concept of the cerebellum 'directed the interpretation of the findings,' p. 128.
[109] On the animal spirits and the origin of sensibility see: G.S. Rousseau, 'Nerves, Spirits, and Fibres: Towards Defining the Origins of Sensibility,' *Studies in the Eighteenth Century,* 3 (1976), pp. 137-57. On Willis's use of the physical model see: Adrian Johns, 'The Physiology of Reading,' p. 138-161.

the clockwork machinery supporting the soul's lower orders, further highlighted a two-tiered hierarchy of the soul – its voluntary and involuntary parts - enshrined in the spaces in which they resided. This was a significant intellectual contribution. What Willis achieved here was to distribute and ground the manifold functions of the soul within the solid-structures of the brain. He thereby altered what the alignment of function and place actually meant in terms of a physiological model of brain function. This is what is meant by the epithet the 'father of localisation' in the modern neurosciences.[110]

Above all, Willis's representation of this interior landscape reveals how anatomical 'facts,' rather than being self-evident, are generated through the projection of specific intellectual or philosophical concerns onto the body. These interests shape the body through language. Lastly, It is important to note that Willis sought to account here for an ideal model, against which patterns and symptoms of dysfunction (pathologies of the soul) could perhaps be identified. He mapped out structural provisions that might, under the right conditions, incline the spirits to follow productive patterns and behaviours. Ultimately, though, the body-container could only speak to the processes and operations it was designed to support, rather than being any consistently reliable measure of how the soul would *act* within or invert those provisions of the brain. The body did, of course, in conjunction with physiological knowledge, provide a framework for establishing a normative model of health against which pathology could be traced out. The specific parts, powers and pathologies belonging to the soul itself will be explored further in the next and final chapter.

[110] On Willis's legacy in this area see: *An Illustrated History of Brain Function: Imaging the Brain from Antiquity*, ed. by Edwin Clarke and Kenneth Dewhurst (Norman Publishing, US; 2nd edition, 1995), p. 77.

Chapter Five

The Soul of Brutes: Parts, Powers, and Passions.

In his *Anatomy of the Brain,* Willis had argued that the material substance and structure of the brain was directly relevant to discussions of the mind. Yet it was the nature of the corporeal soul that formed the proper object of inquiry within his medical and anatomical investigations into the body. Willis had exposed the inner recesses of the brain precisely in order to peer at what could not be seen.[1] Building upon the 'foundations' of his anatomy, in 1672 Willis published a physiological and pathological account of the sensitive soul in *De Anima Brutorum* ('Soul of Brutes'), examining the soul's parts, powers and passions.[2] As he expressed it, this was no simple task: the search for knowledge of the soul was a 'timeless labour,' starkly overshadowed by a 'dark Blackness, not less than the shades of Hell it self' (SB, p.1). This did not appear to dim Willis's conviction that the soul could, in fact, be brought to light using the new intellectual tools of the chemical-corpuscular philosophies. As Willis stated in the preface to *Soul of Brutes,* all theories of the soul in his age were built upon Pierre Gassendi's demonstration that the soul was 'plainly corporeal' and a 'subtil knitting of atoms' (SB, p.2). Here, Willis sought to expand on what was for him an already working model of the sensitive soul, foregrounded in his earlier chemical investigations and his Oxford lectures.[3] It is Willis's ideas around the substantially corporeal nature of the sensitive soul that form the focus of this chapter. It considers the qualities attributed to this soul and by what power they were to be performed, its passions, and lastly, its relationship with the immortal rational soul.

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[1] On pre-modern uses of anatomical investigations into the body as a basis for examining the soul see: Sachiko Kusukawa, *The Transformation of Natural Philosophy: the case of Phillip Melanchthon* (New York: CUP, 2006) and Vivian Nutton, 'Wittenberg anatomy', in *Medicine and the Reformation,* ed. by Peter Grell Ole (London: Psychology Press, 1993). Nancy Siraisi has also addressed these themes in relation to Vesalius's reading of Galen's teleological reasoning, in which evidence of natures providential design in the body reveals an 'instrument' designed to support the functions of the soul: Nancy G. Siraisi, 'Vesalius and the Reading of Galen's Teleology,' *Renaissance Quarterly,* Vol. 50, 1 (Spring, 1997), pp. 1-37 (p. 4).

[2] Thomas Willis, *De anima brutorum* (1672), translated into English by Samuel Pordage, *Two Discourses on The Soul of Brutes* (London, 1683). All in text citations will refer to this edition using the abbreviation 'SB.'

[3] While there are clear threads between his various publications, I do not assume a straightforward ideological continuity here. Willis's on going practices around the brain (chemical, anatomical, clinical) and the advent of new inventions necessarily informed and altered what he was able to say about the soul at different points in his career.

Willis's contributions on these topics have been routinely overlooked in favour of his anatomical discoveries. As Ann Thomson has noted, while his views on active matter and the soul are important, his anatomical study of the brain has generally been considered his 'primary contribution' to medical history.[4] Historian of neuroscience Carl Zimmer also fails to acknowledge the significance of Willis's views on the animal spirits remarking that, despite Willis's work being a 'defining moment in neuroscience', he described the 'wanderings of invisible spirits as if he had travelled alongside them.'[5] In essence, the suggestion here is that Willis had strayed away from what could be (experimentally) verified and indulged in an altogether more imaginative narrative. More recently, Wes Wallace proposed that while Willis's anatomy of the nerves was 'unequivocal,' his explanations of their (physiological) function were conveyed through an alternating 'series of metaphors.'[6] Building on this, in 2014 Jody McNab cited Willis's (over)use of metaphor as an explanation for his 'contradictory' account of nervous transmission.[7]

This chapter argues, in contrast, that Willis's use of multiple figures need not be seen as either equivocation or confusion, but were rather the result of expressing different aspects of a complex and dynamic model. Furthermore, his concepts of animal spirits, active matter and the soul, as with many of his contemporaries, were at the centre of his wider practices around the brain. Conveyed through vivid and dynamic analogies, these concepts were a vital component of, and not accessory to, his intellectual contributions.[8] In this way, *Soul of Brutes* casts a new light onto the famous achievements of *Anatomy*: understood as a basis for constructing an early modern concept of the soul, the account becomes less recognisably 'modern' – certainly than prevailing focuses on his experimental practices would imply. Moreover, Willis's views on the animal spirits, as active bodies of matter, can be used to argue against straightforwardly mechanistic

[4] Ann Thomson, *Bodies of Thought: Science, Religion, and the Soul in the Early Enlightenment* (Oxford: Oxford University Press, 2008), p. 83.
[5] Carl Zimmer, *The Soul Made Flesh: The Discovery of the Brain - and How It Changes the World* (London: William Heinemann, 2004), p. 44.
[6] Though Wallace does go on to examine these metaphors in some detail, pointing to their relevance to his theories and practices, this stance reinforces a broader assumption that anatomy is rooted in visible 'things' and thus exercises a firmer discipline on the use of figurative devices. Wes Wallace, 'The Vibrating Nerve Impulse in Newton, Willis and Gassendi: First Steps in a Mechanical Theory of Communication,' *Brain and Cognition,* 51 (2003), pp. 66-94 (p. 77).
[7] Jody McNabb, 'Thomas Willis: The Faculties and his Two Cognitive Frameworks,' *Brain and Cognition,* 91 (2014), pp. 131-137 (p. 137).
[8] Michael Hawkins further notes that Willis's works are appropriated to provide a historical context for current neuro-anatomical discourses: *The Empire of the Passions: Thomas Willis's Anatomy of the Restoration Soul* (PhD thesis: Imperial College, 2004), p. 11.

readings of his work. Though his account of the brain's structure was unprecedented in its complexity, it was not presented as a functionally deterministic model. It is important, therefore, to consider how the soul was itself thought capable of operating and acting *within* the brain-spaces explored in the previous chapter. It is important also to recognise that Willis's natural philosophical concept of spirits and souls did not grow up in a vacuum: rather, it reflected his particular professional, religious and socio-political contexts. This is a point that has been well made by a number of historians. As Michael Hawkins has argued, Willis 'explicitly linked matters of physiology and pathology to social, political and religious concerns.'[9] In this Hawkins builds on a number of important cultural history approaches to Willis, notably by Robert Frank Jr. in the 1980s and more recently by Robert Martensen, who have insisted on situating Willis's theories in their wider religious, cultural, professional and socio-political contexts.[10] This chapter builds upon these areas of discussion, examining the cultural and socio-political resonances represented in the key metaphors and analogies employed by Willis.

Spirits and Souls in the Seventeenth Century

Early modern souls were multifaceted objects of knowledge, drawing upon competing natural philosophical traditions, theological, socio-political and medical influences. What binds these various accounts in the seventeenth century was the attempt to explain an animating principle that could be used to separate living from non-living bodies in the natural world.[11] These explanations primarily rested upon a notion of 'spirit', conceived of as an atom or 'corpuscle' that moved and enlivened organic bodies. Spirits were at the centre of physiological, medical and theological explanations of the soul in the seventeenth century. They were variously conceived as bodies that produced powerful affective states, which could be used to unite the physical body and mind; moving into the latter part of the seventeenth century, they were a chief object of inquiry for the physiologist or physician, more than the theologian. Despite their core significance in discussions of body and mind, the term spirit did not convey a stable or agreed definition. Whether they were material or immaterial, active or inert, and how they could

[9] Michael Hawkins, *Empire of the Passions,* p. 11.
[10] Robert G. Frank Jr., 'Thomas Willis and his Circle,' in *The Languages of Pysche: Mind and Body in Enlightenment Thought,* ed. by George Rousseau (Berkeley: University of California Press, 1990), pp. 107-147. Robert Martensen, *The Brain Takes Shape* (2004).
[11] Daniel Garber, 'Soul and Mind: Life and Thought in the Seventeenth Century', in *The Cambridge History of Seventeenth century Philosophy,* ed. by D. Garber and M. Ayers (Cambridge: CUP, 1998), pp. 759-795.

even be studied were highly contentious questions. Furthermore, as invisible and insensible particles, any account was explicitly reliant upon the work of metaphor and analogy. Popular tropes compared them to breath, wind, fluids, flame or beams of light.

One of the key principles underlying early modern medical concepts of spirit was Galen's physiological theory of psychic *pnuema.* For Galen, the soul was composed of (or had as its primary instrument) this subtle substance, which bore connotations with 'wind' or 'breath'.[12] The *pneuma* performed all the vital and sensory functions within the brain and body and resided inside the brain's ventricles.[13] Early modern concepts of the animal spirits traced their roots back to the *pneuma,* which were rendered into the Latin *spiritus animalis*.[14] According to Aristotle - whose framework continued to dominate well into the sixteenth and seventeenth centuries - all living things differed from inanimate objects in that they possessed an animating life principle or 'soul' (*anima* in Latin and *psuchê* in Greek); this principle was materially embodied within the animal spirits, which came to be conceived of as the chief instruments of the soul acting inside the body.[15] Willis also referred to the soul as 'anima,' to indicate a corporeal soul. As he notes,

> It is demonstrated […] some subtil particles flow, and cause Animality or life in all […] we rightly call the Animal Spirits, and the constitutive part of the Sensitive Soul (SB*,* p.22).

The corporeal soul was comprised of two kinds of spirit: vital, residing in the blood and the Animal spirits within the brain and nerves (SB*,* p.22). While the powers and attributes of the sensitive soul were substantially corporeal, Willis adhered to the traditional Aristotelian position in assigning the intellective powers and volition (the will) to an

[12] The concept of *Pneuma* was important in sixteenth and seventeenth century pneumatic philosophies, later associated with the element or spirit of air. On this, see: Peter Barker, 'Stoic Contributions to Modern Science,' in *Atoms, Pneuma and Tranquility: Epicurean and Stoic Themes in European Thought,* ed. by Margaret Osler (Cambridge: Cambridge University Press, 1991), pp. 135-154 (p. 147).
[13] Julius Rocca, 'Anatomy,' in *The Cambridge Companion to Galen*, ed. by R. J. Hankinson (Cambridge: Cambridge University Press, 2008), pp. 242-262 (p. 247).
[14] The 'spiritus animalis' of the fifteenth and sixteenth centuries were thought to be produced from the vital spirit and were generally located in the brain - as opposed to 'natural spirits' traditionally located in the liver or vital spirits in the heart, see: C.U.M. Smith and others, eds., *The Animal Spirit Doctrine and the Origins of Neurophysiology* (Oxford: Oxford University Press, 2012), p. 50.
[15] Aristotle defined the soul as a 'substance as form of a natural body which has life in potentiality,' *De Anima,* II, 1, 412b5-6.

immaterial rational soul (*mens* or mind) belonging to man alone, to which the sensitive soul was ultimately subordinate.[16] Man was, therefore, a 'two-soul'd Animal' (SB*,* p.1).

A particularly significant theme in this period is the responses by natural philosophers to the highly influential mechanical philosophy. René Descartes was one of the most notable proponents of this new philosophy. For Descartes, the soul, properly understood, was incorporeal and indivisible - utterly separated from the category of spirit. The soul possessed only one power: thought.[17] The animal spirits residing in the body were, in this model, merely inert or passive atoms, hydraulically shunted about the body-machine like fluids in a mechanical water-fountain. This effectively reduced all bodily functions and sensory perception to mechanistic outcomes; animals (and human bodies) were mere automata.[18] Willis's account of the spirits drew on a number of quasi-mechanistic categories of explanation, some of which echoed Cartesian analogies, while also departing significantly from that philosophy. This comes from the fact that both the new mechanical and chemico-corpusuclar philosophies – which Willis adhered to - drew from influential Epicurean atomism and the *naturalia minima* tradition, concerned with the actions of atoms or spirits as the smallest units of matter.[19] Epicurus had utilised a concept of spirit as the most basic form of matter, proposing that all perceivable natural phenomena could be accounted for by the physical properties of these atoms - their combinations, size, shape and motions, acting below the level of sense.[20] The English physiologists, in contrast to the mechanists, held that living things possessed a material

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16 See Daniel Garber, 'Soul and Mind' (1998), p. 760. Jaime Kassler points out that the Aristotelian tradition continued to influence Willis's work even whilst he rejected many parts of its doctrine: 'Restraining the Passions*:* Hydropneumatics and Hierarchy in the Philosophy of Thomas Willis,' in *The Soft Underbelly of Reason: The Passions in the Seventeenth Century,* ed. by Stephen Gaukroger (London: Routledge, 1998), p. 153.

17Susan James, *Passion and Action: The Emotions in Seventeenth century Philosophy* (Oxford: Oxford University Press, 1997), pp. 87, 89. Descartes, Letter to Arnauld, 4 June 1648, in *The Philosophical Writings of Descartes,* ed. by J. Cottingham and others, vol. iii. *Correspondence* (Cambridge: Cambridge University Press, 1984), p. 355.

18 James, *Passion and Action,* p. 87.

19 On these traditions within the chemical philosophies of 1600's England, see: Allen G. Debus, *The Chemical Promise: Experiment and Mysticism in the Chemical Philosophy 1550-1800* (Sagamore Beach, MA: Watson Publishing International, 2006).

20 In purely materialist accounts (which dispensed with the idea of an immaterial soul altogether), all natural events and changes were the outcome of a 'fortuitous concourse of atoms,' occurring without divine guidance. On the influence of epicurean atomism in English theories of spirit, see: John Henry, 'A Cambridge Platonist's Materialism: Henry More and the Concept of Soul', *Journal of the Warburg and Courtauld Institutes*, 49 (1986), pp. 172-95; idem, 'Occult Qualities and the Experimental Philosophy: Active Principles in Pre-Newtonian Matter Theory,' *History of Science,* 24 (1986), pp. 335-81.

soul responsible for the effects of organic life and the acts of the animal government - the primary category of which were corpuscles or spirits. [21]

A 'certain waving': waves, beams and nervous transmission

Unlike the continent, England witnessed a limited uptake of mechanical philosophy.[22] Like many of his English contemporaries, Willis elected to re-interpret Galeno-Aristotelian notions of spirit through the prism of chemical-corpuscular principles, though still drawing upon selected aspects of the mechanical philosophy. Willis, for instance, described the spirits as driving the 'animal machine' and were moved about the nerves 'as it were [in] Pipes and other Machines' (SB, p.24). Some of Willis's analogies directly echoed Cartesian ones, such as when he described the brain as a 'perpetual fountain' of the spirits, or when he referred to spirits blasted through 'wind-pipes,' 'like the Chest of a musical Organ' (AB, p.105). The use of such analogies did not make Willis a mechanist; just as William Harvey's use of the pump metaphor did not preclude his rejection of a mechanical world-view.[23] A far more substantial influence on Willis was the work of Pierre Gassendi. [24] He drew extensively on Gassendi, for instance, when he sought to ascribe active and self-moving powers to the animal spirits, as opposed to the inert, matter-in-motion categories of the mechanists. [25] As this section explores, despite

[21] On the common belief in a corporeal, lower soul comprised of spirits or atoms, see: Antonio Clericuzio, 'The Internal Laboratory: The Chemical Reinterpretation of Medical Spirits in England (1650-1680)', in *Alchemy and Chemistry in the 16th and 17th Centuries,* ed. by Piyo Rattansi and Antonio Clericuzio (Dordrecht; Boston: Kluwer Academic Publishers, 1994), pp.51-83 (p. 59); John P. Wright, 'Locke, Willis and the seventeenth century Epicurean Soul,' in *Atoms,* Pneuma, *and Tranquillity,* Osler (ed.)*,* p. 244.

[22] Willis's theories are viewed by Clericuzio as 'a chemical re-interpretation of animal spirits,' providing a 'viable alternative' to the Cartesian theory of sensation: 'The internal laboratory,' p. 67.

[23] As Domenico Bertoloni Meli explores, Harvey, like Willis, rejected the mechanical world view but used aspects in 'limited domains': 'Machines of the Body in the Seventeenth Century,' in *Early Modern Medicine and Natural Philosophy,* ed. by Peter Distelzweig and others (Dordrecht: Springer, 2016), pp. 91-116 (p. 93). Furthermore, 'mechanics' did not constitute an unambiguous set of principles in this setting and were applied in conjunction with chemico-corpuscular ideas and longstanding Galeno-Aristotelian frameworks. On the 'semantic ambiguities' of mechanics in this period, see: Peter Distelzweig, '"Mechanics' and Mechanism in William Harvey's Anatomy: Varieties and Limits,' *Early Modern Medicine* (2016), pp. 117-140 (p. 117).

[24] On Willis's debt to Gassendi see: Robert Frank Jr., *Harvey and the Oxford Physiologists* (London: University of California Press, 1980), p. 249; Wright, 'Locke, Willis and the Epicurean Soul', p. 246; Thomson, *Bodies of Thought,* p. 81.

[25] As John Henry argues, few in this period reduced the body to a pure machine, most referred to vital qualities in some form: 'The Matter of Souls: Medical Theory and Theology in Seventeenth Century England', in *The Medical Revolution of the Seventeenth Century*, ed. by Roger French and Andrew Wear (Cambridge: Cambridge University Press, 1989), p. 94. Simon Schaffer argues that, for English natural philosophers in the 1670's, mechanism failed to displace core organising notions of spirit and soul: 'Godly Men and Mechanical Philosophies,' *Science in Context,* 1 (1987), pp. 55-85 (p. 57). On the limited uptake of mechanism in England see: Walter Pagel, *Jan Baptista van Helmont Reformer of Science and Medicine* (Cambridge: Cambridge University Press, 1982).

featuring mechanistic elements, Willis's model was very much premised upon those medical physiologies utilising theories of active matter in this period.[26]

Willis broadly represented the corporeal soul's transmission of sensory and locomotive impressions between body and brain through a dual, hydropneumatic model.[27] The spirits carried their impressions either as the gentle 'winds' of instinct, or the vehement winds of a passion; elsewhere, they 'flowed' through the nerves as a certain fluid 'undulation,' which could be stirred up by the 'winds' of affection (SB, p.45). This clearly distinct from the hydraulics of Cartesian mechanics, whereby fluids (or air) were forced through the nerve-pipes by external forces to move solid parts of the body. Willis's explanations still relied upon the physical motion of material bodies, but explored their effects in terms of their active, internal activities and variable configurations. In particular, Willis used a wave-propagation analogy, informed by corpuscular notions, to express his model of nervous transmissions.

When an impression was received by the soul, Willis described how 'a certain fluctuation or waving is stirred up in the *Hypostasis* of the whole soul,' by which the spirits carried out the acts of sense and motion in the body (SB, p.56). The impressions of sensible objects ('species') were physically carried by the spirits like a 'wavering of waters,' whereby impressions were passed through the nerves, not as a direct physical force, but by encouraging a certain motion or 'inkindling' in neighbouring spirits, spread throughout the entire 'fluid' body. These 'waves' were then 'reflected' and refracted back through the nerves (SB, p.48).[28] This model relied upon the motive predisposition of the spirits and their extension as a continuous body of atoms – rather than upon external hydraulic forces. A wave (*fluctus*) described an irregular pattern, or (forceful) fluctuation, typically denoted in a body of water, usually the sea.[29] It was a term widely used to reflect a variable form of motion, as in a wavering beam of light. For instance, in 1660 Robert

[26] John Henry, 'The Matter of Souls,' p. 90.
[27] Kassler argues that Willis's cerebral physiology was primarily organised around a hydropneumatic model, 'Restraining the Passions,' p. 153. However, the 'human hydraulis' conceit was also complicated by other (potentially conflicting) images within the text.
[28] On this see Frank, *Oxford Physiologists,* p. 248. D. F. Harris suggested that this analogy had a 'germ of truth' and cited Willis's 'reflected' waves as the origins of modern neuroscience's concept of reflex action – despite fundamental differences with seventeenth century concepts of spirits: 'The Metaphor in Science,' *Science,* 36 (Aug., 1912), pp. 263-269 (p. 265). On fluid mechanics in physiological models of the period, see: Des Chene (2001), p. 38; S. Gaukroger (1995), p. 247, 277.
[29] See for example, Richard Huloet who described how 'Waue as water doth in tempest, *fluctuo,*' *Abcedarium Anglico Latinum* (London: G. Riddel, 1552).

Boyle described how bubbles 'ascended with a wavering or wriggling motion.'[30] It could also be metaphorically applied to signify a changeable or fluctuating state of being - such as when the vital flame was cast into fluctuations and 'irregularities' by the 'winds' of passions or when a person displays a 'wavering' resolve. In the Latin original of *De anima brutorum,* Willis used 'fluctuatio' and 'undulatio' together (*'fluctuatione undulosa'*) to indicate the analogy with a wave-motion. *Unda* is the Latin root of wave, later *undulatus*.[31]

Though the notion of undulation originally referred chiefly to bodies of water, it was also being used in this period as a metaphor for the transmission of light and sound through various mediums. In 1637, for example, Descartes published on the refraction of light using an analogy with sound waves.[32] Gassendi had also developed an influential corpuscular theory of light based around the agitation and motion of particles, upon which Robert Hooke developed a new theory of 'pulse' or 'wave' propagation during the 1660s.[33] A wave in this context referred not to the qualities of a specific substance (water), but to a motive mechanism occurring at the particulate level within larger masses. Willis used the term within this specifically corpuscular framework. The corporeal soul, according to such models, shared important qualities with fluids as a continuous 'hypostasis' of atoms suspended and moved within a medium. As Willis had previously stated, the soul was defined by its 'moveable and fluid character' (AB, 108).[34] Wave motion was specifically used to denote the involuntary and transient changes among the normally 'quiet' spirits, when they would 'enter into a peculiar way of Gyration or turning round, or of undulation or waving […]' (SB, p.61). With each spirit itself inherently predisposed to move, the overall form of the soul constantly altered its shape, just as waves in the sea made its form swell and undulate. Here, Willis uses 'fluid,' in respect of the soul, as an adjective to describe its state of being non-fixed, or the inherent pre-disposition of spirits to self-motion.[35]

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30 Robert Boyle, *New Experiments Physico-mechanicall,* xxiv (London: 1660), p. 193.
31 Thomas Willis, *De anima brutorum,* (London, 1672), p. 155, 160, 207.
32 Hanna Pulaczewska, *Aspects of Metaphor in Physics: Examples and Case Studies* (Tübingen: Max Niemeyer Verlag GmbH, 1999), p. 186.
33 On the concept of light as a motion or 'pulse' propagated through a transparent medium, see: Thomas Birch, *The History of the Royal Society,* vol. 3 (London, 1757), pp. 10-15. Hooke studied light patterns and compared them to fluid wave propagation in his 'Observation IX', *Micrographia,* (London, 1665; 1969), p. 81.
34 Wes Wallace reads this analogy as a 'movable printing block whose shape is constantly adaptable,' creating different sentences, p. 79.
35 This comes from the Latin *fluidus* and *fluere,* 'to flow' (related to 'fluent'). From the 1660s onwards it is used as a noun to describe any substance capable of flowing: "fluid, adj. and n." *OED Online*. Oxford University Press, December 2016. Web. 12 March 2017. Robert Boyle was the first to use fluid as a noun to denote specific nature of fluid substance.

Despite having used 'waving' to denote a changeable and fluctuating form (of the soul), Willis also argued that just as impressions passed 'unchanged' through water and air, so they were also conveyed through the hypostasis of the soul. He argued that waves were far from chaotic and in fact offered a useful analogue for the spirits' proposed capacity to carry many distinct images simultaneously - even as they passed across each other's paths. He describes how various sensory impressions were simultaneously received by the corporeal soul like 'a River […] when many wavings have been stirr'd up, by various and divers strokes together.' These wave-like impressions 'pass thorow, or cut one another,' yet remain unchanged, 'still distinct, and inconfused.' As Willis asks, 'why then may we not suppose, that in the Airy *systasis* of the Soul, (which also is founded in a Watry Humor),' such manifold species 'may be at once brought to the Common Sensory, without Confusion?' (SB, p.58-9)

Notably, despite a recurrent use of the fluid analogy to explain the animal spirits' actions, Willis sought to clarify that they were to be properly compared with the 'beamy texture' of 'light rays' – an analogy not used by Descartes (SB, p.32). The animal spirits were 'lucid' and 'airy' particles emanating as rays (*radiis*) of light flowing from the vital flame, implanted throughout the nervous stock were like a 'continued beaming':

> […] the Animal Spirits as Rays of Light, proceeding from this Fire, are Configured according to the Impressions of every of their Objects […] as it were meeting together with reflected irradiations, cause divers manner of motions (SB, p.33).

The sensible impressions held by the spirits were 'irradiated' through the nerves as beams of light, reflected and refracted 'as it were by Dioptrick Glasses' until they at last represented their image on the 'white wall' of the corpus callosum of the brain - the soul's 'inferior chamber' (SB, p.22). The rational soul then 'beheld' these images 'as in a looking glass' (SB, p.32). These explanations explicitly drew on new inventions in the field of optics: the spirits, Willis noted, were represented to the 'Callous Body,' 'as it were upon a white wall,' referencing the inverted images produced by the newly invented camera obscura.[36] The brain acts as a kind of 'light chamber' for the spirits. We also could think back here to the notions of perspicuity – as a quality of language – discussed

[36] On the camera obscura and early modern perspectival ideas see: Svetlana Alpers, *The Art of Describing: Dutch Art in the Seventeenth Century* (Chicago: The University of Chicago Press, 1983), pp. 27-33.

in chapter one; by using light in this context, a sense of innate clarity, or illumination, is granted to the impressions carried by the spirits to the mind.

As with Willis's discussion on the movement of waves, the camera analogy was once again employed here to further his argument that the spirits could be relied upon to faithfully re-present their images without physically 'confounding' one another. This was in answer to the charge that, as a moving mass of particles, the spirits could not possibly carry all the discrete impressions of their objects and represent each with clarity inside the physically limited space of the brain:

> I say none ought to wonder, who hath beheld the Objects of the whole Hemisphere, admitted thorow an hole into a dark Chamber, and there on a sudden upon Paper exactly drawn forth, as if done by the Pencil of an Artist: Why then, may not also the Spirits, even as the Rays of light […] exhibit them without any Confusion or Obscuring of the Species? (SB, p.33)

As with the clock, Willis selects one of the most complex and (presumed) accurate devices in this period. If the camera – a man made device - could replicate the 'whole hemisphere' with exactness then, Willis argued, the corporeal soul (which exceeded any human artifice) could be assumed to equal if not exceed such powers. Unlike the clock, this invention is not intended to convey notions of regularity or autonomy, but the capacity of the soul to reliably communicate complex – and variable - forms and figures to the brain.

Willis referred here not to waves but to light *rays,* which moved 'not by a waving fluctuation, but proceeds with only strait rays or strokes' (SB, p.76).[37] Light waves, unlike fluid waves, were not thought to bend around objects. However, in contrast to the images of straight, beaming 'rays', Willis also noted that the actual image carried by the spirits (comprising these 'rays') were, as motive particles, still subject to a waving motion: 'Yet, the Character of the object, is conveyed […] as it were by a certain waving.' This consisted of an 'inkindling,' as in fire, propagated between neighbouring spirits implanted in the containing medium (SB, p.58). The particles transmitting the illumination (beneath the level of sense) wavered in the sense of being 'inkindled,' like a flame.

[37] 'Strait' comes from *rectus* in Willis's Latin original, *De anima,* p. 207.

There is a distinction, then, between how Willis represents the overarching model of nervous transmission between body and brain (as refracted beams of light) and the specific mechanism by which the form or figure of an object was held and conveyed by the spirits. Here, analogies with light, fluids and flames are being used interchangeably; not because he was being 'contradictory', as McNabb has argued, but in order to express different aspects and levels of complexity within the larger model.[38] They are phenomena united, moreover, by a corpuscular understanding of the wave-propagation model. Furthermore, by having drawn these points of comparison, Willis had pointed to an analogy between the spirits' capacity to carry the visible, audible and tangible qualities of objects to the senses and the actions of the air in transmitting these qualities to the sense organs (SB, p.58). The animal spirits were, however, importantly distinct from those of the air in the respect that they could hold the image and form of their object, which they themselves embodied (SB, p.24-5).

Together, these images assigned an internal mechanism of communication or transmission to the corporeal soul; although the effect is given in response to stimuli, the mode of action belongs to the soul itself. This is bound up in Willis's use of the language of optics and geometry, of 'reflected' and 'refracted' waves, or irradiated and undulating spirits, appropriated within new corpuscular discourses. The corpuscular concept of wave mechanism was a bridge between these discourses, which allowed Willis to easily switch between fluids, winds or light when describing the spirits' various qualities. The spirits were, however, neither one thing nor the other; as a unique class of material, they held no direct analogue in natural bodies and therefore needed to draw upon various objects to convey their multifaceted powers and nature. Importantly, in these discussions, the analogical basis shifted from typical mechanical devices (the pump or clock) to corpuscular processes that also drew upon aspects of mechanical explanation – from distillation to wave propagation. These analogies offered more flexible explanatory tools, which, in keeping with the nature of the animal faculties, were non-determinist and inherently variable types of event.[39]

[38] Jody McNabb, 'Two Cognitive Frameworks,' p. 137.
[39] As Bertoloni Meli (2016) has argued, device-analogies (the pump, clock) express regularity and are less helpful when thinking about disease states, p. 96, 109.

The Vital Flame

A key image in Willis's efforts to ascribe an organic or vital life principle to a material soul came in his image of the vital flame. As I touched upon in chapter three, the vital flame was a notion rooted in Willis's chemical ideas around fermentation. In his model of the soul, as expressed here in 1672, the vital spirits accounted for all the functions that sustained life, from respiration to digestion. He compared this quality of the soul to a flame, lying hidden within the blood, it stirred up the spirits into life as a certain 'inkindling.' Like a flame, the soul existed only 'in so far as it acts […] when motion ceases, so does its existence' (SB, p.8). When 'inkindled', the vital soul was engaged in a constant and rapid self-motion that produced light and heat. The 'winds' of the affections caused the vital flame to constantly fluctuate and change its shape - 'fanning' or extinguishing it altogether. As Willis described it,

> There is not much more difference between an insensible and a sensible Body, than between a thing uninkindled, and a thing kindled […] In like manner, the Vital humour in an Egg, remains torpid and sluggish in the beginning, and like to unkindled matter; but as soon as it is actuated, from the Soul being raised up, presently like an inkindled fire, it excites Life with Motion and Sense, and in the more perfect Creatures with heat. (SB, p.33)

The notion of an animating principle in bodies was commonly expressed through this trope of the flame in the seventeenth century. In 1627, Francis Bacon described the spirits of animate bodies as all being in some way 'kindled and inflamed' as a 'fine commixture of flame, and an aerial substance.'[40] Robert Burton likewise noted that 'as fire is in a torch, so are the spirits in the blood.'[41] The flame analogy of the soul proliferated in theological works as much as it did in medical-physiological writing.[42] Walter Charleton, for instance, also conceived of the soul as a very 'thin' and 'pure flame', embodied by the activity of the spirits placed within the blood and extended throughout the body.[43] William Harvey located the vital life principle in the blood, but considered this to be one and the same as the spirits of the blood and did not ascribe to the flame analogy. He nevertheless similarly defined spirit (according to Hippocrates)

[40] Francis Bacon, *Sylvia Sylvarum* (1627), p. 153.
[41] Robert Burton, *The Anatomy of Melancholy* (Oxford: Printed for Henry Cripps, 1621), p. 28.
[42] Henry, *The Matter of Souls,* p. 110.
[43] Walter Charleton, *Enquiries into Human Nature*, *Anatomic Prælections* VI (London, 1680), p. 384.

according to its motive qualities, as 'whatsoever attempts anything by its own endeavour and arouses any motion with agility and vehemence, or initiates any action.'[44]

Notably, the vital flame attracted new chemical-corpusuclar definitions during the latter part of the period. Willis's own account retained a strong vitalistic and alchemical influence, marking out the vital spirits as a unique sort of matter, which pertained to a life principle – following in the tradition of Helmontian *archaei* or seeds. He followed Gassendi in proposing a certain 'vital materialism,' in ascribing an innate self-moving force or sensibility to the spirits. The souls of brutes were, Willis argued, a 'heap' of 'most subtle Atoms […] extreamly movable,' all 'stirred up with Life into motion' (SB, p.6). Following on from his earlier chemical work, Willis clearly *likened* the vital soul to a flame by defining it as a fermentative commotion - a particulate agitation created by nitre reacting with sulphur to effect a chemical 'ferment'. This established a non-destructive form of heat production: a fire without flame.[45] In this way, Willis explained the analogical basis of the flame: organic heat, and therefore life, was sustained through a chemically induced, particulate 'commotion,' rather than being a literal fire or flame. This account of the vital flame offered an important basis for promoting physiological explanations of sensitive life in Willis's work. However, during the late seventeenth century, this reading of the analogy came under particular scrutiny, eventually leading to Willis amending his position in the *Soul of Brutes.* Here, Willis's use of and reliance upon a particular analogy was explicitly challenged; a whole theory contested on the basis of the apparent limitations (or shifting interpretations) of an analogy. It offers a useful example of how Willis grappled with the indispensability of certain analogies – even as those around him sought to reject the analogical roots of their own discussions.

The Cambridge Platonist Henry More notably dismissed Willis's notion of the vital flame as 'psychopyrism,' by which he meant a reduction of the soul's higher powers to gross chemical events.[46] More drew on mechanical principles in attacking Willis's account, arguing that although a flame might appear to have a self-moving property, it was

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[44] William Harvey, *Disputations touching the generation of animals* (1651), translated by Gweneth Whitteridge (Oxford, 1981), p. 347.

[45] See chapter two of this thesis for more detailed discussion of these ideas. See also, Clericuzio, *Internal Laboratory,* p. 65.

[46] Henry More, *An Answer to a Letter of learned Psychopyrist,* published in Joseph Glanvill's *Saducismus Triumphatus: Or Full and Plain Evidence concerning Witches and Apparitions* (London, 2nd edn. 1682). The idea of a vital life principle being embedded in matter (as with the vital flame) was, for Henry More, potentially heretical. Henry, *The Matter of Souls,* pp. 107-8.

actually moved by the collision of particles: 'when you apply a lighted Candle to light another Candle, the parts […] are put into motion by the moved parts of the lighted Candle.'[47] Here, More was defending his belief in an immaterial and immortal soul – organic heat was a purely mechanical event.[48] Many philosophers (dualists and non-dualists alike) disagreed with the idea, shared by Willis and Lower, that there was some kind of flame or 'inkindling' heat within the blood on the basis that fire was demonstrably destructive, when the organic heat within living bodies was required to be generative. The Galenic physician Edmund O'Meara, for instance, criticised Willis for his 'vague' use of the term spirit by the import of inappropriate chemical terms, but also for having misunderstood the concept of a vital flame by employing it in a literal rather than analogical sense.[49] Echoing O'Meara, in 1667 the physician Conlis Cassin claimed that Willis had significantly mistaken the clearly metaphorical nature of the 'vital flame,' which both Harvey and Descartes had (correctly) recognised.[50] Though Willis did not use the flame literally, he did at times blur its boundaries, as I will shortly demonstrate.

More significant were the criticisms from fellow experimental philosophers at Oxford. Robert Boyle took particular issue with Willis's fermentative explanation.[51] Boyle and John Mayow both called for the flame analogy to be replaced by a more precise chemical definition of the vital spirit (as a reactive nitrous particle).[52] Unlike O'Meara and More, Boyle and Mayow accepted chemico-corpusuclar explanations of the vital principle, but sought a much stricter chemical definition. Boyle called into question the 'omnipotence' of the term spirit, suggesting that the chemists applied it to any distilled, volatile liquid that could be produced: 'as for what the Chymists call spirit, they apply the name to so many differing thing…they have no clear notion of the thing.'[53] In his *Tractatus duo* (1668), meanwhile, Mayow argued that 'we do not need to have recourse to an imaginary

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[47] On the 'psychopyrism' charge see: Henry, *Matter of Souls,* p. 109; Thomson, *Bodies of Thought,* p. 8.
[48] John Henry argues that More's extreme dualism was not representative of the English context - most accepted some variant of the vital flame conceived of as a material spirits: *Matter of Souls,* p. 110.
[49] See Kenneth Dewhurst's conclusion to Richard Lower's *Vindicatio, a Defence of the Experimental Method* (1665)*,* (Oxford: Sanford Publications, 1983)*,* p. 294.
[50] Dewhurst, *Vindicatio,* p. 296.
[51] I explore Willis's use of the analogy between chemical and medical processes in chapter two of this thesis. It is something Michael Hawkins has explored in some detail in his article, "Piss Profits': Thomas Willis, his Diatribae Duae and the Formation of his Professional Identity," *History of Science,* 49.162 (2001), pp. 1-24, (p. 13). On Boyle's wariness of vitalist explanations, see: Thomson, *Bodies,* p. 81.
[52] Both Boyle and Mayow were hostile to Willis's explanation of the vital heat as a product of fermentation, which Boyle condemned in *The Sceptical Chymist* (London, 1661). On this, see: Clericuzio, *Internal Laboratory*, p. 65-6; Thomson, p. 80-81.
[53] Robert Boyle, 'Experiments and Notes about the Producibleness of Chymical Principles', in *The Works of the Honourable Robert Boyle,* ed. by Thomas Birch*,* 6 vols (London, 1772), 1, p. 609.

vital flame' such as Willis employed.[54] He instead proposed that the vital heat was produced by the action of nitro-aerial particles from the air reacting with saline-sulphurous particles within the blood. [55] Here, the issue was less about "correct" use of the flame (as figuration) as it was an attempt to move away from the concept's analogical foundations altogether, replaced by an empirical, chemical reality. The spirits were to be 'disciplined' (as objects of knowledge) by being made to carry a direct and specific link between words (spirit) and object (nitre plus sulphur). The vital spirits, in this context, function as a sort of forgotten or 'dead' metaphor.

By 1688 Willis had amended his position in his tract on the *Pathology of the Brain and Nerves*.[56] By the time he published *Soul of Brutes* in1672, he had accepted the prevailing notion that the vital spirit was in fact aerial nitre, reacting with sulphur in the blood.[57] However, the flame continued to offer a more effective vehicle for expressing the phenomena now defined as ariel nitre. The flame analogy persisted long after the debates of the 1670s. For instance, in 1691 John Ray, the famous naturalist and Royal Society member, wrote that the body was a machine enlivened and driven by the active powers of the soul, which he again likened to the flame of a candle: 'the Body is but the Machine or Engine, the Soul that actuates and quickens it; the Body is but the dark Lanthorn, the Soul or Spirit is the Candle of the Lord that burns in it.'[58] On Willis's part, even though he had recently accepted the ariel nitre definition, in 1672 he went on to reaffirm the flame comparison, writing:

> […] wherefore, after so many Learned Men, it will be no Paradox to affirm, *That the Soul lying hid in the Blood, or Vital Liquor, is a certain fire or flame;* which Opinion agrees well enough with right Reason (SB*,* p.5).[59]

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[54] John Mayow, *Tractus Duo* (Oxford, 1668), English translation in *Medico-Physical works* (Oxford, 1926), pp. 105-9.
[55] Mayow, *Tractus Quinque* (Oxford, 1674), in *Medico-Physical Works,* pp. 34. Clericuzio, *Internal Laboratory,* p. 58; Thomson, *Bodies,* p. 79. On Boyle's own views on the spirit of nitre, see: Frank, *Oxford Physiologists,* pp. 259-60 (esp. p. 255).
[56] Much of the pathological discussion in *Soul of Brutes* drew on material from Willis's medical lectures from 1661 and his tract, *An Essay on the Pathology of the Brain and Nervous Stock,* (London, 1668) in *Medical Practice*, translated by Samuel Pordage (London, 1681)*,* p. 3.
[57] Willis here refers his reader to his views 'wrote lately' on the 'Accension of the Blood', *Soul of Brutes*, p. 22. *Ibid*, pp. 21-23.
[58] John Ray, *The wisdom of God manifested in the works of the creation being the substance of some common places* (London: Printed for Samuel Smith, 1691), p. 124.
[59] Willis stated that he was able to 'stand on the authority of one *Gassendus*' in this matter, but also cited other figures such as Faber and Hogelande, *Soul of Brutes,* p. 5.

Without being conclusive either way, he noted that all authorities 'shook hands' on the principle that the corporeal soul was either a flame or at least something analogical to it: 'its Act or Substance is either a Flame or a Breath, neer-to, or a-Kin to Flame' (SB, p.5). He further attempted to clarify that it was only similar to a domestic flame in the specific respect that it was similarly *fed* by the nitrous particles derived from the air, reacting with sulphurous particles in the blood. The chemical nitre definition did not displace the (still effective) image of the vital spirit as flame, so much as it worked to clarify the analogous (rather than metaphorical) nature of the relationship: the blood and fire are both 'fed' by nitre, in which sense they share a structural relationship, but they retained important differences. Here, Willis's vital materialism intersected with his chemical principles: if natural fire and the vital heat were both instances of sulphur 'fed' by nitre, then what exactly was it that separated them? The idea that these spirits (unlike other substances) possessed vital, active powers or a 'life-force' that went beyond what could be explained by their physical or chemical properties alone was one such way to address this. The vital spirits bestowed life where fire destroyed.

However, the problem of how the flame could be both like and different to a domestic (destructive) flame remained. Willis continued to grapple with and blur the boundaries between metaphor and analogy here. He stated that he had rejected the ancients 'dictated' notion that the soul be 'actual fire or flame,' and instead redefined the flame as 'a heap of most subtil Contiguous particles, and existing in a swift motion,' fed by sulphur and 'some other nitrous thing in the Air.' In the same work he later stated that the vital soul 'is not so like to flame, but even a flame it self' (SB, p. 33-7). Ultimately, Willis could not have conclusively resolved these issues, but he did look to draw on another analogy to expand and upon his position. He noted that the chemist's own use of fire could be seen as productive rather than destructive: it dissolved all natural bodies into their constituent parts and thereby revealed the basic components of 'life.' It represented a process of revealing hidden qualities and 'opening up' material bodies, like anatomy. This reconstituted new bodies out of compound states, rather than destroying matter. As he noted, the vital flame was not like a 'common flame', but 'silently burns with a gentle and friendly heat, like a Fire shut up in a *Balneo Marie* […] and as so destroys not the Blood, but inkindling the Liquor,' it gives life to the organism (SB, p.22). The vital flame is 'friendly' and 'gentle' - a generative catalyst. It evokes the flame of the alembic and thus the practices used by the alchemist to 'produce' spirits as things that

existed in the world - just as the flame 'procreated' the animal spirits from the matter of the blood. He described the body (specifically, the hearts left ventricle) in this context as a 'fireplace' – a cradle of life. The flame analogy was also deeply entangled in the wider model Willis promoted in his writing. It helped to make sense, for example, of the relations between the spirits of the blood and those of the nerves – the latter being cast as a 'beamy' radiation emitted from the vital flame in the blood. The flame's propensity to change its shape and fluctuate in that familiar, lively dance also provided a useful and compelling visual schema for the 'flames' of the passions, illustrating the physical alterations imposed upon the soul when afflicted by the 'winds' of the passions. It is an image that remained useful and effective, even when set against the demands of the new chemical learning.

A 'Knowing Power'

Whilst the vital spirits were the basis of organic life, it was the animal spirits of the sensitive soul, which properly enacted the complex tasks of animal government (SB, p.6). As Willis acknowledged, the vital portion of the soul was 'scarce sensible or knowing' (SB, p.55). Even Gassendi had 'pass'd over' how 'the flame […] however framed with the most excellent artifice […] can be able to produce the Acts of the animal Faculty' (SB, p.4). These powers – if they were to be assigned to the corporeal soul itself - necessitated the animal spirits' capacity to *act*.[60] As Willis concluded, it is plain that the sensitive soul performs its tasks 'beyond the Virtue or force of any other machine, and to perform by its own proper Virtue or strength' (SB, p.32). Willis therefore argued against what he termed the 'vulgar' opinion that matter is 'merely passive' noting that, 'on the contrary, Atoms, which are the matter of sublunary things, are so very active and self-moving, that they never stay long […] they cut forth for themselves Pores and Passages, into which they are Expatiated' (SB, p.33).[61] Using striking imagery here, Willis proposes that the spirits had the power to actively 'cut' and carve out their own tracts in the soft tissue of the brain. This somewhat undermined (or at least sat in tension with) the

[60] Thomson, p. 82; Clericuzio, *Elements, Principles and Corpuscles: A Study of Atomism and Chemistry in the Seventeenth Century* (London: Kluwer Academic Publishers, 2000), p. 100.

[61] On the agency granted to the animal spirits as part of the vitalism characterising English corpuscular theories see: Thomson, pp. 80-82. On Willis's views on active matter see: Charles T. Wolfe, *Materialism: a Historico-philosophical Introduction* (Switzerland: Springer, 2016), p. 53; Kathryn Tabb, 'Struck, As it Were, With Madness: Phenomenology and Animal Spirits in the Neuropathology of Thomas Willis' in *Brain, Mind and Consciousness in the History of Neuroscience,* ed. by C.U.M. Smith and Harry Whitaker, vol. 6 of the series History, Philosophy and Theory of the Life Sciences (Dordrecht: Springer, 2014), pp. 43-57.

anatomical provisions and safeguards in the brain that he had so carefully set out previously. The brain is more of a *tabula rasa* for the spirits' own activities, than a set of architectural confines.

Both Willis and Gassendi invoked a form of personified language to emphasise the spirits' self-moving powers; Gassendi noted the spirits' 'capacity to take hold of each other, to attach themselves to each other, to join together.'[62] Moreover, in executing their roles, the animal spirits were thought to display a notable agency: when faced with an object, the spirits could in effect choose how to respond based on their ability to apprehend natural objects and form (non-rational) responses.[63] These spirits were not only chemically active, but approached powers of sensible perception, a form of natural or 'sensitive reason' that guided them to make beneficial choices. Willis argued that the sensitive (rather than vital) part of the soul picks and 'choose[s] Acts' from a 'Council, or a certain Deliberation.' This soul, 'being so gifted naturally […] is knowing and Active, concerning some things necessary for it' (SB, p.32). Mechanical explanations were inadequate, he held, when looking to express how the soul 'perceives itself to feel, and is driven according to that perception into divers Passions and Actions' (SB, p.34). Organised in a certain way, these spirits amounted to a material system of 'thought'.[64] This power was required to belong to the corporeal soul alone in order to allow it to respond to sensory objects without the need for a direct and continuous involvement of the rational soul; such oversight would require the rational soul to be divisible and therefore finite (SB, p.32).[65]

These complex ideas were importantly bound up in Willis's use of language and imagery around the spirits. A key theme here was the use of a personification and anthropomorphic metaphors. [66] When talking about the sensitive soul, for instance, he

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[62] This language is reminiscent of Willis's earlier descriptions of spirits 'recoupling' and 'divorcing', as discussed in chapter two of this thesis, p. 25.
[63] Wright, 'Locke, Willis and the Epicurean Soul,' p. 246.
[64] As Wright has noted, Willis followed Gassendi here in ascribing life to atoms structured in a particular way, p. 246.
[65] Hawkins notes that the autonomy of these spirits in responding to localized needs in the body harks back to Helmont's notion of the *archaei,* implanted in specific organs and tasked with different roles: Hawkins, *Empire,* p. 36. See chapter four of this thesis for Willis's explanation of the autonomic nervous response.
[66] Kathryn Tabb has convincingly explored the use of anthropomorphic metaphors by Willis and argues that this works against the mechanistic reductionism often attributed to Willis: 'Struck, as it were, with Madness', (2014). On the agency granted to the animal spirits as part of the vitalism characterising English corpuscular theories see: Thomson, pp. 80-82.

describes *her* 'flying away from some approaching evil […] she retires inwardly, and leaving her watch, hides her head' (SB, p.32). In another example, he describes the spirits placed within in the organs of sense as being like 'Watchmen,' furnished with a 'peculiar Provision, and an appropriate manner or Disposition' appropriate to their assigned roles (SB, p.57). The spirits here embody human roles, complete with dispositions and manners peculiar to them – and even desires. In the passion of desire, the spirits are 'as it were naked and destitute of all helps, like Beggars ask an Alms, which they most greedily desire' (SB, p.52). The spirits were also made to embody specific pathological states: as Willis noted, madness 'begins' with the spirits, which acquire, in themselves, the 'disposition' of madness becoming 'furious' or 'depressed' (SB, p.202-3). [67] The characteristics of the melancholic similarly derived from the 'opaque, 'gloomy' and 'stygian' nature of the animal spirits themselves (SB*,* p.188).[68] Here, the stygian analogy refers here to the Greek mythology of the River Styx – a dark infernal blackness.[69] Spirits could further be induced into madness by a chemical imbalance of the blood, also described as a stygian water: this water 'as it were possess[ed] with a certain madness, the Spirits therein flowing, and implanted.'[70] These descriptions were used to make the spirits convey certain (disordered) states of mind; they become a proxy, narrative embodiment of the mental states experienced by the patient. It is not the patient who rages, but their spirits. As Willis noted in his *Pathology of the Brain,* the spirits were the 'immediate subject of […] Disease' (PB*,* p.15). These linguistic tools helped to underline Willis's broader proposition that, far from being inert bodies, the animal spirits were in fact the immediate and vital agents of the corporeal soul.

Willis illustrated his idea that the sensitive soul could produce effects beyond the 'art' imitated by mechanical devices through an analogy with the musical organ. The organ was, he noted, capable of producing complex musical harmonies by 'the labour of him playing on it,' yet he had also seen such harmonies reproduced by 'the mere course of Water' in a 'self-moving water organ' (SB, p.34). The key distinction here was that the water organ could only produce a determined set of melodies; in contrast, the corporeal

[67] On the use of this language see: Tabb*, Struck with Madness*, (2014).
[68] Hawkins, *Empire,* pp. 45-6.
[69] From the Latin *Stygius,* referring to a dark underworld, derived originally from the Greek myth of the River Styx: "Stygian, adj. and n." *OED Online*. Oxford University Press, December 2016. Web. 12 March 2017.
[70] Willis, 'Pathology of the brain and nervous stock: on convulsive diseases,' in *The Remaining Medical Works of Dr Thomas Willis,* translated by Samuel Pordage (London: Printed for T. Dring, 1681), p. 10.

soul had the power to vary its 'tune' by disposing the spirits into any order or arrangement. In humans, 'their souls […] ought to be attributed a certain faculty of varying their Types, and of composing them in themselves' (SB, p.34). The soul 'institutes' a great 'many series of Actions,' as are 'necessary for itself' (SB, p.34). In other words, the capacity of the corporeal soul to adopt and hold the manifold figures and forms of any sensory object, or an impression sent from the rational soul, required the ability to vary and re-formulate its spirits into new series and orders – to change their shape, like a flame or fluid. The sensitive soul possessed the capacity of the musician-composer to *vary* the tune

These notions were also notably represented in Willis's ideas around the transmission of nervous impressions. Upon receiving an impression (external or internal) the spirits, stationed like soldiers in the body, as in a 'watchtower', were immediately 'ordered into various special groups and formations.'[71] Willis compared these variable formations to something akin to a bodily gesture, an act of communication. As he continued, 'the faculties of the same Soul depend upon the various *Metathesis* and gesticulation of those spirits' (*varia metathesis and gesticulatione dependent*). This was an act of communication between the inferior and the superior soul: 'she [the soul] induces according to the various impulse of the Objects, various Gestures and Species in herself ' (SB, p.56). Metathesis, a Greek word later translated into the Latin for 'transposition,' was a quite technical term referring to the reordering of sounds, syllables, letters which could amount to a shift in sense or meaning. In 1633, for example, Thomas Adams had noted that 'idle misplacings' of meaning, 'like Anagrammes' were a 'transposition of letters […] the beginning is where the end should be.'[72] In 1673, Richard Allestree reflected on how a 'little transposition may quite alter the case.'[73] The re-ordering of spirits is comparable here to the construction and re-construction of a sentence.[74] By re-arranging their configurations, order or disposition they were able to represent new ideas or forms; just as words, transposed in a sentence or speech, effect new and different meanings. Significantly, the analogy reflected Willis's view that nervous impressions were in some aspects akin to an act of communication.

[71] Wallace, 'The Vibrating Nerve Impulse,' p. 80.
[72] Thomas Adams, *A commentary or, exposition upon the divine second epistle general* (London: 1633), p. 1632.
[73] Henry Ainsworth, *The Art of Logick* (London; 1657), p. 77.
[74] Wallace, p. 79.

The reordering of words in a sentence is also comparable to the way in which re-organising one's limbs creates a new kind of physical gesture. To gesture comes from the medieval Latin *gestra,* or *gerre,* meaning to carry.[75] It could refer to one's physical posture or deportment, or an arrangement of the limbs intended to (externally) signify some interior affection – as in an act of worship. It was often the involuntary expression of a violent affection of the soul – a physical signification of interior passions. It was, above all, a communicative act linked to the art of speech. Bacon had considered gesture in relation to the art of speech, as a means by which oratory is enhanced or emphasized. It could also be used in place of verbal speech, such as when nations 'of different Language […] serve their turne, by Gestures.'[76] It was an act that, metaphorically, 'speaks to the eye.'[77] Bacon further noted that gestures had 'some similitude with the thing signified, and are kind of Emblemes'.[78] This echoes the sense in which Willis used gesture here to denote the soul's ability to (physically) signify a certain image of the thing felt, a figure or representation of the object. As the body uses physical gesture to communicate, so the soul analogously performs 'gestures' to communicate with (or make representations to) the judgement and intellect. Gestures were also essentially transient; like the fluidity of the soul, or its fluctuating flame, a gesture reflected the soul's state of being 'un-fixed' and actively changeable. For Willis, it was a means of expressing the soul's fluid form when subjected to an affection: in desire or aversion, for instance, Willis examined after 'what manner or ways of Gesticulations or Gestures, she [was] composed in either Affection' (SB, p.52).[79] In Willis's account of nerve transmission, his use of gesture in partnership with *metathesis* supports a dynamic model of communicative acts by the corporeal soul - more akin to a language than a purely mechanical action.[80] Used together in this way, these analogies – drawing on linguistic structure and bodily gesture - spoke to an embodied form of signification, wherein the spirits are moved around like words or limbs to represent variable meanings.

The nerve 'impulse' had, of course, also been described by Willis as a form of particulate wave mechanism of propagation and diffusion and compared to the physical vibration

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[75] "gesture, n." *OED Online.* Oxford University Press, September 2016. Web. 18 November 2016.
[76] Francis Bacon, 'The Knowledge concerning the organ of speech […] also called Grammer,' *The Advancement of Learning* (1640), in *Francis Bacon: The Major Works,* ed. by Brian Vickers (Oxford: Oxford University Press, 1996), Book 6, p. 258.
[77] Bacon, *Advancement,* p. 182.
[78] *Ibid,* p. 259.
[79] In *De anima brutorum,* the Latin for this is '*animae componere gestus,'* p. 155.
[80] Wallace points to the 'semantic terms' used by Willis here as an indication of the linguistic nature of the analogy, p. 79.

caused when the strings of a harp are plucked (SB, p.61). These explanations are not necessarily in conflict with the analogies of gesture and (linguistic) transposition. There remained an undisputed physical element to the performance of these 'impressions' or 'gestures', but this could not on its own fully express the nature of the event. The 'vibrations' of the spirits in the nerves were not uniform or routine; as with the musical tune, the soul needed to be able to reconfigure itself based upon its own needs (and perceptions of need) – this went beyond what vibration *alone* could express.[81] Fluid waves, light beams, and the camera analogy all picked up on the same idea being considered here: that the spirits could actively and dynamically carry the form of their objects and that they could vary these formations accordingly to communicate clearly and reliably with the soul, without the immediate direction of the rational soul or by the application of some mechanical force. In the previous chapter, I touched upon this argument as it was used by Willis to explain the providential design of the cerebrum's random and convoluted spaces – suggesting that these spaces, being irregular, would not confer deterministic patterns of motion onto the spirits. In the above passage, the emphasis has been shifted to the spirits themselves: how they conducted themselves within these 'free' (non-determined) spaces of the brain. It asks what directs them and by what power they perform their tasks. For Willis, the mechanical philosophy did not have an answer to these questions.

A Protean Soul

The active, self-moving attributes of the spirits expressed, on the one hand, their capacity to perform the complex actions of the animal faculties; on the other, it suggested that the faculties were entirely vulnerable to the passion states which afflicted this inherently moveable soul. As Willis had noted in his *Anatomy*, the brain kept a plentiful store of the spirits within the orbicular prominence, which it constantly replenished with its 'fountain'; this essentially produced a concentrated mass of highly volatile, easily disturbed spirits in the seat of the faculties, leaving humans exceptionally vulnerable to the effects of the passions.[82] Early modern passions were a hugely important, multi-faceted concept that united natural philosophical, medical, religious and moral accounts

[81] Wallace argues that these waves were not 'stereotyped' or 'uniform' in Willis, p. 79.
[82] As Michael Hawkins has argued, Willis's physiological model of the passions marked humans out as the most vulnerable of all creatures: 'A Great and Difficult Thing': Understanding and Explaining the Human Machine in Restoration England,' in *Bodies/Machines,* ed. by Iwan Rhys Morus (Oxford: Berg, 2002), p. 21.

of human behaviour and experience.[83] A passion described an unnaturally vehement affective state – a movement or change - imparted upon the soul. [84] An affective state only became a passion, in the sense of a pathological state, when the motions of the spirits became unnaturally vehement or immoderate. All of the 'vehement' (and therefore pathological) affections belonged to the corporeal soul, seated in the brain. If the spirits were 'quiet' then the body functioned along expected lines; if their motions were violent, then the faculties could be unseated, or else grow 'deaf' to the rational soul (SB*,* p.45).[85] This occurred when the animal spirits received an especially forceful impression of an object promising good or evil, or else received an impression of internal fault or corruption from within the body (e.g. from chemical imbalance), which was then transmitted to the phantasy in the brain.

The passions – as disordered physiologies of the spirits - involved both the mind and body in the resultant 'discordant motions' of the soul. As Willis illustrated, through a naturalistic analogy, just as a violent blast shook both the tree and its leaves, so the passions affected the body and mind in substantial ways (SB*,* p.56). The animal faculties were especially liable to disarray as they relied upon arranging the spirits into specific 'orders' and 'series'; if this process was thrown into disorder, then the rational soul would receive corrupted and false ideas from the imagination. Willis describes how the impressions (of good or evil) disturbed the 'beamy' radiation of the animal spirits and, by 'undulations or waverings brought to it', fanned the vital flame in the blood creating 'irregularities' and 'inequalities,' like the blasts of wind acting on water (SB, p.32). The flame was 'in danger to be always blown out,' by sudden joy or suffocated by sadness (SB, p.31). In extreme cases, passions could be fatal: the animal faculties so seriously 'perverted' that the vital functions, over which they governed, would be left to decay until 'by degrees is abolished' (PB, p.13). Increasingly, the passions were explained via chemical-corpuscular categories, rather than by reference to traditional notions of the four humors, or as the outcome of purely spiritual or moral failings – though aspects of

[83] On the nebulous boundaries between physiological, religious and political concerns reflected in theories of the passions, see: Harold Cook, 'Body and Passions: Materialism and the Early Modern State', *Osiris*, 17 (2002), pp. 25-48; Peter Dear, 'A Mechanical Microcosm: Bodily Passions, Good Manners, and Cartesian Mechanism', in *Science Incarnate: Historical Embodiments of Natural Knowledge,* ed. by C. Lawrence and S. Shapin (Chicago: 1998), pp. 51-82; Hawkins, *Empire,* p. 9.

[84] On the passions as a distinctly early modern category of knowledge see: Thomas Dixon, *From Passions to Emotions: the Creation of a Secular Psychological Category* (Cambridge: Cambridge University Press, 2003); Susan James, *Passion and Action,* (1997).

[85] For a useful summary on this model see: Kassler, p. 148.

humoral pathology continued to be interwoven within these accounts.[86] The passions were not, however, necessarily harmful or pathological; the drive to seek out food was helpful, for example (SB, p.53).

One of the most vivid images employed by Willis in his treatment of the passions was that of a 'protean' soul:

> Truly the Sensitive Soul, like a *Proteus,* is wont to be so diversly disturbed and altered, into manifold Kinds, with the various Fluctuation, and divers sorts of Inclination of the Animal Spirits, Blood and other Humors, that a cense or view of all the Passions, can scarce be had. (SB, p.49)

Illustrating the inherent instability within the animal oeconomy, Willis evokes an image of a fluid tempest. In Greek mythology the proteus was a sea-god, which, like the passions of the soul, eluded attempts to define it by its propensity to constantly change its shape. The proteus provided a useful motif here for Willis's chemico-corpuscular understanding of the passions and his rejection of scholastic approaches. The passions were to be understood, he argued, by knowledge of the underlying physiological behaviours of the spirits (rather than by external effects), and of the chemical conditions that altered the various states of the spirits (as either fixed, active or volatile). In contrast, scholastic models had organised the passions into eleven types, arranged under two headings: the Concupiscible, which has six passions – pleasure and grief, desire and aversion, love and hatred; and the Irascible, which has five passions – anger, boldness, fear, hope, and desperation (SB, p.49). Willis noted that the list overlooked many notable passions, such as shame and pity. Moreover, as he had illustrated through the proteus, such a complete view of all the passions could 'scarce' be had under these circumstances. Instead, he plotted the passions along a continuum between two states of spirituous activity (quiet or active), along which an infinite number of variations could be plotted. As the proteus analogy suggested, the varied passions were united only by their common (corpusuclar) mechanism. The proteus was therefore a vivid articulation of the principle

[86] In medical practice more generally, the influence of humoral pathology and Galenic therapeutics persisted late into the seventeenth century. Hawkins notes that even anti-scholastic physicians continued to employ the qualitative language of humoral pathology, *Empire,* p. 45. See also Dewhurst, 'Willis in Oxford: some new MSS,' *Proceedings of the Royal Society of Medicine,* (April, 1964), pp. 26-31 (p. 27); Stephen L. Sigal, 'Fever Theory in the Seventeenth Century: Building Toward a Comprehensive Physiology,' *The Yale Journal of Biology and Medicine,* 51 (1978), pp. 571-582 (p. 577).

that the passions were not discrete or bounded 'things'; each passion was a disturbance or change in the hypostasis of the soul. All the passions were characterised as the soul becoming 'unequal, and as it were not Comfortable to the Body' by being either enlarged or reduced to a varying degree (*SB,* p.45).[87] The passions reflected this fluidity; an ever-changing balance of spirits, chemicals and humors in the blood or nervous juice.

Willis was not the first to use the proteus as an image to represent a physiological model of the mind. Robert Burton, in his *Anatomy of Melancholy* (1621), had also used the image to convey his notion that the phantasy was easily thrown into a swirling chaos, which made its ideas unreliable and uncertain: 'so diversly doth this phantasie of ours affect, turne & winde, so imperiously command our bodies, which as another Proteus or a Camelion can take all shapes (though for Burton the phantasy did not represent the 'knowing part' of the corporeal soul, as Willis suggested).[88] This imagery also harked back to older, humoral notions of fluid bodies – which had by no means been entirely displaced in this period. In 1650, for example, Thomas Vaughan used the proteus to signify the inconstant and variable nature of humoral bodies, subject to fluctuating passions, when he wrote 'This is it makes the Soul subject to so many Passions, to such a Proteus of humors.'[89] Notably, in alchemical traditions the proteus was a name given to the volatile spirit known as *Mercurius* or *Hermes*, the *prima materia* or first matter (sometimes represented as the sea). In order to create the philosopher's stone – a universal cure - the alchemist was required to first capture Mercurius and tame him. This was a trope also utilised in literature. In *Paradise Lost* (1667), John Milton wrote that the alchemists, 'by their powerful art they bind/Volatile Hermes, and call up unbound/In various shapes old Proteus from the sea,/Drained through a limbeck to his native form' (3.602-5).[90] Here we see how the image of the proteus connects up with Willis's concepts around the spirits as chemical corpuscular bodies; in the last line of Milton's poem, he describes the proteus being chemically distilled (through the 'limbeck') into his 'native' form – that is into spirits, as the basic components of matter.

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[87] Willis acknowledges this schema as an amendment of the Aristotle's 'forked measure' of the sensitive appetite, *Soul of Brutes,* p. 48.
[88] Robert Burton, *The Anatomy of Melancholy* (Oxford: Printed by John Lichfield and James Short, for Henry Cripps, 1621), p. 110.
[89] Thomas Vaughan, *Anthroposophia Theomagica; or a discourse of the nature of man and his state after death* (London, 1650), p. 46.
[90] John Milton, *Paradise Lost* (1667) in *The Norton Anthology of English Literature,* ed. by M. H. Abrams and Stephen Greenblatt, 7th edn, vol I. (London: W. W. Norton & Co., 2000).

The proteus figure also drew on more traditional tropes of the passions as natural tempests, conveyed through images of storms, floods, and thunderous explosions.[91] The passions of the corporeal soul, for instance, raged underneath the seat of the rational soul, like 'clouds and thunder gathered beneath the feet of Olympus.' The soul was either a 'calm Sea' or a body of 'water shaken into various Circles' by the blasts of winds in a storm (SB, p.45). These illustrations were a common means of conveying the disruptive power of the passions. In 1630, Thomas Wright, for instance, wrote that 'we may compare the Soule without Passions, to a calme Sea, with sweete, pleasant and crispling streames; but the Passionate, to the raging Gulfe, swelling with waves, surging by tempests, minacing the stony rockes, and endevouring to overthrowe Mountaines.'[92] These images spoke to pervasive fears around bodies long subjected to the fluctuating imbalances of the humors.[93]

These themes also relate to contemporaneous research around the pneumatic qualities of the air. It was during this time that Boyle was researching the chemical composition of particles in the air (namely, ariel nitre), conducting public experiments to demonstrate its 'elastic' force with his new mechanical vacuum pump.[94] In *Soul of Brutes,* Willis drew upon these ideas when he remarked that both the nitrous particles of the air and animal spirits are calm when free and 'unmixed,' but have an explosive potential when shut up in the muscles, just as air shut up in clouds might produce a hurricane or thunder (SB, p. 24). Natural storms were an effective and vivid way of representing the amplifications in the force of the spirits, which were (together) capable of producing effects far larger than their individual size suggested – just as particles in the air. These analogies were also a means of establishing the violent force of the passions; something which occurred beyond the powers of blasts made by manmade machines. Ultimately, the proteus highlighted the futility of the ordering imperatives of the brain-cabinet – its movements

[91] Willis himself had drawn heavily on these associations in his *Anatomy*, where he uses images of the blood cast into 'whirlpools' or breaking the 'banks' of the brain's flood defenses, p. 49. As Jaime Kassler has argued, in Willis, the passions created 'cerebral storms' which inferred disordered mental states onto the patient, p. 157.
[92] Thomas Wright, *The Passions of the Minde in generall* (London, 1630), p. 59.
[93] On early modern anxieties around fluid, humoral bodies and the 'wriggle work' of the animal spirits, see: John Sutton, 'Spongy Brains and Material Memories', in *Embodiment and Environment in Early Modern England,* ed. by M. Floyd-Wilson and G. Sullivan (London: Palgrave, 2007), pp. 14-34; Gail K. Paster, Katherine Rowe and Mary Floyd-Wilson, eds., *Reading the Early Modern Passions: Essays in the Cultural History of Emotion* (Philadelphia: University of Pennsylvania Press, 2004).
[94] On Boyle's Oxford experiments with the 'pneumatic engine' see: W. Bray, ed., *The Diary and Correspondence of John Evelyn,* 3 vols (London: 1852), III, p. 255; Frank, (1980), p. 52.

could be managed by the physician (like the chemist-vintner attending to ferments), but never controlled.

One of the most notable aspects of the above passage was the tension created by placing the soul within a body 'cabinet' – to which the 'proteus' soul was meant to be both adequately 'fitted' and to also water 'gently.' Willis described how,

> The whole Corporeal Soul, so long as she is quiet and undisturbed, she is fitted to her proper Body equally, as to a certain Chest or Cabbinet, and waters all its Parts gently, both with little Rivulets of Blood Circulating, and actuates and inspires them every where with a gentle falling down of the Animal Spirits. (SB, p.45)

Opening his chapter on the passions with this image, Willis drew upon the tension implied by a fluid juxtaposed against the spatial order suggested by the cabinet's role to underline how the passions were, fundamentally, a physiological disordering of the arrangement of the spirits. A passion state, according to this description, involved two primary changes to the soul: it would move from a state of being 'quiet' to one of disturbance or 'raging' and, as a result of this, would no longer 'fit' equally to the body cabinet. This inverts a previous analogy, where the soul (under normative conditions) was said to bear a close relationship to the form of the body as its 'shadowy hag,' fitted as it were to a 'sheath.' All the major passion states were perversions, of one kind or another, of the spirits movements within the brain and nerves. The proteus, as a being defined by its un-fixed form, neatly encapsulated this position. Here, the blunt forces observable in nature are set against the intricacies of brain structure, detailed in his anatomical work: what use are cabinets, cloisters and cells when trying to contain a proteus soul or defend against a raging flood? The brain may have displayed an incomparable artifice, but this was as nothing when considered against the effects of the passions.

The cabinet as an analogy for the bodily-container of the soul was an immensely rich and well-established trope, but it was quite unusual, however, to find it coupled with a fluid soul in a physiological setting. Wider examples of the trope cast the soul as a precious jewel placed for safekeeping within the body-cabinet. In a sermon from 1668, Thomas Vincent remarked that 'whilest the soul doth abide in it, the body is the inferior part, the

body is but the Cabinet, the soul is the jewel."[95] John Donne likewise, in his *Sermons* (1631), commented that the soul was placed like 'the best jewell in the best Cabinet' – the brain being the most elaborate and highest placed organ of the body. In these examples, the cabinet-jewel pairing conveys the hierarchy between flesh and spirit, the body reduced to a mere, if elaborate, container. Originally a room containing private collections, or a room in a museum, the cabinet came to represent an elaborate piece of furniture designed for the safekeeping for high value objects.[96] In the original Latin edition, Willis used *thecæ* which could refer to a reliquary – a cabinet or chest were religious relics might have been stored; this complemented the notion of the brain as the seat of the corporeal soul and 'throne' of its pure spirit, the rational soul. In the late fourth century, for instance, St John Chrysostom (347-407) urged the faithful to kiss a theca containing saintly relics.[97] Coupled with the Latin *capsulæ* (used in the plural) this conveyed the sense of the brain as a container for a precious object that also possessed a number of discrete compartments or capsules – key features of Willis's vision of cerebral-anatomy. The image also fed into the tradition of the 'cabinet of curiosity' - a prominent object in the material culture of the university based, humanist natural philosophy in the sixteenth and seventeenth centuries.[98] In 1665 Robert Hooke, writing about nature's storage of plant seeds, noted 'in what delicate, strong and most convenient Cabinets she lays them.'[99] The cabinet, in this sense, also functioned as an anatomical metaphor of knowledge. As Henry Oldenburg wrote, 'by Anatomy we have sometimes enter'd into the Chambers and Cabinets of Animal Functions.'[100] This underlined Willis's claims about the uses of anatomy for revealing the secret hiding places of the soul and were especially pertinent to his arguments about the localisation of the soul, secreted away in bounded spaces, draws and compartments.

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[95] Thomas Vincent, *The wells of salvation opened, or, Words whereby we may be saved* (London: printed for Thomas Pankhurst, 1668), p. 50.

[96] "cabinet, n." *OED Online.* (Oxford University Press, December 2015). Web. 26 January 2016.

[97] John Crook, *English Medieval Shrines* (Woodbridge: Boydell Press, 2011), p. 13.

[98] On early modern cabinets, see: Oliver Impey and Arthur MacGregor, eds., *The Origins of Museums: The Cabinet of Curiosities in Sixteenth- and Seventeenth century Europe* (Oxford: Clarendon Press, 1985; 2nd edn., 2001); Ken Arnold, *Cabinets for the curious: looking back at early English museums* (Aldershot: Ashgate, 2006); Helmar Schramm et al., eds., *Collection, Laboratory, Theater: Scenes of Knowledge in the 17th Century* (Berlin: Walter de Gruyter & Co. KG., 2005).

[99] Robert Hooke, 'Observation XXIX,' *Micrographia* (London: 1665), p. 90.

[100] Henry Oldenberg, *Philosophical Transactions of the Royal Society,* 2 (London, 1667), p. 411. Walter Charleton also wrote that he had employed 'all my collections, Observations, and Speculations Philosophicall, only to the furnishing the little Cabinet of my own brain,' *The Immortality of the Human Soul* (London, 1657), p. 11.

While it is possible that Willis's contemporary reader could have been able to draw out these rich and manifold cultural associations from his use of the cabinet, it is not possible to attribute them all at once to the analogy. When situated in the context of this specific chapter, dealing with the pathological passions, the cabinet analogy does something quite specific. As I have explored in relation to the proetus image, a fluid soul placed within the cabinet inverted traditional images of the soul as precious jewel, to a specifically physiological end. It jars when we try to imagine a fluid entity being contained in this manner, let alone to conceive of it consistently obeying the organisational possibilities of the cabinet, within its draws and shelves; as might also be the case in relation to cells, chambers and cloisters. Willis had elsewhere described the brain as a 'castle' or 'citadel', complete with ramparts and defensive flood-gates and these were, like the cabinet, also images of the brain as a containing place for the soul. However, the focus here was on the brain's external defences; how it protected, rather than organised or arranged the soul within it. The cabinet re-draws the reader's focus onto the (far more vulnerable) internal space of the brain. Though the brain could marshal a defence against the "enemy at the gate" (keeping out 'morbifick' matter in the blood), it faced a different order of threat from within its own walls – in the store of volatile spirits stockpiled there. Even when the flood defences held, the spirits were liable to being disrupted by any forceful sensory impression delivered to them. A cabinet – awkwardly awash with the proteus-soul – encapsulates this problem far more vividly: the external defences displayed in the brain-castle could not negate the threat contained within.

Passionate times

While Willis's account of the corporeal soul was primarily built around a set of naturalistic explanations (incorporating themes around vital and active matter), the metaphors and images he employed in this account also reflected aspects of the specific socio-political setting in which he was writing and his own religious commitments. Robert Martensen and Michael Hawkins in particular have examined Willis's work with a focus on the context of the civil war (Hawkins) and the religious politics of Restoration England and Willis's Anglicanism (Martensen). I do not look to substantially revisit these discussions here, but it is nevertheless important to recognise how the metaphors Willis chose to employ also necessarily relate to these broader contexts.

It is important not to conflate, in any straightforward way, Willis's acknowledged devoutness and commitment to the established Anglican Church with the motivations and outcomes of his natural philosophical arguments. Martensen has, for instance, described Willis as having produced an Anglican anatomy, marshalling the evidence of his experimental practices to support orthodox liturgical practices within the church.[101] Whilst the 'light' of natural reason, expressed through the learning of experimental philosophy, was undoubtedly being utilised by philosophers in attacking the mystical claims of certain nonconformist groups, in choosing to write about the soul within (rather than in contrivance of) a broadly Anglican framework Willis did not necessarily construct a natural philosophical argument in order to support the political and social cause of the established church. We should be cautious not to reduce Willis's complex ideas and practices (anatomical, chemical, physiological) to derivatives of his religious orthodoxy. However, as I've mentioned, there were elements of his discourse that certainly could have been perceived (by the contemporary reader) as supporting the position of Anglican church in relation to contemporary forms of religious non-conformism in this period.[102] Specifically, in forwarding medical explanations for the 'natural causes' of radical evangelism (e.g. melancholy or frenzy) Willis's account – among others – undercut the legitimacy of alternative spiritual claims of illumination.

An important context here was Willis's direct, first hand experiences of the English Civil War.[103] While fighting for the Royalist cause, he would have witnessed the devastating impact of – what would have been understood as – symptoms of unrestrained passion on the correct model of social order and governance. Willis evoked the spectre of civil war and societal conflict when he characterised the relationship between the two souls in the body as one of continuous conflict - an 'intestine strife' that caused the two souls to

[101] Robert Martensen has argued that Willis's naturalistic explanations of the passions supported the established church by providing a context in which unorthodox religious experiences could be explained through new physiological learning: "Habit of Reason': Anatomy and Anglicanism in Restoration England,' *Bulletin of the History of Medicine,* xvi (1992), pp. 511-535.

[102] Following the Act of Uniformity in 1662, which required clergy to follow all rites and ceremonies as set out in the Book of Common Prayer, a Nonconformist could be defined as any subject who followed a non-Anglician or non-Christian religion. This included Puritans, Evangelists, Calvinists, Baptists, Presbyterians, Methodists and Quakers. The restored Anglican Church thus positioned itself as the 'true church' (the Bride of Christ in England). Archbishop Gilbert Sheldon – Willis's patron – himself 'endorsed' legal action against Nonconformists during the mid-1670s. On this see: Elizabeth Clarke, *Politics, Religion and the Song of Songs in Seventeenth century England,* (Houndmills, Basingstoke, Hampshire: Palgrave Macmillan, 2011), p. 182.

[103] Hawkins has examined the influence of the civil war on Willis's theory of the passions: Hawkins, *Empire,* p. 17. On the civil war in Oxford, see: Ian Roy and Deitrich Reinhart, 'Oxford and the civil wars', in *The History of the University of Oxford,* ed. by N. Tyacke, iv (Oxford: Oxford University Press, 1997).

move against each other 'more than Civil Wars' (SB, p.38). Willis also depicted the corporeal soul as the metaphorical subject living under the rule of the rational soul, with the former 'growing weary of the yolk of the Other' and often looking to 'free it self from its Bonds, affecting a Licence or Dominion' (SB, p.43). The corporeal soul, possessing natural appetites and instincts that made it disposed to the attractions of the flesh, could not always be 'restrained' by reason and could defy the its rightful governance.

The socio-political imagery used here picks up on the much older metaphors of 'government' and 'oeconomy' used in representing the soul's relationship to the body-system in this period. Plato used 'government' as a metaphor to think on the nature of the soul in his *Republic*, which he imagined as a city-state governed by the 'philosopher king' (the rational part of the soul).[104] In this model, the king ruled over four lesser forms of government within the Republic, which broadly corresponded to human temperaments. Willis, as I explored in chapter four, had also represented the lower faculties of the sensitive soul (particularly the spirits of the cerebellum) as forming a regional arm of government or city province, operating under the sovereign rule of the rational soul (AB, p. 410). The 'animal oeconomy' was another important metaphor, frequently employed by Willis, which referred to the order and governance imposed by the faculties of the soul upon the workings of the body-system. As Willis notes in the preface to *Soul of Brutes,* the corporeal soul 'serves for the Vital oeconomy or government' (SB, 'Preface,' ii). Originally an Aristotelian metaphor, *oeconomy* was derived from the Greek word *oikos* meaning 'house' or 'household' to denote the proper guidance – or rules applying to the running of – a household or estate.[105] In the table of Greek and Latin terms provided for the reader in Samuel Pordage's 1681 edition of Willis's *Practice of Physick,* 'Oeconomie' is listed as referring to 'a certain order of doing anything, an household rule, regiment or governance.'[106] We could also think back here to Willis's metaphor of an 'emporium' or 'mart' inside the brain where animal spirits publically met in order to conduct their business: these metaphors represented systems for ordering and arranging the activities of its agents - be they citizens, members of a household, divisions of government – or animal spirits. A passion state was, in contrast,

[104] Plato, *The Republic,* introduction by Melissa Lane and translation by Desmond Lee (London: Penguin Classics, 2007).
[105] Xenophon, *Oeconomicus: A Social and Historical Commentary with a New English Translation,* ed. Sarah B. Pomeroy (Clarendon Press, 1995).
[106] Samuel Pordage, *The Practice of Physick* (London, 1681), p. 511.

a disruption to the proper application and order of this government or oeconomy, as it was overseen by the soul within the body.

These themes – of (reasoned) governance and order – were structuring concepts in models of the soul. Set against the political and societal turmoil of the time, such expressions gestured to an overlapping discourse which positioned health – both of the medically and social conceived body – as resting on the maintenance of a natural state of order and hierarchy between parts, organised around a model of sovereign rule. They are particularly pertinent to Willis's discussions of the animal spirit's capacity towards extreme volatility, characterised in places as a personified form of political disobedience, in their propensity to grow 'deaf' to and disregard the rule of their sovereign rational soul. Willis made vivid reference to humans being 'drawn several ways, by a double army' within themselves by the on going struggle between appetites of the flesh and the dictates of reason (SB, p.43). The passions afflicting the soul were at once medically and politically conceived phenomena, entangled by a shared language and core metaphors.

The imagery of social division and conflict within the animal oeconomy – between the instruments of government (the 'army' of animal spirits) and the government itself (the soul's rational faculties) – would have certainly echoed with themes of societal schism generated by disputes over the position of religious nonconformists in relation to the Anglican Church during the Interregnum and beyond the Restoration itself. Where models of household economy and political government had provided a metaphorical basis for thinking about the operations of the soul within the body, the body could now similarly offer up a model (of pathology) that would prove useful for those seeking to articulate, and ultimately dismiss, religious dissent against the established church and state.

Indeed, experimental philosophers were able to offer naturalistic, medicalised explanations for the dangerous religious passions that had incited such divisions, which could in turn be read as a rebuttal of the spiritual claims of nonconformist groups. Méric Casaubon, for example, was a French-English humanist scholar who resided in Oxford during the civil war. A figure sympathetic to the Royalist and Anglican causes, he caused some controversy in 1656 when he published his *Treatise Concerning Enthusiam*, in which he critiqued the displays of enthusiasm and claims of mystical illumination propagated by

radical nonconformist (a threat, as he saw it, to the classical text based learning of the humanist tradition).[107] Employing medically orientated interpretations, he cast the zeal of their orators as symptomatic of individuals moved to frenzy, who thereby opened themselves up to devilish possession. In a language similar to that which Willis's would use in his discussion of fermenting animal spirits, Casaubon noted that enthusiasm was a 'naturall fervency, or pregnancy of the soul, spirits of brain, producing strange effects, apt to be mistaken for supernaturall.'[108] These orators were, moreover, likely to move their audiences to frenzy, leading to societal conflict.[109] As he wrote: 'To commend [ecstatic rhetoric] to ordinary people…is to perswade them to madnesse; and to expose them to the illusions of the Devil.'[110]

Willis, himself a staunch Anglican and Royalist, later described the conditions that drove men from a proper allegiance to church and state as the product of delirium and madness.[111] His arguments around the capacity of a passion state to potentially corrupt or invert the mind's powers of perception, judgement and reason certainly offered a naturalistic framework wherein certain claims of religious experience and personal revelation could be cast as the effects of pathological conditions; as the ravings of the person suffering under a delusion.[112] If the rational soul were subject to an excessively powerful (metaphysical) passion, such as the love of god, it might temporarily abandon its oversight of the corporeal soul or even induce a passion in the animal spirits. All restraint would then be removed from the corporeal soul as the seat of our sensory perception and judgement. As Richard Allestree similarly claimed in his *Forty Sermons* (1684), when a passion 'lays restraint upon the superiour part of the Mind, [it] keeps the understanding in fetters [...] [and] takes off all ties from the inferiour. Gives not only

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[107] On Casaubon's proposal that experimental philosophers should 'purge' society of 'demonic tropes' see: Ryan Stark, *Rhetoric, Science and Magic in Seventeenth century England* (The Catholic University of America Press, 2009), p. 148.

[108] Méric Casaubon*, Treatise Concerning Enthusiasm*, ed. by Paul Korshin (Gainesville, Fla.: Scholar's Facsimiles and Reprints, 1970), p. 22. Michael Heyd, "*Be Sober and Reasonable": the Critique of Enthusiasm in the Seventeenth and Early Eighteenth Centuries* (New York: E.J. Brill, 1995), pp. 72-91. Heyd argues that Casaubon was suspicious of visions, prophecies and mystical experiences and therefore attempted to provide explanations from 'naturall causes' rather than spiritual experience, p. 75.

[109] Casaubon, *Treatise Concerning Enthusiasm*, p. 219. See also: Heyd, *Sober and Reasonable,* p. 72.

[110] Casaubon, *Treatise,* p. 286. For discussions on Casaubon's theological position, see: Stark, *Rhetoric, Science and Magic,* (2009), p. 153; Heyd, p. 77.

[111] On perceptions of the rise of atheism in England during this period and its treatment in the context of physiological theory see: Harold Cook, 'Body and Passions: Materialism and the Early Modern State', *Osiris*, 17 (2002), 25-48; Heyd, *Sober and Reasonable,* pp.195-8; Adrian Johns, 'The Physiology of Reading,' pp. 136-170.

[112] Hawkins has argued that religious nonconformity could be viewed as a pathological condition, aligned with contemporary notions of madness, *Empire,* pp. 192-3.

licence, but incitation to the other Passions to take their freest range, to act with the utmost impetuosity.'[113] With the potential for the 'knowing power' of the corporeal soul and the intellect to be mutually involved in the formers disturbance, those suffering a passion could be working upon false or corrupted ideas and, crucially, be unaware of it. As Joseph Glanvill remarked, 'We scarse see any thing now, but through our Passions."[114] These people were wrong, but also very sick; mislead by their own minds.

This stance was reflective of Willis's broader rejection of any clear distinction between the physician's role in care of body and soul: a frenzy aroused within the sensitive faculties of the mind stood to impart harm onto its incorporeal counterpart, the rational soul. Willis thus stated in 1668, that 'the health of the Soul should take its beginning from the restored health of the Body' (PB, Epistle). As he had argued, the corporeal soul was disposed to embroil the rational in its own 'sicknesses', as disturbed spirits in the brain could 'induce alterations' in both the body and the Rational soul (SB, p.45). Consequently, the need to maintain proper order and governance within the animal oeconomy stood both as an issue of medical and spiritual concern: were the physician to treat the fervent spirits of an epileptic, he also stood to potentially save the patients spiritual soul by keeping them open to right reason and true religion. The physician claims a role here in maintaining the interconnected spiritual and physical health of the patient, through manipulating the underlying causes of pathology in the body. It was, he argued, 'no new thing that there should be an Entrance into the Church thorow the Spittle' (PB, Epistle).

This would have consequences for how patients conducted themselves as members of the religious-political community: as Willis observed, the sick 'saying good-bye to their errors and disease at the same time, become not only healthy and wise men but more virtuous' (PB*,* Epistle). Though he did not explicitly employ the body-politic metaphor, Willis gestured to a relationship between the unrestrained passions acting upon the mind and corresponding socio-religious schisms.[115] As he observed, the delusions of the mad and the melancholic were a sickness of the brain that at the same time drove the sufferer away from a spiritual life and from the spiritual community at large:

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[113] Richard Allestree, *Forty sermons* (Oxford: 1684), vol. I, p. 346.
[114] Joseph Glanvill, *The Vanity of Dogmatizing: or Confidence in Opinions* (London, 1661), p. 119.
[115] Hawkins, *Empire*, p. 10. Heyd, *Sober and Reasonable,* pp. 195-8; Johns, 'The Physiology of Reading,' pp. 136-170.

> And truly, as the Stupid *Deliriums* of Melancholicks, the Caninish madness, and others sprung from an infirm Brain, have driven some, both from the Communion of Saints, and from the Society of men (PB*,* Epistle).

In 1668, he described the disease of the 'Epilepticks' as comparable to the symptoms of insane or delirious evangelists described in the gospels: 'These I say, and many other Sick men whom I here every where describe, seem not much to differ from those whom we read of in the Evangelists' (PB, Epistle). With humans so vulnerable to the effects of unrestrained passions, the physician's role was of the upmost significance – to the patient and the religious community at large. Where, in his earlier discussions, the body had offered Willis with an analogue for the chemist's laboratory, home to fermenting spirits acting upon the mind, when coupled with the metaphors of animal government and oeconomy these fermenting spirits could also be cast as political and even radical agents – as bodies conducting civil war or overrunning sovereign rule. The body is a microcosm, here, for the religious ferments driving divisions in society at large.

The entanglement of natural philosophy with the religious politics of the day was widely expressed among Willis's contemporaries: the physiologist Walter Charleton noted that the passions were the source of all 'false opinions' in their age while the theologian and Oxford Royalist, Henry Hammond cast the errors of judgement belonging to the phantasy as the 'dangerous mother of heresies' within the Christian community.[116] While Willis's account, like Causubon's, offered an implicit support for the authority of the Anglican Church - in undermining the claims of personal revelation forwarded by some religious enthusiasts - this doesn't demonstrate that Willis came to those conclusions in order to specifically promote his religious commitments.[117] It was not uncommon for experimental philosophers of this period to conceive of - and address - phenomena such as religious enthusiasm through the lens of naturalistic, physiological explanatory categories. Moreover, the medical explanations he provided were derived from and

[116] Walter Charleton, 'Epistle Prefatory', *Natural History of the Passions* (London: Printed by T.N. for James Magnes, 1674). Henry Hammond, *Sermons Preached,* April, 1663 (London: printed for Robert Pawlet, 1675), p. 157. On Hammond's theological views see: Caron, *Philosophical Reception* (2011), p. 81; Hawkins, *Empire,* p. 151.

[117] Robert Martensen, "Habit of Reason': Anatomy and Anglicanism in Restoration England,' (1992), pp. 511-535. Willis did not directly cite a body-politic metaphor, as Hawkins has noted (p. 16), although Martensen proposes its significance in Willis's works is implied. Certainly, there is some analogy drawn between treating the individual and helping to heal the spiritual community.

consistent with the broader conceptual architecture of his natural philosophical model of the soul and his practices investigating the body: a model of the soul and body, which, as this thesis has been examining, drew on a variety of eclectic influences and practices from across his career.

Though medical and political discussions (around the passions) were clearly very much entangled during the period, Willis was writing first and foremost on a matter of natural philosophy. That he did not directly engage in the polemics of the church and its perceived detractors does not mean, however, that readers of his natural philosophy would not have been entirely able to relate his imagery (of the soul engaged in civil war and strife) to the political and religious tensions of the day. These associations were supported by a long-standing set of metaphors which took the body and society as templates for thinking about the other. This reminds us of metaphors chief power – being to actively move between and possibly invert recognised boundaries between kinds of discourse, be it medical, political, social or religious.

For supporters of the established church and state, it was possible to conceive of metaphors as tools that could be used to invert the 'true' sense and meaning of things by nonconformists.[118] Tensions between rival religious groups were often expressed through the contested use and interpretation of scriptural metaphors (e.g. The Song of Songs and the trope of mystical marriage became especially controversial in the 1630s).[119] Metaphors had, after all, been subject to a long history of suspicion as the chief vehicle by which the rhetorician persuaded an audience through an appeal to (or incitement of) the passions. Hobbes's, for example, made an explicit attack on 'monstrous' metaphors, which he positioned as the mother of 'seditious philosophies' - even as metaphor sat at the centre of *Leviathan.*[120] The notion that the mystical and ecstatic rhetoric of nonconformists, which invited potential possession and madness in those whom it struck, could overpower the rational faculties, feeds back, then, into wider discussions (chiefly among those philosophers who supported the established church and monarchy)

[118] To quote Robert Stillman, 'the attack on metaphor forms part of the vocabulary of linguistic crisis that has its political origins…in the specific requirements of the Jacobean discourse of power': Robert E. Stillman, *The New Philosophy and Universal Languages in Seventeenth century England: Bacon, Hobbes, and Wilkins,* (London: Associated University Presses, Inc., 1995), p. 125.
[119] Elizabeth Clarke, drawing on the arguments of R. F. Jones, notes that metaphor was central in the attacks on nonconformity in this period: *Politics, Religion and the Song of Songs* (2011), p. 181, 178.
[120] Stillman notes that metaphors were 'recurrent and indispensible to *Leviathan's* conceptual design': *The New Philosophy* (1995), p. 118.

of the need for a 'plain style' to act as the instrument of reasoned discourse.[121] Willis's use of metaphor was not in itself problematic or 'unscientific' in this setting, any more than Hobbes' use of it in *Leviathan* was: in the hands of certain groups, metaphor could be cast as a tool of sedition and inversion, while in the hand of the experimental philosopher it was a tool of discovery and invention. As Robert Stillman argues, Metaphors were both a threat and opportunity for Renaissance writers.[122]

Willis nevertheless clearly looked to accommodate his Christian faith within his physiological explanations. This was no easy task; in his endeavour to advance a greater set of physiological powers for the corporeal part of the soul, he ventured down what he described as a 'path beset by thorns.' His arguments posed the question of what (if any) role remained for the immortal or rational soul. The chemico-corpuscular arguments put forward by Willis were not necessarily atheistic but could nonetheless be perceived as paving the way for a heretical monism which rejected any ontological distinction between body or soul – accepting only a material soul or animating principle.[123] However, there is no reason to suggest that Willis saw his pursuit of physiological explanations of the soul and his Christian faith as incompatible. Indeed, Willis viewed his theories as entirely orthodox and 'agreeable to a good Life, and Pious Institution' (SB, p.1).[124] As we can see in his description of epileptics, despite following a predominantly chemico-humoral explanation of the affliction, Willis did not exclude the role of faith and prayer in its treatment and saw the renewal of 'true religion' as part of the wider work of the physician treating such conditions.[125]

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121 Stark, p. 57.

122 Stillman, p. 125.

123 This refers to the form of monism growing out of the medical tradition, and not the mechanical philosophies, as promoted by Francis Glisson and William Harvey. This branch saw matter as having active powers, which could amount – if taken to its full conclusion – to all vital powers being the result of a purely material soul. On this, John Henry also notes that Willis's *Soul of Brutes* would have been particularly attractive to mechanical and materialist monist positions: 'The Matter of Souls,' p. 90-1, 94. See, also: Thomson, *Bodies of Thought,* p. 83.

124 As Martensen has argued, Willis's naturalistic explanations helped to buttress his Christian stance on the rational soul by incorporating new physiological learning whilst retaining a space for the superior work of the divine. Jody McNabb's 2014 article goes further, arguing that *Soul of Brutes* reflected a puzzling 'return to orthodoxy' in its continued support of the rational soul and that 'Willis abandoned the empirical basis of observation for the authority of the Church,' p. 136. This significantly neglects the ways in which anatomical knowledge was given meaning by notions of the soul in this period.

125 Willis employed new iatrochemical remedies alongside traditional Galenic therapeutics, including the use of bloodletting. For an example of Willis's recommendation of chemical remedies, see: *Soul of Brutes,* p. 131. Hawkins discusses this in some depth, *Empire,* p. 55. Sigal noted that Willis was 'not above turning to Galenic argument, when it served his purposes,' (1978), p. 577.

Far from looking to dispense with the immortal soul, Willis used his anatomical and physiological work to buttress its superior work.[126] By having pushed at the limits of the sensitive soul's (physical) capabilities, Willis believed that he had outlined a much reduced, but clearly demarcated role.[127] Restricted to purely intellective and immaterial powers, the rational soul was placed at a remove from the fault and corruption which material bodies where inherently subject to. This was not intended to undermine the existence of a rational soul, but rather to exclude it from matters of the flesh.[128] As Willis stated in the 'Preface', the two souls needed to be differentiated and not just viewed as two points on a scale of perfection so as to preserve the 'Dignity, Order and Immortality' of the Rational soul (SB*,* p.1). He had intended to show 'the utmost thing that living Brutes can know or do,' by its corporeal or sensitive powers, in order to reveal the work of the rational soul (SB, p.34). The rational soul therefore existed in the negative spaces created by the physiological powers of the sensitive soul – as the corporeal soul was itself illuminated by the empty spaces of the body, as its 'shadowy hag'.[129] Again, light features as a recurring metaphor for knowledge here, even if the shadow is only an indirect product of illuminating an object.

Like the dualists More and Cudworth, Willis tested the limits of what could be explained physically (and mechanically) in order to demonstrate – by its very limitations - the *necessary* existence of an immortal soul, though he came to very different conclusions.[130] It is this aspect of Willis's thinking that has been seen as his most conflicted or confused because he sought, on the one hand, to rely on physiological explanations of the sensitive soul while at the same time trying to maintain a role for an immaterial, rational part. Jaime Kassler has therefore referred to Willis's philosophy of the soul as 'janus faced,' in

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126 As Hawkins notes, while aspects of mechanical philosophy were being utilised within seventeenth century physiological theory, this did not necessarily exclude the role of an immaterial soul, though this certainly 'relocated' and 'restricted' its actions to a realm beyond the body, *Empire*, p. 15.

127 Lester S. King notes that Willis 'had to whittle away at the functions of the rational soul, whose properties he relegated more and more to the animal soul,' *The Philosophy of Medicine. The Early Eighteenth Century* (Cambridge, Maa., 1978)*,* p. 142. Martensen, p. 98.

128 Willis's work was welcomed at least by the Greenwich vicar, John Turner in his *Physico-Theological Discourse,* where he quoted at length from the 'excellent and judicious' *Soul of Brutes* and repeated Willis's claim that man's superiority was only accounted for by an immaterial soul, (London: 1698), p. 58.

129 As John Henry has remarked, the rational role is inferred from the outlines of the primary account (of the corporeal soul), p. 98.

130 The Cambridge Platonists, such as Henry More, adopted a radical dualism between soul and body while employing mechanistic explanations of body functions in order to show – by the very limitations of mechanical explanation – the necessity of an entirely immaterial soul. For More, atoms needed a continuous and providential guidance from the divine, *The Immortality of the Soul* (London: 1659), p. 130. On this see: B. J. T. Dobbs, 'Stoic and Epicurean Doctrines in Newton's System of the World,' in *Atoms, Pneuma and Tranquility,* ed. by Osler (1991), pp. 222-238 (p. 223).

that it adopted mechanistic aspects while trying to accommodate his Christian faith.[131] The important point here is that, for Willis, these were not incompatible goals.[132]

Interestingly, Willis used a comparison with new computational inventions from the field of mathematics and astronomy to evidence the necessary and perfect powers of the rational soul. Because the mind can propose and solve abstract algebraic 'riddles' - which deal with hidden values and universals, rather than sensory knowledge – Willis held that the soul's powers were themselves purely immaterial, abstract and intellectual:

> What shall I say concerning the Proportions of a Circle […] being most exactly computed? What besides, that the Humane Intellect having learnt the Precepts of *Geometrie* and *Astronomie,* takes the spaces of inaccessible places, and their heights […] yea the dimensions of the whole Earthly Globe […] there will be no place for doubting, but that the humane soul […] must needs be far above the Brutal, Immaterial and Immortal' (SB, p.40).

The rational soul can, in the manner displayed in the art of geometry, 'compute' dimensions that exceed sensory perception. Computed comes from the Latin 'com' (together) and 'putare' (to settle an account). *Computare*, and *compute* were first used in 1613 to describe a person who performed calculations; this was therefore a relatively new term, which Willis is using to support his claims about the relative powers of the two souls.[133] Willis makes reference here to the 'truly amazing' and 'certain demonstrations of mathematicks,' taking these practices as an analogue for the more perfect reasoning powers of the mind: the discipline is noted as being 'a-Kin or greatly alluding to the Humane mind' (SB, p.40). These abilities point to the possession of the rational soul as the defining feature of what it is to be human. Interestingly, what are often cited as the new intellectual tools of modern 'science' (geometry, astronomy) are used here to reinforce a Christian notion of the immortal soul, challenging any clear distinction in this period between the intellectual tools of 'philosophy' or 'science.'

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131 Kassler, p. 147.

132 Stanley Finger notes that Willis 'had no intention of offending the ecclesiastics,' *Minds Behind the Brain: A History of the Pioneers and their Discoveries* (Oxford: Oxford University Publishing, 2000), p. 90.

133 In 1623 the first mechanical calculating machine was invented by the German professor of astronomy, Wilhelm Schickard. In 1642, Blaise Pascal invented a machine called the Pascaline that could add and subtract and carry between digits. See, April J. Wells, Chapter one 'History', *Grid Database Design* (London: Auerbach Publications, 2005), p. 5.

Conclusion

As this chapter has demonstrated, Willis's conception of the corporeal soul was far from materially reductive or simply mechanistic. Instead, it reflected important vitalistic and alchemical influences, vividly expressed in his language around the active and vital powers of the spirits. The historical impact of *The Soul of Brutes* has, somewhat unfairly, been assessed by a number of scholars as laying a foundation for the reduction of the mind to the physical functions of the brain; but this is more accurately the outcome of our own preoccupation with Willis's anatomical explanations and dismissal of his vitalist views around material spirits.[134] Others have suggested that Willis's attempts to appease the church amounted to little more than kotowing to convention in order to protect him from accusations of atheism.[135] However, to point to political expediency as a reason for Willis's position on the soul is to incorrectly suggest that his religious views were somehow inconsequential to his intellectual practices: that religion was outside of his 'science'. These views neglect the ways in which Willis used his anatomical and physiological arguments – through a dynamic set of metaphors and analogies - to support his notion of a dual corporeal and incorporeal soul. Just as the body created a 'shadow' outline of the corporeal soul, this in turn created a negative space for the rational soul.

Where images of devices such as the alembic or the clock had helped Willis, in his earlier works, to express a normative model of regular processes and routine functions, these images did little to extend his discourse on pathology and disease (where outcomes were decidedly un-predictable and irregular). Instead, new chemico-corpusuclar analogies were being utilised around distillation, light rays and wave-patterns or propagation. These metaphors and analogies – tied as they were to a wealth of new inventions in this period - provided new ways of articulating complex physiological phenomena. Moreover, in

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[134] Zimmer argued that the soul's 'mental' faculties were made a 'prisoner of its fleshy structures and weaknesses' by Willis, *Soul Made Flesh,* p. 229. Marc Jeannerod also argues that Willis's insistence that the soul could be physically divided and extended to all parts of the body helped to fatally undermine the concept of a singularly indivisible soul and that this was a necessary pre-condition for dispensing with a concept of 'soul' (in the immortal sense) altogether: *Le Cerveau-machine,* p. 19; quoted by Thomson, *Bodies,* p. 85. These readings can be set against what Simon Schaffer has described as a tendency to view mechanical explanations as 'indicative of 'progressive,' '*Godly Men'*, p. 55.

[135] Thomson, p. 83. Hansruedi Isler, *Thomas Willis, 1621–75, Doctor and Scientist,* (London: Hafner Publications Company, 1968), pp. 172-3. Paul F. Cranefield suggested that Willis was at pains to stress his religious affiliations so as to legitimise his otherwise naturalistic pursuits: 'A Seventeenth century View of Mental Deficiency and Schizophrenia: Thomas Willis on "Stupidity or Foolishness", *Bulletin of the History of Medicine,* xxxv (1961), pp. 291-315 (p. 306). This is an argument John Henry rejects in *Matter of Souls,* p. 98.

attempting to demonstrate how the corporeal soul could itself form a material basis for all the aspects of our vital and sensitive life, Willis looked beyond these images. Anthropomorphising and personifying the spirits, or looking to bodily gesture and linguistics, he expressed the animal spirits capacity to 'vary the tune' of the musical organ; to make decisions and communicate with the higher soul. In exploring these ideas, this chapter has further underlined that, despite his use of apparently proto-scientific intellectual tools (observation, experiment) and his import from the new learning (geometry, optics, pneumatics), Willis's ideas could not be divorced from the wider socio-political and religious contexts in which he lived and worked. The body was more than an anatomical structure to Willis; it was a vessel designed for, enlivened and given meaning by the actions of the vital and sensitive souls.

Conclusion

Willis, Literature and Science

Outlining Willis's contributions to the concept of nerve transmission in 2003, Wes Wallace drew attention – like many before him - to Willis's 'fanciful' language, noting that his scientific insights had displayed a 'quasi-poetic intuition.'[1] Willis's apparently 'literary' inclinations continue to mark him out as an equivocal figure in the history of modern science and medicine.[2] Though a number of notable historians have sought to address this situation by examining Willis's ideas within their cultural and social contexts, notably Robert Frank, Robert L. Martensen and Michael Hawkins, this thesis offers the first extended study of the metaphors and analogies Willis used to describe, investigate, and comprehend the brain. This thesis has explored the relationship between language and scientific practices in the work of Willis, with the aim of enriching and deepening our historical understanding of Willis's extraordinary career and legacy, while also contributing to broader discussions about language and science.

I have argued that the apparently 'literary' devices of metaphor and analogy are, in fact, an integral component in the production of scientific knowledge, rather than accessories or embellishments to it. Drawing on this position, this thesis has addressed the tendency within scholarship on Willis to 'cherry pick' his clinical and anatomical discoveries while being dismissive of his theoretical writing on the physiological functions of the brain and nerves as confused or fanciful. As Julian Jaynes once notably described, Willis's works are marked by an 'astonishing combination of worth and worthlessness.'[3] These approaches have attempted to separate out what Willis *did* in his physical examination of the brain and nerves from the intellectual explanations offered in his writing. A historical reputation for a florid and embellished style of writing is clearly not the only reason for selective readings of Willis. These can also be explained by the present-day fascination

[1] Wes Wallace, 'The Vibrating Nerve Impulse in Newton, Willis and Gassendi: First Steps in a Mechanical Theory of Communication,' *Brain and Cognition,* 51 (2003), pp. 66-94 (p. 75, n. 20).
[2] On the social and cultural turn in medical history, see: Frank Huisman and John Harley Warner (eds.), *Locating Medical History: The Stories and Their Meanings* (London: Johns Hopkins University Press, 2004), esp. p. 95. On Willis's equivocal position, see: William Bynum, who argues that Willis's historical reputation has proved less secure than his contemporary one, 'The Anatomical Method, Natural Theology, and the Functions of the Brain,' *Isis,* 64.4 (Dec., 1973), pp. 444-468 (p. 450).
[3] Julian Jaynes, 'The Problem of Animate Motion in the Seventeenth Century,' *Journal of the History of Ideas,* 31.2 (Apr., 1970), p. 230.

with the neurological brain, and the preoccupations of medical professionals with an explicitly medical interest in Willis, who have been the authors of key works on his contribution.

These readings of Willis also intersect with – and reproduce – a set of deeply entrenched historical attitudes to the role of literary strategies (and especially the use of metaphors) within science. As Chapter One demonstrated, a sense of hostility towards and rejection of metaphor (and to a lesser extent analogies) emerged out of a specific set of debates within seventeenth century natural philosophy and was then embraced as part of the character of modern science. While these devices (metaphors and analogies) are generally considered to be useful tools in modern science, especially in relation to communication with various wider publics, metaphors and analogies are still viewed as devices that are to be managed with caution to ensure they inform, rather than mislead.[4]

One 2016 article attacks the use of anthropomorphic metaphors in virology, arguing that the metaphor leads to claims that viruses are 'alive' and that 'goals' and intentions can be attributed to them to explain infection processes (viruses have 'wars' and adopt 'strategies').[5] We could think here about Willis's use of anthropomorphic metaphors to attribute agency to the animal spirits in his pathological discussions. The effectiveness of anthropomorphic metaphors, and the unease they generate, are nothing new. The author, M. van Regenmortel, cites the warning that while metaphor might be 'effective in enlivening a lecture or an article,' we must remain alert to the fact it is '*only* a metaphor.'[6] Again, metaphor and analogy are accepted here as valuable 'tools', but also as something to be approached with caution.

The question is, what *kind* of tools are they? Science has long suggested that metaphor should be employed 'neutrally', primarily for communicating with an external, non-specialist public. They are distanced from the work of science itself.
The boundary between pre-modern and modern science is often drawn with reference to attitudes towards the appropriate use of figurative language in science (as opposed to its

[4] Phillip Ball, 'A Metaphor too Far,' *Nature* (23 February, 2011).
[5] M. H. V. van Regenmortel, 'The Metaphor that viruses are living is alive and well, but it is no more than a metaphor,' *Studies in History and Philosophy of Biological and Biomedical Sciences,* 59 (2016), pp. 117-124 (pp. 117-118).
[6] *Ibid*, p. 118.

use in literature or politics).[7] In Chapter One, I explored this in relation to the work of Gentner and Jezoirski, who attempt to formulate parameters for the 'scientific' use of metaphor and analogy. As the thesis has shown, Willis repeatedly falls foul of such modern distinctions and stipulations about what is a 'proper' use of language in science. His own remarks in *Cerebri anatome* - that it was from 'analogy and frequent ratiocination' that a 'true and genuine use of it occurred' - are often cited in support of these readings (AB, p.91). As the physicians Meyer and Heirons concluded, this was *not* the language of somebody truly interested in anatomy, but spoke to his ultimate motives in using the body to discourse on the mind and soul.[8] In Chapter Two, I explored how some current scholars have proposed that Willis employed analogy in the 'wrong' way; that is, like the alchemists rather than in the manner adopted by his experimental colleagues. He was 'owned' by his analogies, rather than controlling them, and thus belonged to an older style of analogical reasoning.[9]

Although Willis is celebrated for his notable discoveries relating to clinical observation and structures within the brain, his historical position is nevertheless tarnished by what such authors claim to be his love of 'words as words.'[10] Falling back on present-centred concepts of usefulness and relevance, the medical or scientific 'content' of Willis's works is seen as somehow extractable from the historical jargon of his writing. There have been many reasons cited to explain Willis's 'fanciful' writing style and, notably, our discomfort with it: his vanity and a love of fame; an effort to conceal inadequate empirical foundations; the confusion wrought from haphazardly importing terminology from one discipline to another.[11] The last proposal – that of an inexpert use of foreign terminology (applied from chemistry to human physiology) is a particularly illuminating one. As seen in Chapter Two, the import of chemical terms into new and alien contexts (physiology or anatomy) was not a case of Willis 'dressing up' in the clothes of his peers (as Wallace implied), but a vital means by which new meanings and new ideas could be generated. The metaphor of the brain as an 'alembic,' through its association with alchemical ideas and practices, helped to import (what was, for Willis) a familiar explanatory framework

[7] Dedre Gentner and Michael Jeziorski, 'The shift from metaphor to analogy in western science', in *Metaphor and Thought,* ed. by A. Ortony (Cambridge: Cambridge University Press, 1993), pp. 447-480.
[8] Alfred Meyer and Raymond Heirons, 'On Thomas Willis's concepts of neurophysiology: Part I & II,' *Medical history*, ix (1965), II, p. 150.
[9] Gentner and Jeziorski, 'The Shift from Metaphor to Analogy', p. 448.
[10] Michael Foster, *Lectures on the History of Physiology During the Sixteenth, Seventeenth and Eighteenth Centuries* (Cambridge: Cambridge University Press, 1901), p. 270.
[11] *Ibid,* p. 270; Meyer and Heirons, 'On Thomas Willis's concepts of neurophysiology,' p. 145; Wes Wallace, 'The Vibrating Nerve Impulse,' p. 75.

of chemical distillation: this enabled him to express his idea that the animal spirits were 'procreated' by the brain, in a transformative rather than purely mechanical sense. These arguments are an important means of countering claims that Willis reduced brain function to anatomical structures. Moreover, this example also speaks to the impact of the material environment and practice in the availability of certain metaphors: Willis looked to the alembic; today, we might look instead to a circuit board or computer to express ideas about brain function. These are incompatible, historically contingent notions of the brain.[12]

Chapter five, in particular, challenges readings which have cast Willis's neurophysiology as 'equivocal' or 'confused' on account of his use of an alternating series of metaphors and analogies. What it demonstrates is that these figures were not intended to be read as a single, coherent picture of the brain; rather, they were used selectively in order to focus on specific aspects of a complex model. In setting out his theory of neurotransmission, Willis described blasts of wind and 'strait rays or strokes' of light moving through the nerves; shortly afterwards, he spoke about the images carried by these rays in terms of a fluid, moved 'as it were by a certain waving' (SB, p.58, p.76). What united these images was Willis's corpuscular concept of wave mechanism, which provided an atomistic definition of action in both fluid and air. These examples were not the product of confusion or equivocation, but reflective of Willis's recourse to a specific, early modern theory of matter.

Another theme, which arises in conjunction with the overtly medical emphasis in placed on Willis's works, has been to explain away his 'embellished' and 'fanciful' writing as a result of it having been translated by the poet, Samuel Pordage. Undoubtedly, translations produce errors and can reproduce the ideas and assumptions of the translator. However, what is of interest here is the particular concern caused by the poetic (rather than medical) background of this particular translator. This points to a special concern over the accuracy of technical, *medical* terms, which are most often the cause of complaint here.[13] Importantly, these views overlook a vital difference between

[12] For a recent discussion of the conceptual basis of the circuit metaphor in neuroscience see: George Lakoff, 'Mapping the Brain's Metaphor circuitry: metaphorical thought in everyday reason,' *Frontiers in Human Neuroscience,* 16 December, (2014) https://doi.org/10.3389/fnhum.2014.00958.

[13] Charles Symonds described Pordage's translations as 'ponderous and ambiguous,' also claiming this obscured the 'true' worth of Willis: 'Thomas Willis, F.R.S.', *Notes and Records of the Royal Society of London,* 15 (Jul., 1960), pp. 91-97 (p. 97).

early modern anatomy and our own understanding of the discipline: that the boundaries between what constituted natural philosophical enquiry and poetry were less well defined and distinctly more fluid. As Jonathan Sawday has convincingly shown, poetry and anatomy engaged in overlapping discourses of the body in this period.[14] Many of the tropes and metaphors used by Willis would have been recognisable to Pordage, who himself expressed a keen interest in anatomical learning within his own poetry. Here, once again, historical context can be used to challenge traditional assessments of Willis contributions and the 'literary' problems they appear to suffer from.

Willis and neuroscience: disciplines and their histories

In 1799, Hutchinson's *Biographia Medica* observed that 'perhaps no writings which […] prove such uncommon talents to have been in the writer, were ever so soon laid aside and neglected as the works of Willis.'[15] Far from it, Willis has been the subject of a significant reappraisal by historians, which took off around the same time that scholars coalesced around ideas of neuroscience as a scholarly community founded in the early 1960s: these stories are intertwined.[16] Notably, in the 1990s, the neuroscientific community formalised its desire to marshal a specific historical narrative: Gordon Shepherd recalls how, in the face of pressures to engage the public with its research, he recognised the discipline's need to 'take responsibility' for its history and worked to establish the Committee on the History of Neuroscience, which met from 1992 onwards.[17] In seeking to forge a collective identity from among many disparate fields, modern scholars connected with neuroscience have sought to present a deep, shared history for the brain sciences - grouped around a nucleus of neurology.

By projecting a set of present-centred concerns back onto historical practices around the brain – including those of Willis - modern neuroscience has looked to reproduce historical ways of investigating and thinking about the brain in its own image. As Stephen Casper, among others, has noted, the reproduction of the long history of neuroscience

[14] Jonathan Sawday, *The Body Emblazoned* (1995).
[15] B. Hutchinson, *Biographia Medica* (London, 1799), vol.11, p. 68.
[16] On the emergence of the term 'neuroscience' in the 1960s see: Nikolas Rose and Joelle M. Abi-Rached, *Neuro: The New Brain Sciences and the Management of the Mind* (Princeton, New Jersey: Princeton University Press, 2013), pp. 26-8.
[17] Gordon M. Shepherd, *Creating Modern Neuroscience: The Revolutionary 1950s* (Oxford: Oxford University Press, 2010).

involves obscuring the various intellectual, linguistic, cultural and institutional contexts in which knowledge about the brain has been produced.[18] The universalist claims on which present-day neuroculture is built allow the brain and nerves to be situated beyond history as an essential model of human nature.[19] These factors have impacted on the treatment and uses of Willis as a historical figure within the discipline. To the extent that this thesis roots Willis's account of the brain in a specifically early modern conceptual framework, through his metaphors and analogies, it contests how neuroscience uses historical practices to reaffirm aspects of its modern identity. It argues that we should resist the use of them in any simple anchoring or decontextualized way.

The use of language, metaphor and analogy is key part of this story. As this thesis has explored, what Willis's metaphors and analogies express is just how 'other' the conceptual architecture of his brain is. When Willis cut open the brain he saw a laboratory for animal spirits; a cabinet or fountain for the soul; a castle, furnished with chambers and cloisters, to house securely and to organise the material substrates of thoughts and memories, a clock operating the involuntary nervous system. Ultimately, his effort to understand its structure was, unlike modern neurology, part of a much broader project to map out the hidden operations of the *soul* and to treat its afflictions. Equally, as we saw in chapter five, Willis's physiology was also intended to address issues around the 'civil war' between the passions of the flesh and the sovereignty of reason. In these discussions, he addressed not only neurological or 'medical' matters, as we might understand them, but also a set of theological concerns concerning the health of the (Anglican) soul. The over-arching point being made across these chapters is that we cannot understand Willis's ideas or discoveries on our terms: it must be on his.

Analogy, metaphor and science: eternal vigilance?

The idea of a binary opposition between a scientific and literary use of language is part of a deeply entrenched set of attitudes, which continue to exert a strong influence. As Clive Sutton argued in 1994, 'no scientist or science teacher wants to be caught dabbling with

[18] Stephen T. Casper, 'History and Neuroscience: An Interactive Legacy,' *Isis,* 105.1 (March, 2014), pp. 123-132.
[19] For an example of historical scholarship situating the nerves and Brain beyond history and culture, see for example: Daniel Lord Smail, *On Deep History and the Brain* (London: University of California Press, 2008).

'mere words.'[20] Literature and science are not, however, inevitably or inherently oppositional categories, rather, the categories emerge *as opposites* out of a specific set of arguments put forward during the early modern period.[21] Indeed, in light of the cultural turn in medical history and the emergence of scholarly fields examining the integral relationship between literature and science, it might be pertinent to ask whether it is still necessary to defend or explain the role of metaphor and analogy in science at all. It has been argued, for instance, that the indispensable role of metaphor and analogy in science is now so widely agreed upon that it effectively operates as a truism, especially among linguists and cognitive scientists.[22] This is not, however, the whole argument.

While the effectiveness of metaphors and analogies (beyond mere embellishment) is now broadly accepted, the nature and limitations of their work – whether they are simply tools of public engagement or a part of the very fabric of how we 'do' science - remain matters of some considerable debate. In 2000, Sabine Maasen observed that metaphors continue to be regarded within the social sciences as 'educational, yet lacking genuine insight; as economical carriers of complex meaning, yet easily misleading.'[23] Indeed, the use of metaphors and analogies in science today are accepted on account of a body of work that has sought to demonstrate how they are said to operate *differently* within the scientific context: as neutral 'tools' to help inform the public.[24] Work around the future of metaphor in science therefore tends to focus on how these tools can be made more effective, while remaining cautious of their potential restrictions on the 'content' of scientific knowledge itself.[25]

A recent example is Timothy D. Giles's book *Motives for Metaphor,* where he discusses the 'problem' of metaphor as it applies to technical communications in science: can they be relied upon to accurately convey precise, 'technical' information as well as broader

[20] Clive Sutton, 'Nullis in verba' and 'nihil in verbis': Public Understanding of the Role of Language in Science, *The British Journal for the History of Science,* 27.1 (Mar., 1994), pp. 55-64 (p. 59).
[21] Elizabeth Spiller, *Science, Reading and Renaissance Literature: The Art of Making Knowledge, 1580-1670* (Cambridge: Cambridge University Press, 2004), p. 1.
[22] Hanna Pulaczewska, *Aspects of Metaphor in Physics: Examples and Case Studies* (Tübingen: Niemeyer, 1999), p. 1.
[23] Sabine Maasen, 'Metaphors in the Social Sciences: Making Use and Making Sense of Them,' in *Metaphor and Analogy in the Sciences,* ed. by Fernand Hallyn (Dordrecht; London: Kluwer Academic Publishers, 2000), p. 199.
[24] James Bono, 'Science, Discourse and Literature: The Role/Rule of Metaphor in Science,' in *Literature and Science: Theory and Practice,* ed. by Stuart Peterfreund (Boston: Northwestern University Press, 1990), pp. 59-89 (p. 60-1).
[25] Timothy D. Giles, *Motives for Metaphor in Scientific and Technical Communication,* ed. by Timothy D. Giles and Charles H. Sides (London: Routledge, 2016 [2008]), p. 2.

concepts (such as the 'clockwork' universe of Newton's metaphors).[26] His discussions are a useful summary of the themes discussed here. Metaphor and analogy, he acknowledges, are valuable, but the issue here – the 'problem' with metaphor – is that the success (or not) of new ideas, as they are conveyed from a scientific community to the public beyond them, is too reliant upon the success or failure of a metaphor. As Giles reflected, even after many years of debate, the general public are still not convinced by the claims for human cloning, a failure he links to the lack of an effective, central metaphor to communicate cloning to the public.[27] Giles doesn't actually argue that metaphors should *not* be used in technical writing, but that there should be educational training given to ensure the correct use of these tools.[28] However he is also wary of how such devices can become conservative or restrictive. Metaphor becomes a 'problem' in science, he argues, when it becomes 'myth, which can occur when a scientist has too much invested in a metaphor and resists a paradigm shift.'[29] There is still a sense here, then, that metaphor can obstruct the processes by which knowledge is produced, (in this case, blinding the scientist to new findings), rather than it being co-constitutive of knowledge itself.

There is clearly knowledge bound up with metaphor – to insist that the two are co-constitutive is not to deny the real existence of things in the world, but to say they are nevertheless inseparable. For instance, the metaphor of the 'living' or goal-orientated virus cant simply be dispelled in order to get at a truth lying 'underneath' the metaphor; it can, however, be displaced by a new – perhaps more useful or productive metaphor. Exposing the metaphorical roots of knowledge doesn't necessarily more clearly reveal the 'truth' of its object, however we can certainly *interrogate* metaphors and analogies to suggest where they are no longer being productive or illuminating. A metaphor which might initially give rise to a new way of thinking about something can, in time, become to be seen as restrictive as the practices and findings that are grouped around it start to push at its limits or even come into conflict with it. Recent attacks on the hardwired brain – which now sits in conflict with the competing metaphor of the malleable, 'plastic' brain - is one example of where a leading metaphor might have reached its limits.[30]

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[26] *Ibid,* p. 2.
[27] *Ibid,* p. 1.
[28] *Ibid,* p. 153.
[29] *Ibid,* p. 3.
[30] For a recent example, see: Edward Hallowell M.D., 'Your Brain is Not the Hard-Wired Machine You Think It Is,' *Psychology Today,* Jan. 10 (2014)
<www.pyschologytoday.com/blog/driven-distraction/201401>

One area in which metaphors are increasingly seen as relevant, therefore, is on the matter of disciplinary change. As Lina Hellsten and Brigitte Nerlich suggested in 2011, we ought to 'worry' about metaphors especially in light of their current role in 'reducing' biology to the digital domain; the presumptions involved in these metaphors ought to be challenged, the authors suggest, in order to halt this reductionism.[31] As Hellsten and Nerlich identify, these concerns have supported an increased interest in research around complex, mixed metaphors in science and how these complex metaphorical chains inform public understanding.[32] The metaphors and analogies that have enabled the extension of modern neuroscience across a plethora of discourses – from mental health to crime – deserve, and attract, particular attention here. To say that metaphors are an integral part of disciplinary change is not to contradict the argument that they are integral and even constitutive of knowledge: metaphors rise and fall because they are perishable, in the sense that their meaningfulness is rooted in historical and cultural contexts. This does not make them 'other' to the knowledge they produce; all it means is that as knowledge changes so do the metaphors considered useful.

In these discussions, we should also consider the role played by metaphors that appear to have passed over into the realm of definite description, such as Harvey's 'pump' metaphor of the heart or the 'blueprint' model of DNA. These metaphors move from a figurative to a literal description in terms of their common usage; they are so successful that they cease to operate as *visible* metaphors at all. It is difficult, for instance, to imagine how we might return to a position where the 'pump' action of the heart recalls a mechanical *metaphor* of the body – rather than a very real sense of the existence of biological mechanisms. This prospect, of the inseparability and invisibility of certain metaphors in relation to what we know, goes to the heart of anxieties around the relationship between metaphors and science: that they can become so bound up in knowledge that we cease to recognise (and thus be able to interrogate) their work.

While it is problematic to insist on a denotable boundary between metaphor and knowledge, it is nevertheless helpful to think about what benefits might be had from seeking out *new* metaphors to intervene in and open up innovative ways of thinking. Looking to historical metaphors - with an awareness of how they are involved in *changes*

[31] R. Jones (2010), quoted in Lina Hellsten and Brigitte Nerlich, 'Synthetic Biology: Building the Language for a New Science Brick by Metaphorical Brick,' *New Genetics and Society,* 30.4 (2011), pp. 375-397.
[32] *Ibid,* p. 377.

to thought – can play an important a role here. Willis's imagery of the 'unfolded' brain can be used to interrogate current assumptions around the 'objectivity' of imaging and brain scans. Learning from and examining the brain is increasingly a matter of computerised imaging techniques, rather than a physical encounter; many neurological scientists might struggle to correlate what is being represented by a MRI scan of the brain with the visceral object, if it were laid before them. Willis's discussion of the rolled and unfolded presentation of the brain could be used to ask questions around how we access and handle the *material* brain (beyond simply learning surgical procedures).

What this thesis contributes to these discussions is a vital historical context to shed light on the ongoing role of these devices in modern science. As Chapter One explores, members of the early Royal Society – many of whom are used as leading figures of the 'scientific revolution' – did not ascribe to any simple rejection or suppression of these devices, at least in practice, despite a keen sense of the possible risks (as well as benefits) of metaphor in their work. These devices were – and remain – a vital component of scientific concepts and practices; this was true as much for Willis as it was William Harvey or Robert Boyle. Willis was nevertheless himself challenged by the difficulties of drawing a firm boundary around metaphor, analogy and the things he sought to describe. As he remarked, the corporeal soul '*is* either a Flame or a Breath, neer-to, or a-Kin to Flame' (SB, p.5). While Willis clearly accepted these figures as useful and even indispensible, he also acknowledged an inherent ambiguity in their work. As Nietzsche once observed in relation to metaphor, 'truths are illusions of which one has forgotten that they are illusions.'[33] Clearly, metaphors and analogies are sites of massive contest in science but also more generally: they are seen as productive, dangerous and illusory while being indispensible to human thought. With this in mind, to dismiss or overlook them seems irresponsible; to believe we can operate without them is naive. Instead, as this thesis has shown, we need to recognise how their power to make knowledge is embedded in historically specific systems of thought.

[33] Friedrich Nietzsche, 'On truth and falsity in their extramoral sense', in *Essays on Metaphor,* ed. by W. Shibles (Whitewater: The Language Press, 1972), p. 5.

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