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"That puzleing Problem": Isaac Newton and the Political Physiology of Self

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Where religions once demanded the sacrifice of bodies, knowledge now calls for experimentation on ourselves, calls us to the sacrifice of the subject of knowledge.[1]

In the past few years, historians have developed a series of new techniques for recovering the practices and contexts in which people understood the relations between mind and body. From the recognition that modern compartmentalizations do not correspond to earlier accounts of this link, and are thus inadequate as a basis for historical research, a new "material-social" account of the mind-body relationship has emerged. This approach embraces a multiplicity of discourses about the causes of behaviour and disease, including commonplace tropes associated with social identities, humoral pathology, and the interplay between vulgar and elite accounts of individual responsibility. It has proved possible to link these histories to contemporary physiologies and the often complex accounts of the "wiring" which linked the soul's place in the brain to the rest of the body.[2]

In the early modern period, the mind-body connection was continuously resubjected to a series of mappings, and experts recognized that this relationship was one of mutual causation. A physician like Richard Napier, for example, would have at his disposal a wide range of sources such as astrology and Burton's *Anatomy of melancholy* to explain the bodily origins of deviant behaviour. The defects of the body, such as the role of the humoral balance, of dreams, or of the passions, might be contrasted in a particular setting with the possibility of divine inspiration, of demonic possession or subversive enthusiasm, and any one of these causes might retrospectively appear to have been complicit in the formation of a malady. With such a variety of different resources, there was no obvious "progressive" move in the medical sphere away from a humoral conception of the person towards a radical dualism, and, as Brown has pointed out, physicians like Jerome Glaub who remained loyal to Descartes in the eighteenth century "continued nevertheless to adhere firmly to the neoclassical notions of psychosomatic interaction". Nor does dualism

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[1] M Foucault, 'Nietzsche, genealogy, history', in P Rabinow (ed.), *The Foucault reader*, London, Penguin, 1986, p. 96.

[2] See R Porter, 'Barely touching: a social perspective to mind and body', in G Rousseau (ed.), *Languages of Psyche: mind and body in Enlightenment thought,* Berkeley, University of California Press, 1990, p. 45. For secondary literature on these sociological and moral neurocartographies, see amongst others W F Bynum, 'The anatomical method, natural theology and the functions of the brain', *Isis*, 1973, **64:** 445–60; S Tomaselli, 'The first person: Descartes, Locke, and mind-body dualism', *Hist. Sci.*, 1984, **22**: 185–205; C Taylor, 'The moral topography of the self', in S Messer, L Sass and R Woolfolk (eds), *Hermeneutics and psychological theory*, New Brunswick, Rutgers University Press, 1988, and *idem*, *Sources of self. The making of the modern identity*, Cambridge University Press, 1992, especially pp. 143–231.

remotely capture the sophisticated interactions between soul and body postulated by Descartes himself. In an important sense, the soul—its location and its function as the active and moral essence of the individual— should be seen as the product of this forensic and physiological knowledge.[3]

Non-mental explanations for behaviours were transformed by the new anatomy of the late seventeenth and eighteenth centuries, and the causes of a number of disorders were re-routed up towards the brain. Nevertheless, the fact that the mind could very easily have deleterious effects on the body remained a commonplace with as much anecdotal evidence as the corporeal aetiology of mental disease. The philosophical analysis of the workings of the soul was traditionally part of the domain of natural philosophy, and in this system it was generally held to be composed of two parts, the organic and the intellectual. Unlike the functioning of the intellect and the will, the operations of the organic soul required the physical organs and were concerned with vital operations in addition to those of imagination and memory. Since (following Aristotle) most authors believed that sensation was the basis of cognition, it was held that there were a number of internal senses which corresponded to the external sense organs and which were localizable in specific areas of the brain. In the sixteenth century, theorists of the soul moved away from adhering rigidly to faculty psychology and drew more and more from contemporary work in medicine, though this was of course still limited by theological doctrine.[4]

In the seventeenth century, anatomists and philosophers expressed a renewed interest in locating the precise place of the soul. Notoriously, Descartes located it in the pineal gland, but others, like Thomas Willis, disagreed. Willis, who remarked in his *Cerebri anatome* that he had "addicted [himself] to the opening of heads especially", followed Gassendi and divided the mind up into the rational soul and the animal or corporeal soul, allowing only humans to have an immortal soul that could not be affected by disease or other external problems. The corporeal soul, which humans shared with brutes, was composed of the so-called vital soul (in the blood), and the sensitive soul (located in the nervous system). This sensitive soul was closely linked to the rational soul, while the cerebral cortex served to elaborate the animal spirits in the nervous system which were extracted from the most subtle and active portions of the blood. The cortex was the seat of memory, while in general the animal spirits were essential for memory and imagination:

[3] Porter, 'Barely touching,' op. cit., note 2 above, pp. 66, 45–6; M Macdonald, *Mystical Bedlam: madness, anxiety and healing in seventeenth-century England*, Cambridge University Press,1983; R S Kinsman, 'Folly, melancholy, and madness: a study in the shifting styles of medical analysis and treatment, 1450–1675', in R S Kinsman (ed.), *The darker vision of the Renaissance*, Berkeley, University of Columbia Press, 1974, pp. 273–320; T M Brown, 'Descartes, dualism and psychosomatic medicine', in W F Bynum, R Porter and M Shepherd (eds), *The anatomy of madness. Essays in the history of psychiatry,* vol. 1, *People and ideas*, London, Tavistock, 1985, pp. 40–62. For an extended examination of this issue in the work of Descartes, see R B Carter, *Descartes' medical philosophy: the organic solution to the mind-body problem*, Baltimore, Johns Hopkins University Press, 1983, especially pp. 65–78 and 110–44. For an excellent example of the dynamic interrelations between physiological, religious, and forensic accounts of the individual see the discussion of reaction to the Camisard Prophets in H Schwartz, *Knaves, fools and madmen and 'that Subtle Effluvium'. A study of the opposition to the French prophets in England, 1706–1710*, Gainesville, Florida, University Presses of Florida, 1978, pp. 31–73.

[4] See in particular Katharine Park, 'The organic soul', in C B Schmitt, *et al.* (eds), *The Cambridge history of Renaissance philosophy*, Cambridge University Press, 1990, pp. 464–84, and E R Harvey, *The inward wits: psychological theory in the Middle Ages and the Renaissance*, London, Warburg Institute, 1975.

the Imagination is a certain undulation or wavering of the animal Spirits, begun more inwardly in the middle of the Brain, and expended or stretched out from thence on every side towards its circumference: on the contrary, the act of the Memory consists in the regurgitation or flowing back of the Spirits from the exterior compass of the Brain towards its middle.

The rational soul was placed in the corpus callosum, seat of the "imagination" or "phantasie", because "the Rational Soul depends very much, as to its operation, on the Phantasie, without the help of which, it can know or understand nothing".[5]

As Willis suggested, the role of the imagination (by the seventeenth century nearly always identified with the fancy or phantasie) was centrally important in the healthy working of the individual. Located by many writers along with common sense in the anterior central ventricle, it was held to be the most powerful source of a host of maladies such as madness and melancholy. It was closely related to the passions, and worked by reproducing images in the absence of those objects they represented. It could recombine stored images and, when under the guidance of reason, worked so as to produce new images. A number of traditions stressed the dangers of an ungoverned fancy. Ficino and Paracelsus linked the imagination to magical medicine and in *De virtute imaginativa* Paracelsus argued that "imagination can cause disease, can cause dreadful disease . . . [it] is more than nature and rules it". Bacon claimed that the restoration of man involved "delivering and reducing" the mind from the deceptions of the imagination, while contemporaries like Burton complained that the deluding imagination would constantly "usurp no small authority to itself".[6]

In the wake of the civil wars in England, the power of the imagination was invoked to account for what many took to be the lawless fury of the radicals. One of the most significant writers on this issue was Henry More, whose *Enthusiasmus triumphatus* of 1656 and *Immortality of the soul* of 1659 offered a mixture of evidence on the soul and the imagination drawn from anecdotal, philosophical, medical and theological sources. In the remainder of this paper, I look at More's work and then the use by Isaac Newton of this material and of other texts by authors such as Thomas Hobbes and Joseph Glanvill. I look at how Newton maintained a practical and experimental interest in the problem of self-movement throughout his career, a project which was sustained by means of a number of medical, alchemical and chemical researches. I conclude by looking at how he publicly presented the experience of free will and self-motion as an undeniable fact which pointed to the existence of non-mechanical laws of nature.[7]

[5] Willis, *Cerebri anatome: cui accessit nervorum descriptio et usus*, London, 1664, p. 53; R G Frank, Jr, 'Thomas Willis and his circle: brain and mind in seventeenth-century medicine', in Rousseau (ed.), op. cit., note 2 above, pp. 107–8; Bynum, op. cit., note 2 above, p. 456. For a general history of the understanding of the brain, see E Clarke and K Dewhurst, *An illustrated history of brain function*, Oxford, Sandford Publications, 1972.

[6] Park, op. cit., note 4 above, p. 471; Francis Bacon, *Novum organon*, in J Spedding, R L Ellis, and D D Heath (eds), *The works of Francis Bacon*, 7 vols, London, Longman, 1857–61, vol.1, p. 49; and in particular Schwartz, op. cit., note 3 above, 48–53. For the secondary literature on the imagination see M W Bundy, *The theory of imagination in Classical and Medieval thought*, Urbana, University of Illinois Press, 1927; L J Rather, 'Thomas Fienus (1567–1631), dialectical investigation of the imagination as cause and cure of bodily disease', *Bull. Hist. Med.*, 1967, **41**: 349–67; E Fischer-Homberger, 'On the medical history of the doctrine of the imagination', *Psychol. Med.*, 1979, **9**: 619–28, and B C Southgate, '"The power of imagination": psychological explanations in mid-seventeenth century England', *Hist. Sci.*, 1992, **30**: 281–94.

[7] More, *Enthusiasmus triumphatus; or, a brief discourse of the nature, causes, kinds and cure of enthusiasm*, London, 1656; *idem*, *The immortality of the soul. So farre forth as it is demonstrable from the*

1. The soul of Henry More

In response to the descriptions of the soul in the writings of a host of authors including Descartes, Walter Charleton and Hobbes, Henry More published his *Immortality of the soul* in 1659. He began from a series of considerations about the state of the soul and the experience of free will on the Hobbesian assumption that perception and consciousness were nothing but "Corporeal Motion and Reaction", or conversely, that matter could sense or even think. If there were nothing but matter in the world, then of course Hobbes was correct, but this could not explain phenomena such as the sense one has of being free to move one's own body, or the well-attested capacity of a woman's imagination to work on her embryo. Moreover, we appeared to have an awareness of an internal power "to cleave to that which is virtuous and honest, or to yield to pleasures, or other vile advantages". More reconciled one's sense of freedom with Divine omniscience by remarking that although we had a faculty of free will, the soul was "not alwaies in a state of acting according to it". It could be "Heroically Good"—"though that happen in very few"—or degenerate to the extent that "it may be as certainly known what she will doe upon this or that occasion, as what an hungry Dog will doe when a crust is offered him". This was "the generall condition of almost all men in most occurrencies of their lives".[8]

If all we were was simply matter in motion, then, More proceeded to prove, "the seat of common sense" or Common Sensorium was neither the whole body, the orifice of the stomach, the heart, the brain, the septum lucidum nor the conarion [i.e. the pineal gland]. If the soul was in the body, then (contra Hobbes) it must indeed be in the head, as a number of experiments showed:

> I have seen with mine own eyes a *Frog* quite exenterated, heart, stomack, guts and all taken out by an ingenious friend of mine, and dextrous Anatomist, after which the *Frog* could see, and would avoid any object in its way, and skipped as nimbly and freely up and down, as when it was entire, and that for a great while. But a very little wound in the *Head* deprives them immediately of Life and Motion. Whence it is plain that the derivation of Sense and Spontaneous Motion is not from the *Heart*.

Moreover, when nerves were ligated, one had feeling on the head's side of the binding but not on the other, while in the cases of diseases which "deprave a mans Imagination and Judgement; Physitians alwaies conclude something amiss within the *Cranium*".[9]

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knowledge of nature and the light of reason, London, 1659; I use the edition in the *Collected works* of 1662. See also J Henry, 'The matter of souls: medical theory and theology in seventeenth century England', in R French and A Wear (eds), *The medical revolution of the seventeenth century*, Cambridge University Press, 1989, pp. 87–113.

[8] More, *Immortality*, op. cit., note 7 above, sig. A4, pp. 134, 151–2. The commonplace of the mother's imagination working on the development of the foetus is mentioned at pp. 95, 105–7 and 299; for good accounts of this phenomenon see P Boucé, 'Imagination, pregnant women and monsters, in eighteenth-century England and France', in G Rousseau and R Porter (eds), *Sexual underworlds of the Enlightenment*, Manchester University Press, 1987, pp. 86–100, and P Wilson, '"Out of sight, out of mind?" The Daniel Turner-James Blondel dispute over the power of the maternal imagination', *Ann. Sci.*, 1992, **49**: 63–85. For the contexts of More's work on the soul, see John Henry, 'Medicine and pneumatology: Henry More, Richard Baxter, and Francis Glisson's *Treatise on the energetic nature of substance*', *Med. Hist.*, 1989, **31**: 15–40, and *idem*, 'A Cambridge Platonist's materialism. Henry More and the concept of soul', *J. Warburg and Courtauld Institutes*, 1986, **49**: 172–95. For the theological issues surrounding the problem of free will, see J B Korolec, 'Free will and free choice', in N Kretzman, A Kenny and J Pimberg (eds), *The Cambridge history of later Medieval philosophy*, Cambridge University Press, 1982.

[9] More, *Immortality*, op. cit., note 7 above, pp. 154–60, 190, 191.

Within the brain, a number of different sites were possible for the location of the soul. Although Descartes' notion of the conarion as the seat of the soul had been subjected to intense criticism, More defended its plausibility. While the nerves which met at the beginning of the spinal marrow appeared to be a much more noble place for the soul than the conarion, in fact when the nerves got into the brain, "they are devoid of Tunicles, and be so soft and spongy, that the motion of the Spirits can play through them, and therefore . . . they might ray through the sides, and so continue their motion to the *Conarion* . . .". Nevertheless, the conarion appeared to be a region which housed a number of "stones", and More admitted that it was "environ'd with a net of veines and arteries which are indications that it is a part assigned for some more inferiour office". This being so, the most likely place for the soul was in the animal spirits in the so called "fourth ventricle" of the brain.[10]

In this ventricle, the "thinner matter" which was termed the "animal spirits" was found in its "greatest purity and plenty", and even those who had followed Hippocrates in placing the common sensorium in the heart had done so because they believed that its left ventricle "was the fountain of these pure and subtile spirits . . .". The significance of these spiritous entities was confirmed by an "ocular demonstration" of Henricus Regius which More took to be "both ingenious and solid". This involved the observation of a shell-less snail which was moving in a glass:

> so soon as she begins to creep, certain Bubbles are discovered to move from her tail to her head; but so soon as she ceases moving, those Bubbles cease. Whence he concludes, That a gale of spirits that circuit from her head along her back to her tail, and thence along her belly to her head again, is the cause of her progressive motion.

The spirits were the "immediate instruments of sense and motion", as well being the chief organs of sight. This was clear from the fact that "dimness of sight comes from deficiency of these spirits . . ." and the common experience that when one's leg reawakens having "gone to sleep", one "may plainly feel something creep into it tingling and stinging like Pismires . . . which can be nothing but the Spirits forcing their passage into the part". In the light of these considerations he concluded that the function of the brain and nerves was to "keep these *subtile Spirits* from over speedy dissipation".[11]

There were significant objections to this conception which More fended off with customary braggadocio. Some had argued that the nerves contained a "milky white juice" and were unsuitable for the passage of the spirits, while others maintained that the brain's ventricles were too big for the purpose given them by More and were intended only for "receptacles and conveyances of such excrementitious Humours which the Brain discharges itself of". Furthermore, if these spirits were the means by which spontaneous motion were achieved, then "it could never be so sudden as it is, for we can wag our finger as quick as thoughts, but corporeal motion cannot be so swift". More replied that the nerves had to be porous, allowing for the easy passage of these spirits, for how otherwise did they derive their juice? The motion was instantaneous because it took place by pressure, just like sunlight does "through the aetherial Matter betwixt". Finally, whether or not the brain had the function assigned to them by his critics,

[10] Ibid., pp. 195–6, 197.

[11] Ibid., pp. 199–200, 203, 204–5, 207, 208.

The Diastole . . . of the Brain keeping time with the pulse of the Heart, is a manifest indication, what a vehement steam of Spirits, by the direct and short passage of the *Arteriae Carotides*, are carried thither. For if one part of the Blood be more fiery and subtill than another, it will be sure to reach the Head.[12]

The soul was diffused throughout the body at its earliest stages of growth and indeed supervised its development, while the movements of the heart and lungs were more than mechanical and were carried out by means of a "plastick power". This pervasiveness of the soul explained passions and "sympathies" and, whereas Descartes had used the phenomenon of a man's involuntary winking at the shake of another's hand near his face to argue for a purely corporeal reflex to all such situations, More argued that not all these responses were mechanical. The soul operated in many of these responses such as that of reacting to a terrifying monster: "it is the effect of her as she resides in the *Heart* and *Stomack*, which sympathize with the horrid representation in the Common *Sensorium*". This was put down to the "exquisite unity of the Soul with her self". Likewise, vision required the existence of a soul extended all the way from the sensorium to the eye, for otherwise the colours of the things seen would be confounded and "the bigness of the Object diminished". More explained this by pointing to the path that the inverted image took from the retina to the optic nerve; without the presence of the soul to keep the initial image intact, it would become confused en route by the "depainture of sundry colours" already present on the retina.[13]

Having located the soul, it was possible to account for other bodily phenomena. It was obvious, for example, that the imagination's seat of action was in the animal spirits in the fourth ventricle. Following the analysis in his *Enthusiasmus triumphatus* of 1656, More argued that the imagination—used in "*Romantick Inventions*, or such as accompany the more severe Meditations and Disquisitions in Philosophy, or any other Intellectual entertainments"—was aided by "fasting, fresh Aire, moderate Wine, and all things that tend to an handsome supply and depuration of the Spirits . . .". This was also the setting for the exercise of memory, which could not be reduced to the physical transformation of the brain in the shape of the things it represented. Again, animal spirits were essential for the proper functioning of this faculty, which he re-examined in a section on the preexistence of souls. Here he recounted a host of examples of individuals whose memory had been blighted by disease and violence, such as Messala Corvinus, who forgot his own name, another, who lost "all his learning" by means of "a blow with a stone", and "a young student of *Montpelier*, [who] by a wound, lost his memory so, that he was fain to be taught the letters of the Alphabet again".[14]

Animal spirits also explained spontaneous motion which was performed "by the continuation of the *Spirits* from the seat of common sense to the *Muscles*, which is the gross Engine of motion". The precise manner in which this took place, More continued,

[12] Ibid., pp. 209–10, 211–14. For an account of knowledge of nerves in this period, see E Clarke, 'The doctrine of the hollow nerve in the seventeenth and eighteenth centuries', in L G Stevenson and R P Multhauf (eds), *Medicine, science and culture*, Baltimore, John Hopkins Press, 1968, pp. 123–41.

[13] More, *Immortality*, op. cit., note 7 above, pp. 217–18, 219, 220, 223–4.

[14] Ibid., pp. 228–9, 231–2, 255–6. There is a more elaborate analysis of imagination and its operation in the behaviour of enthusiasts and atheists in *Enthusiasmus triumphatus*, which drew heavily from Fienus's *De viribus imaginationis*, and Burton's *Anatomy of melancholy*.

"we partly feel and see; that is to say, we find in ourselves a power, at our own pleasure to move this or the other member with very great force, and that the Muscle swells that moves the part . . .". This clearly showed the "influx of Spirits, thither directed or there guided by our meer will". It was the "vinous" animal spirits that swelled the muscles, and More "look[ed] upon the Fibrous part of the Muscle as the main engine of motion". The soul "moistens" these fibrous parts with "that subtle liquor of the Animal Spirits", and this makes them "swell and shrink, like Lute-strings in rainy weather". This was the main cause of the "notable strength of our Limbs in Spontaneous motion".[15]

Once this explanatory system was in place, there was no need to seek any further for hypotheses. The fact that such spirits had been seen in the fibrous matter of the muscles and the experience of our control over our own body was "sufficient to salve all Phaenomena of this kind". Spontaneous motion happens because the soul is extended throughout the body and that part of it which is in the muscles "guides the Spirits into such Pores and parts, as is most requisite for the shewing the use of this excellent Fabrick . . . by a power near a-kin to that by which she made the Body and the Organs thereof". By these means humans could walk and play music without thinking about the processes involved.[16]

Medico-theological projects which aimed to tease out the home of the soul and which claimed to be able to explain the complexities of mind-body interaction formed an integral part of the work of early modern divines and natural philosophers. Within this genre, More's books formed a particularly useful resource in the aftermath of the Restoration of 1660, since they pointed out how godly academics might steer a path between atheistic and enthusiastic models of the action of the soul. One intellectual who swiftly picked up More's approach as a basis for his own was Isaac Newton. More's system, and in particular his view of the soul was not directly embraced by him although he did succeed in transforming More's approach into an experimental programme, and he took much of the empirical evidence in *The immortality of the soul* at face value. In the next section I look at how Newton created an experimental project aimed at elucidating the workings of the soul from his reading of a series of texts by More, Joseph Glanvill, Walter Charleton, and Thomas Hobbes. In so doing, Newton was also concerned with avoiding the deleterious theological and political consequences of ungodly accounts of the soul.

2. The Brain of Isaac Newton

Although he is of course best known for his work in mathematics, optics and mechanics, recent studies have suggested that alchemy and theology played central roles in Newton's private intellectual life. Indeed, as his unpublished manuscripts have been progressively examined from the 1950s to the present day, it has become increasingly apparent that he does not wholly fit the Enlightenment depiction of him as the archetypal rational mechanical philosopher. In the rest of this paper, I want to enhance the unorthodox picture of his private concerns still further by showing that his attempts to explain the action of the human soul upon the body formed a central interest from the very beginning of his researches at Cambridge, right up to his battles with Gottfried Leibniz

[15] More, *Immortality*, op. cit., note 7 above, pp. 231–2, 255–6.

[16] Ibid., pp. 233, 234.

nearly sixty years later. This project started as an attempt to determine the limits of mechanical aspects of vision and the workings of memory and the imagination; later it turned into a phenomenal truth according to which Newton asserted that the very *fact* of our capacity to move our own bodies—regardless of how this was accomplished—demonstrated that there was a limit to mechanistic accounts of the workings of the world. This did not mean that natural philosophy was incapable of determining how this extraordinary facility was performed. Indeed, Newton was adamant that only a proper understanding of this process could shed light on the relationship between God and his creation.

In June 1691, he wrote a letter to John Locke thanking him for his attempt to use his influence in procuring a place for Newton at the Mint and questioning Locke's hermeneutic identification of Christ with the Ancient of Days. He went on to respond to a question raised by Locke concerning an experiment in Boyle's Book of Colours which, he admitted, "I once made upon my self with y^{e} hazzard of my eyes". This involved looking "a very little while upon y^{e} sun in a looking glass wth my right eye", and then looking at the colours of the impressions made when winking in the direction of a dark corner of his chamber "to observe the impression made & the circles of colours w^{ch} encompassed it & how they decayed by degrees & at last vanished". This was repeated twice, after which he waited until "the phantasm of light & colours about it were almost vanished", when

> intending my phansy upon them to see their last appearance I found to my amazemt that they began to return & by little & little to become as lively & vivid as when I had newly looked upon y^{e} sun. But when I ceased to intende my phansy upon them they vanished again.

After this, Newton found he could make the "phantasm" return, without looking at the sun.[17]

In time, strange things happened. When he looked on a bright object, he "saw upon it a round bright spot of light like y^{e} sun". And so long as he "intended [his] phansy a little while" upon bright objects, this "phansy" began to make an impression on his left eye as well as his right, even though he had used only his right eye for the experiment. Each time, the effort required to do this was lessened, and soon Newton was unable to avoid seeing the sun wherever he looked, so much so that he had to shut himself up in his "chamber made dark for three days together & used all means to divert my imagination from y^{e} Sun". By remaining in the dark and "imploying [his] mind about other things" he was able to use his eyes again, though for the next few months: "the spectrum of the sun began to return as often as I began to meditate upon y^{e} phaenomenon, even tho I lay in bed at midnight with the curtains drawn". On top of this, he told Locke that he could probably make the image reappear "by the power of my phansy". Having finished telling this tale, he told Locke that the peculiar phenomenon related by Boyle, in which a man constantly saw the "phantasm" of the sun in bright objects, probably involved a concurrence of the man's "phansy" and the "impression made by y^{e} sun's light":

[17] Newton to Locke, 30 June 1691, in A R Hall, *et al.* (eds), *The correspondence of Isaac Newton*, 7 vols, Cambridge University Press, 1959–81, vol. 3, pp. 152–54, p. 153. Sixty years after the events, the same experiment was recounted to Conduitt in the mid 1720s; cf. King's College, Cambridge, Keynes Ms. 130 (15).

and so your question about y^e cause of this phantasm involves another about y^e power of phansy w^{ch} I must confess is too hard a knot for me to untye. To place this effect in a constant motion is hard because y^e Sun ought then to appeare perpetually. It seems rather to consist in a disposition of y^e sensorium to move y^e imagination strongly & to be easily moved both by y^e imagination & by y^e light as often as bright objects are looked upon.[18]

Newton's problem involved the function and location of the soul, the sensorium and the imagination, issues which captivated his interest right up to the end of his life and which went back to some of the earliest researches of his student days. His early notebook detailing these investigations constitutes an experimental programme based on carefully chosen notes from a number of sources. The basis of this programme was the search for the precise roles of the soul and the "outside" world in contributing to experience and knowledge, and under a heading initially entitled 'Occult Qualityes' but then changed to 'Philosophy', he noted that the nature of things was "more securely and naturally deduced from their operacouns one upon another y^n upon or senses". When this was done by experiments and "we have found y^e Nature of Bodys, by y^e latter we may more clearly find the Nature of or senses". But as long as we "are ignorant of y^e nature of both soule and body, we cannot clearly distinguish how far an act of sensation proceeds from y^e soul and how far from the body". Indeed, the last aspect of this formulation appeared to be the goal of Newton's researches. What was the moral and mental topology of the brain? What powers did the soul possess?

To answer the topological issue, Newton read a number of different works, the most significant of which was More's *The immortality of the soul.* Information from More such as "to them of Java Pepper is cold" (under the heading 'Of Sensation') helped him formulate basic principles such as that "the senses of men are diversely affected by the same objects according to the diversity of their constitution". More was a fund of other material, such as ten possible sources for the location of the soul, and Newton drew liberally from the wealth of anecdotal and empirical information in his book:

A frog's braine being peirced it looseth both sence and motion but it will leape and have its sence though its bowells bee taken out. Phisitians find y^e causes of lethargies Apoplexies Epilepsies &c diseases y^t seiz on y^e Animall functions in y^e head. Unles y^e braine be peirced so deepe as to reach y^e ventricles y^e wound will not take away sence & motion. A man cannot see through y^e hole w^{ch} a trepan makes in his head. Stones have beene found in y^e glandula pinealis & it is invironed with a net of veines & arteries. A Vertigo must be from y^e turning round of y^e spirits. The least weight upon a mans braine when hee is trepanned maketh him wholly devoyd of sensation & motion.[19]

From these examples it is clear that he was fascinated both by the different responses of men to the same objects, and by the often negligible role of the soul in the performance of bodily activity. In a note entitled 'Of Motion', for example, he took down Joseph Glanvill's example of an artist who "plays a lesson not minding a stroke [and] sings neither minding nor missing a note", and argued—again using data from *The immortality of the soul*—that "the motion of y^e stomack in vomitting (though wholly against our will

[18] Hall, *et al.* (eds), op. cit., note 17 above, vol. 1, pp. 153–4.

[19] J E McGuire and M Tamny (eds), *Certain philosophical questions: Newton's Trinity notebook,* Cambridge University Press, 1983, pp. 377, 383–4 (from CUL Add. Ms. 3996). I cite the transcriptions in this edition.

and therefore merely mechanicall) by y^e touch of a whalebone only", was a much better demonstration that "y^e actions of brutes to be mechanicall & independent of soules, than Chartes his instance of y^e winking at y^e shaking of a friends hand by y^e eye". Continuing this line of enquiry, he noted the passage from More on the visible causes of a snail's motion, and compared this to a critique of a revolving wheel in Glanvill's *Vanity of dogmatizing*.[20]

In spite of this appreciation of the possible significance of mechanical motion in human action, there was a vast realm of behaviour which could not be reduced to mechanism. In a section entitled 'Of y^e soule', he followed More in rejecting Hobbes' materialism although he concurred with the author of *De corpore* that "probably y^e soule perceives noe bodys but by y^e helpe of their motion", Nevertheless (in an argument recollected in his letter to Locke), he claimed that thought could not be reduced to matter in motion, because then we would never be able to recall anything to memory. For "so long as y^t action continews we must thinke of & remember y^t phantasme", and not before that action ceases can we stop thinking of it in order to remember it. But if the act of remembering is itself merely matter in motion, "how shall we call this thing into memory y^e action being done & we haveing no principle w^{th} in us to begin such a motion againe w^{th}in us [?]" In the light of these notes on Hobbes he then considered why it was that we perceived images to be outside our bodies when they were actually experienced in the sensorium. Although such operations took place somewhere in the brain, we did not *see* the brain "it not being in motion, & probably y^e soule perceives noe bodys but by y^e helpe of their motion". Images appear to be outside our bodies because "in y^e image of things delineated in the braine by sight, y^e bodys image is placed in y^e midst of y^e images of other things, is moved at or command towars & from those other images".[21]

Such considerations privileged the "principle" within us which began motion and which exercised control over the position of the body with respect to the outside world. In his quest for the seat of the soul—the place of this "principle"—Newton turned to the location of imagination, and indeed his startling experiments on his own eyes were initially entered in a section entitled 'Immagination. & Phantasie & invention.' Towards this end, he took down conventional lore surrounding the optimal body and control of the fancy for the scholar:

> We can fancie y^e thing wee see in a right posture w^{th} y^e heeles upward. Phantasie is helped by good aire fasting moderate wine but spoiled by ~~not~~ drunkenesse. Gluttony, too much study, (whence & from extreame passion cometh madnesse) dizzinesse, commotions of y^e spirits. Meditation heates a y^e ~~oun~~ braine in some to distraction in others to an akeing & dizzinesse. The boyling blood of youth puts y^e spirits upon too much motion or else causet too many spirits, but could [i.e. old] age makes y^e brain either two dry to move roundly through or else is defective of spirits yet theire memory is bad. A man by heitning his fansie & immagination may bind anothers to thinke what hee thinks as in y^e story of y^e Oxford Scollar in Glanvill Van of Dogmatizing.[22]

[20] Ibid., pp. 418–20.

[21] Ibid., pp. 448, 450, 452. He dutifully noted the sections in *The immortality of the soul* which pertained to the causes of memory loss in 'Of Memory', ibid., pp. 392–4 (but cf. p. 450).

[22] Ibid., pp. 394–6. Throughout, struckthrough words indicate deletions. The occupational hazard of the scholar was melancholy, which if severe was reckoned by contemporaries to be a species of madness. See L Babb, *The Elizabethan malady: a study of melancholia from 1580–1642*, East Lansing, Michigan State College Press, 1951, especially pp. 25–42, and MacDonald, op. cit., note 3 above, p. 28.

In the notebook, this section on the imagination continues with the report of his optical self-experiment (although this was added some time later), but about the same time that he was taking these notes (in mid 1664), he was already considering the extent to which vision might be due to motion. Under the heading 'Of light', he suggested that "light cannot be by pression, for y^{n} wee should see in y^{e} night a wel or better y^{n} in y^{e} day we should se a bright light above us because we are pressed downwards" while "A man goeing or running would see in y^{e} night". Similarly, in 'Of Vision', he remarked that relative permanency was required for perfect vision "thus a coale whirled round is not like a coale but fiery circle". A Morean note on the role of spirits in the functioning of vision was followed by some physiological considerations about the capillaments of the optic nerve, in order to explain why it was that we did not see two images. Again, his central concern was the distinction between the mechanical and the voluntary movements of the eye and the fancy. Some time later, he attempted to resolve these issues by means of a series of eye experiments.[23]

The reports of these trials suddenly appeared in a section on the imagination and fantasy. He remarked on how when he had finished looking at the sun, "I ~~shut my eyes & there appeared nothing untill I strongly fancied y^{e} ⊙ to be befo~~ all light couloured bodys appeared red & darke coloured bodys appeared ~~red~~ blew". When the motion of spirits in his eye had almost "decayed", so that he "could see all things w^{th} their natur colours", he shut the eye again and "could see noe colour or image till I heightned my fantasie of seeing ⊙ . . .". The conclusion of this part of his investigation was that "I gather my Phantasie & y^{e} ⊙ had y^{e} same operation uppon y^{e} ~~optick~~ spirits in my optick nerve & y^{t} y^{e} same motions are caused in my braines by both". He looked on some white paper and "by means of a strong phantasie" saw a spot which was darker than the paper, and he saw the same "phantasme" when looking at a bright cloud until at last he was able to make the spot glitter against the background of a "dusky red (whither I look upon y^{e} paper or cloude) like y^{e} ⊙ in a cloud so bight my eys watered".[24]

Although—as he later confessed to Locke—this seriously damaged his eyes and resulted in his confinement to bed for a number of days, this was not before the same experiments had been rigorously retried: "Imploying my selfe in other exercises for two or 3 howers ["an hower before ⊙ sed [i.e. set] hee being wholly clouded" added] when I thought my eye was prety well restored I repeated all y^{e} former experiment". A slight variation was that now when he looked at clouds with his good eye, "I could see y^{e} ⊙ pictured on y^{e} cloudes or other white objects almost as plaine as if I had looked w^{th} my distempered ey y^{e} other being shut ["& every where about ⊙ appeared a dusky red & blacknesse" added]". At the end of all this, his visual machinery was wrecked: "I made such impress on y^{e} optick nerve y^{t} let me looke w^{th} w^{ch} eye I would ⊙ offered itself to my vew unless I set my fantasie to work on other things w^{ch} w^{th} much difficulty I could doe". When the impress of the sun's image was not permanently in view, "I could easily imagine severall shapes ~~to be where I usually appre~~ as if I saw y^{m} in y^{e} ⊙ s place", from which "perhaps may be gathered y^{t} y^{e} tenderest sight argues y^{e} clearest fantasie of things visible & hence something of y^{e} nature of madnesse & dreames may be gathered". This last entry

[23] McGuire and Tamny (eds), op. cit., note 19 above, pp. 380, 382, 386.

[24] Ibid., pp. 396, 442–4. ⊙ was conventional shorthand for gold or (as in this case) the sun.

shows how Newton's programme in these operations was premissed on the understanding of an intimate connection between his optical work and the more general account of the body's operations evidenced by his notes from More, Hobbes and Glanvill.[25]

Some time after these researches, he performed some of them again in an even more radical manner. He put a bodkin between the eyeball and socket "as neare to y^e backside of y^e eye as I could". A number of circles appeared if he continued to rub his eye with the end of the bodkin, but the images grew fainter if he held his eye and the bodkin still and they "would grow fainte & often disappeare untill I renewed y^m by moving my eye or y^e bodkin". Perhaps, he suggested of another experiment in which a variegated series of colours had appeared to the sight, "y^e spirits were strained out of y^e Retina . . . or otherways made incapable of being acted upon by light & soe made a lesse appearance of light y^n y^e rest of y^e Retina".[26]

This was followed by an account of a dissection of an optic nerve. Newton argued that each point in the retina of one eye had a corresponding point in the other eye, and from these two points ran "two very slender pipes, filled w^{th} a most lympid liquor . . . w^{th}out either interruption or any other uneavenesse or irregularity". These joined up on one side of the brain "& there unite into one pipe as big as both of them, & so continue in one passing . . . into y^e brain where they are terminated". This place was "perhaps at y^e next meeting of y^e nerves twixt y^e Cerebrum & cerebellum, in y^e same order that their extremitys were scituate in the Retinals". From these observations it was clear why two retinal images made one image in the brain, and why two things could not appear in the same place, namely because both could not "be carried on y^e same pipes . . . into y^e braine, that w^{ch} is strongest or most helped by fantacy will there prevaile and blot out the other".[27]

In the place where information from both sides of the brain arrived at a contact point, "by their externall figure they seeme as if the capillamenta concentered like y^e radij of a hemisphere to a point in y^e lower part of the juncture". This was the probable location of the "visive faculty", for why otherwise "doe the nerves swell there to so great a bulke as it were preparing for their last office . . ."? This was where the cerebral texture was the finest, "in y^e midst of the brain, constituting y^e upper part of that small passage twixt all

[25] Ibid., p. 444. Newton later took notes from Boyle on "tender" sight and hearing; see CUL Add. Ms. 3975 fol. 22. For the relationship between sensitivity and madness, see G Speak, '"An odd kind of melancholy": reflections on the glass delusion in Europe (1440–1680)', *Hist. Psychiatry*, 1990, **1**: 191–206, and for madness in general, see R Porter, *Mind-forg'd manacles: a history of madness in England from the Restoration to the Regency*, London, Athlone Press 1987. In his graduate notebook Newton set down some queries concerning whether the soul, being seemingly able to remember some dreams while one is awake, "be perpetually employed in sleepe", and he went on to ask accordingly if "dreames are of y^e body or soule"; see McGuire and Tamny, op. cit., note 19 above, p. 452.

[26] CUL Add. Ms. 3975 fols 15–18, reproduced in McGuire and Tamny, op. cit., note 19 above, pp. 482–8. For his early account of the dissection of a sheep's eyeball, see his 'Description of the optick nerves and their juncture in the brain', printed in D Brewster, *Memoirs of the life, writings and discoveries of Sir Isaac Newton*, 2 vols, Edinburgh, T Constable, 1855, vol. 1, pp. 432–6. On the manuscript (CUL Add. Ms. 3970 fol. 650^r) Newton noted: "I was prevented by an accident from taking y^e distance of y^e Christalline Humor from y^e Horny Tunick w^{ch} I would gladly have done to have had y^e conformity of all y^e Parts one to another in one & the same eye." For his views on this subject in the early 1680s see his letters to William Briggs in Hall, *et al.*, op. cit., note 17 above, vol. 2, pp. 377–8, 381–5 and 417–19.

[27] McGuire and Tamny, op. cit, note 19 above, pp. 484–6. For later use of this material in post-1706 drafts for the *Opticks*, see CUL Add. Ms. 3970 fol. 233^r, and for the final version in the 1717/18 edition see *Opticks*, reprint, New York, Dover, 1979, pp. 346–7 and 353–4.

y^e ventricles". Light hit the retina and the vibration caused thereby produced a motion which was either carried to the sensorium or produced other motions. Water was too coarse a substance to carry this motion intact, while as for the putative role of animal spirits in this process, "though I lyed a peice of y^e optick nerve at one end & warmed it in y^e middle to see if any aery substance by that meanes would disclose it selfe in bubbles at the other end, I could not spy the least bubble; a little moisture only & y^e marrow it selfe squeezed out".[28]

There was no need to suppose the existence of such fine particles, a hypothesis which in any case was liable to the problem that if such matter could enter the pores of the brain and nerves it "would be too subtil to bee imprisoned by y^e dura mater & Skull". Such a conjecture was redundant since

> Motion is ever lost by communication especially twixt bodys of different constitutions: and therefore it can noe way bee conveyed to y^e sensorium so entirely as by the aether it selfe. Nay granting mee but that there are pipes fill'd w^{th} a pure transparent liquor passing from y^e ey to y^e sensorium & y^e vibrating motion of y^e aether will of necessity run along thither . . . y^t motion cannot stray through y^e reflecting surfaces of y^e pipe but must run along (like a sound in a trunk) intire to y^e sensorium.

This, Newton suggested, was "conformable to the sense of hearing w^{ch} is made by like vibrations", while the whiteness of the brain and nerves implied extraordinarily slender vessels. "Its pretty", he concluded, "to consider how these agree w^{th} the utmost distinctnesse in vision".[29]

3. Trepanning the aether

By the end of the 1660s, Newton had performed a number of dissections and related experiments to divine for himself how information might travel to and from the brain by means of the nerves and visual capillamenta. Implicit in this programme was a view of the role of the imagination in producing vision, as well as an account of the way in which the sensorium might control the motions of the muscles. His concern with this project continued into the 1670s and was further explored with the tools which he was developing in alchemy and which were related to biological issues. Betty Dobbs has recently argued that in a brief series of alchemical propositions from about 1669 (Keynes Ms. 12A), he was already showing his belief in a living vegetable chemistry, while this is clearly visible in two major writings of the early to mid 1670s. In the 1669 manuscript he spoke of a vitalistic alchemical agent and "fermental virtue" or "magnesia" which "accommodates itself to every nature. From metallic semen it generates gold, from human [semen] men etc.". In a work from the early 1670s called 'Of Nature's Obvious Laws and processes in vegetation' he argued that the earth resembled "a great animall ["or rather inanimate vegetable" added]", which "draws in aetheriall breath for its dayly refreshment and vital ferment and transpires again w^{th} gross exhalations". The aether was "probably a vehicle to some more active sp^t. & y^e bodys may bee concreted of both together", while "in y^e aether y^e sp^t is intangled". This spirit was the "material soule of all matter" and "perhaps

[28] McGuire and Tamny, op. cit., note 19 above, pp. 487–8.

[29] Ibid., pp. 488.

the body of light", on the grounds (amongst other things) that both "have a prodigious active principle ["both are perpetuall workers" added]" and "heate exites light & light exites heat, heat excites y^{e} vegetable principle & that ~~excites~~ increaseth heat". Whatever its precise nature, it was an aetherial agent which was the "only principle and ferment of all vegetation" and

> There is therefore besides y^{e} sensible changes wrought in y^{e} textures of y^{e} grosser matter a more subtile, secret & noble ~~change wrought~~ ["way of working" added] in all vegetation which makes its products distinct from all others & y^{e} immeadiate seate of thes operations is not y^{e} whole bulk of matter, but rather an exceeding subtile & ["inimaginably" added] small portion of matter diffused through the masse, w^{ch} if it were seperated, there would remain but a dead & inactive earth.

He proposed to examine the union of the soul with the body by these means and it was not long before his interest in life and self-motion was heard by a much wider audience.[30]

It became known to a small group of people in the mid 1670s that he had immersed himself in these chemical pursuits, and John Collins told James Gregory in October 1675 that he had not seen Newton for nearly a year, "not troubling him as being intent upon Chimicall Studies and practises, and both he and Dr Barrow &c beginning to thinke math^{call} Speculations to grow at least nice and dry, if not somewhat barren". 'Of Nature's Obvious Laws' was re-used for the alchemical portions of the 'Hypothesis' which he composed in November and December 1675 as a hopeful means of ending disputes over his notions of light and colours. In the version of this which he sent to Oldenburg on the 7 December, he inserted a number of alchemical phrases. In the printed version, he argued that Nature was perhaps composed of "nothing but various Contextures of some certaine aetheriall Spirits or vapours condens'd as it were by praecipitation, much after the manner that vapours are condensed into water or exhalations into grosser substances", although this replaced a manuscript version in which he had stated that Nature "may be nothing but aether condensed by a fermental principle". He cited electricity as an example which demonstrated that "something of an aetheriall Nature" seemed to be condensed in bodies, and in the initial version he argued that a similar aetherial spirit might be "condensed in fermenting or burning bodies, or otherwise inspissated in y^{e} pores of y^{e} to a tender matter w^{ch} may be as it were y^{e} succus nutritious of y^{e} earth or primary substance out of w^{ch} things generable grow". In a passage retained in the version published in the *Philosophical Transactions*, he proposed that the Earth, "w^{ch} may be evry where to the very centre in perpetuall working, may continually condense so much of this Spirit as to cause it from above to descend with great celerity for a supply".[31]

30 Smithsonian Institute, Dibner MSS. 1031B, fols 3^{v} and 5^{v} , now printed in B J T Dobbs, *The Janus face of genius. The role of alchemy in Newton's thought*, Cambridge University Press, 1991, pp. 256–70, pp. 264 and 269. Compare with CUL Add. Ms. 3970 fol. 292^{r}: "(once light) enters into the composition of all bodies, why may it not be the chief principle of activity in them?" Cf. also Dobbs, op. cit., pp. 14, 24–5.

31 Collins to Gregory, 19 October 1675, in Hall, *et al.*, op. cit., note 17 above, vol. 1, pp. 355–6, p. 356. The 'Hypothesis' is printed in ibid., vol. 1, pp. 362–86 (cf. pp. 364–5). The version printed in Thomas Birch's *History of the Royal Society* has been republished in I B Cohen (ed.), *Isaac Newton's letters and papers on natural philosophy*, Cambridge, Mass., and London, Harvard University Press, 1978, pp. 177–235. The remarks about condensed aetherial spirits are lifted from a significant passage in 'Of Nature's Obvious Laws . . .' fol. 3^{v}; cf. Dobbs, op. cit., note 30 above, pp. 100–2 and 265.

Describing nature as a "perpetuall circulatory worker", he argued that like air the aether was much rarer in "the pores of chrystal, glass, water, and other Naturall bodyes" than in "free aethereall Spaces, & at so much a greater degree of rarity as the pores of the body are Smaller". From this it may be, "that Spirit of Wine, for instance, though a lighter body, yet haveing Subtiler parts & consequently Smaller pores then water, is the more Strongly refracting liquor". To an earlier draft of this paper he added a long section on the principles underlying self-motion, maintaining that a difference in density between the aethers outside and inside the body's muscles might explain what he called "that puzleing Problem"; namely "by what means the Muscles are contracted and dilated to cause Animal motion". He hoped that this could "receive greater Light from hence then from any other means men have hitherto been thinking on". For example, if a man could "condense & dilate at will the aether that pervades the muscle; that condensation or dilatation must vary the compression of the Muscle, made by the Ambient aether, & cause it to Swell or Shrinck accordingly". Water could not easily be compressed, but Spirit of Wine and Oil could, and he suggested that Boyle's experiment of "a Tadpole Shrinking very much by hard compressing the water in w^{ch} it Swam, is an Argument that Animal juices doe the same". Hence the aether in a muscle would swell or shrink according to its relative density to the ambient aether.[32]

The question of how muscles acted in various states had very recently been the focus of renewed attention by scholars such as Nicolaus Steno, Richard Lower and more particularly Thomas Willis and John Mayow. Willis outlined an account of muscular contraction using chemical principles in his *Cerebri anatome* of 1664 and in his *Pathologiae cerebri* of 1667. In 1664 he argued that contraction occurred when animal spirits from the nerves met up with "saline-sulphureous" particles from the arterial blood, whereupon the "copula" formed by the union of the two would break and give rise to an "explosion" when stimulated by the nerves. In *Pathologiae cerebri*, this explanatory system changed so that the explosive nature of muscular action was caused by a meeting of "spirituo-saline" particles from the nerves and "nitro-sulphurous" particles from the blood. In his *Tractatus duo* of 1668, Willis's student Mayow argued against this that Willis's theory implied that the two different kinds of particles had at some previous stage been conjoined in the brain—in which case why would the chemical explosion not happen there? Rather, Mayow developed his account of aerial nitre to suggest that "nitro-saline" particles travelled in the arterial blood to the muscles where they remained. Animal spirits produced in the brain were dispersed to the muscles by means of the nerves, and after contact between them an explosion and hence muscular contraction occurred.[33]

In 1670, Willis published a response to Nathaniel Highmore's treatise on hysteria and hypochondria to which he appended two tracts, one of which was a further assessment of

[32] Hall, *et al.*, op. cit., note 17 above, vol. 1, pp. 366–7. In the original autograph (CUL Add. Ms. 3970 fols 538^r–547^r) the section on self-motion is taken from another source and starts on a separate sheet; see ibid., fols 540^r–541^r. Boyle's experiments, actually carried out between August 1662 and May 1663, were initially published in 'New pneumatical experiments concerning respiration', *Philosophical Transactions*, 1670, **5:** 2011–31 and 2035–56 (especially 2041–3).

[33] Willis, op. cit., note 5 above, and *idem*, *Pathologiae cerebri et nervosi generis specimen*, London, 1667; J Mayow, *Tractatus duo. Quorum prior agit de respiratione: alter de rachitide*, Oxford, 1668. My account is based on R Frank, *Harvey and the Oxford physiologists. Scientific ideas and social interaction*, London, University of California Press, 1980, pp. 222–3 and 230–4, and M A Nayler, 'The insoluble problem: muscle in the mid to late seventeenth century', PhD thesis, University of Melbourne, 1993, pp. 335–452.

the causes of muscular motion. Incorporating Steno's recent work on muscle structure into his hypothesis, Willis now paid more attention to the question of how the "tender and immoveable Brain" could bring about muscular contraction by means of the "small and fragile nerves". Since such a situation could not be effected by the brain alone, the cause of violent contraction had to lie in the explosive potential of a meeting between the animal spirits supplied to the tendons or in the muscle itself, and a subtle sulphureous or nitrous liquor derived from the blood. The precise mechanism by which the brain regulated the flow of animal spirits in and out of the tendons was complicated in Willis's scheme, although it was this feature that controlled the extent of contraction. Finally, in the fourth book of Mayow's *Tractatus quinque* of 1674 (*De motu musculari et spiritibus animalis*), he reasserted his view that nitro-aerial spirit played the major role in animal motions although he concurred in general with Willis that muscular motion was caused by the admixture of two different sorts of particles, in Mayow's case nitro-aerial particles (usually but not always identified with the animal spirits) and saline sulphureous particles. In a departure from his previous position, he asserted that the nitro-aerial particles came into the muscle by means of the nerves and not the blood. Furthermore, he now believed, following researches of Lower and Steno, that muscle volume did not increase during contraction and hence could not be explained by inflation due to an explosion. Instead, he suggested that heat given off by the movement of the nitro-aerial particles caused the contraction of transverse fibrils of the muscle.[34]

These well-informed researches and speculations on the causes of muscle movement formed the context of a conversation that took place between Newton and Boyle in the spring of 1675, when the former visited London. In a letter of 14 December 1675 he asked Oldenburg to thank Boyle for the discourse in London during which they had discussed what Boyle had called Newton's "conceit of trapanning y^e^ common Ether". The sense of his reference to Boyle "entertain[ing]" this proposal "with a smile" is obscure, but the topic of their talk clearly related to his project of accounting for the physiology of animal motion, and he expressed his hope that when Boyle had "a set of exp^t^s to try in his air pump, he will make that one to see how y^e^ compression or relaxation of a muscle will shrink or swell, soften or harden, lengthen or shorten it". Although this would have been a more limited experiment involving the medium of air, Newton evidently hoped—to the apparent amusement of Boyle—that there might be some experimental means of manipulating the aether to see what effect this had on the muscle. The chemical notion of "sociability" offered him a way to do this.[35]

It was possible that the soul had "an imediate power over the whole aether in any part of the body to Swell or Shrink it at will", but this left unresolved the nature of the dependency of muscular motion on the nerves. Alternatively, it could be done by means of the soul acting upon the "aetheriall Spirit included within the *Dura Mater*", but "still

[34] T Willis, *Affectionum quae dicuntur hystericae et hypochondriacae pathologia spasmodica vindicata contra responsionem epistolarem Nathanael Highmore. M.D. Cui accesserunt exercitationes medico-physicae duae. 1. De sanguinis accessione. 2. De motu musculari*, London, 1670, pp. 40–4; Mayow, *Tractatus quinque medico-physici*, Oxford, 1674; Nayler, op. cit., note 33 above, pp. 419–34; Frank, op. cit., note 33 above, pp. 271–2. For a good account of the religious and social contexts of Willis's "rational" neurophysiology, see R L Martensen, '"Habit of Reason": anatomy and Anglicanism in Restoration England', *Bull. Hist. Med.*, 1992, **66**: 511–35.

[35] Hall, *et al.* (eds), op. cit., note 17 above, vol. 1, p. 393.

theres a difficulty why this force of the soule upon it does not take off the power of its Springines whereby it should susteyne more or less the force of the Outward AEther". A third possiblility was that the Soul could *directly* instill this spirit into any muscle by means of the nerves, but this foundered on the difficulty of conceiving how the "tender matter" of the brain could accomplish "a forcible intending the Spring of the aether in the muscles by pressure". Drawing from his earlier researches on the optic nerve, he argued that the spirit was so subtle on this assumption that there appeared to be no good reason why it should not "go away through the *Dura Mater* & Skins of the muscle . . .".[36]

Instead, he now conceived of a number of "Animal Spirits . . . of an aethereall Nature, Subtile enough to pervade the Animal juices as freely as the Electric or perhaps Magnetic effluvia do glass". One might imagine how the "Coats of the braine, Nerves & muscles may become a convenient vessell to hold so subtile a Spirit" by taking into account "how liquors & Spirits are disposed to pervade or not pervade things on other accounts then their Subtility". Some fluids, like oil and water, are prevented from mixing "by some secret principle of unsociablenes . . . though their pores are in freedome enough to mix with one another". This "unsociablenes" might exist in aetherial substances while possibly "the reason, why Air stands rarer in the boxes of small Glass-pipes, & aether in the pores of bodies, then elsewhere may be, not want of subtlety, but Sociablenes". If this were so, then no matter how subtle the "aetheriall vital Spirit" was in man, it could be contained within the "coats" of the brain nerves and muscles if it was "unsociable" to them though "very Sociable to the marrow and Juices". Such a spirit could be sufficiently subtle "to pervade readily the Animall juices, [and] as any of it is Spent", be "continually supplyed by new Spirit from the heart".[37]

To make it suitable for animal motion, Newton brought to bear the phenomenon whereby "some things unsociable are made Sociable by the Mediation of a Third". Just as any two substances were naturally unsociable to one another but could be made "sociable" by the addition of yet another substance, so

> in like manner the aethereal Animal Spirit in a man may be a mediator between the common aether & the muscular juices to make them mix more freely; & so by sending a litle of this Spirit into any muscle, though so little as to cause no sensible tension of the muscle of its owne force, yet by rendering the juices more Sociable to the common external aether, it may cause that aether to pervade the muscle of its owne accord in a moment more freely & copiously then it would otherwise do & to recede againe as freely so soon as this Mediator of Sociablenes is retracted.

To produce major motions in bodies, he supposed only that the "Spring" of the aether in the muscle was extremely great so that even a little alteration in its density caused great alteration in the pressure. Such a mechanism might also be the cause of the motions of the heart, except that in this case the "Spirit" was "continually generated there by the fermentation of the Juices [and] let out by starts into the braine through some convenient ductus . . .".[38]

For Newton, the production of the "Spirit" from this ferment was identical to the creation of electrical attraction from a glass caused by rubbing, or the "burning out of fewel to penetrate glasse, as Mr Boyle has showne, & calcine by corrosion Mettals melted

[36] Ibid., vol. 1, p. 368.
[37] Ibid., vol. 1, p. 368–9.
[38] Ibid.

therein". This highly original analysis of self-motion was also linked in the 'Hypothesis' to the processes underlying the phenomenon of light. That one should be wary of offering simplistic mechanical explanations of light was evidenced by the fact of self-motion: "God who gave Animals self motion beyond our understanding is without doubt able to implant other principles of motion in bodies w^{ch} we may understand as little". The fact of free will and the capacity for self-motion were always held by Newton as evidence that the normal laws of motion had application over a limited domain. Self-motion remained an undoubted phenomenon, whatever hypotheses were adduced for its explanation, and it was even possible that the same cause operated in the vegetable and animal spheres as worked to produce light. He concluded: "Some would readily grant this may be a Spiritual one; yet a mechanical one might be showne, did I not think it better to passe it by".[39]

In the draft 'Conclusio' to his 1687 *Principia*, he again returned to the researches of the late 1660s on the structure of the optic nerve, but this time he rejected the use of animal spirits in volitional motion. In the context of discussing "vibratory motion" which could be "propagated in solids by the forces of even non-contiguous particles", he discussed how the retina was agitated by light and "the remaining nerves by tangible objects . . . propagated to the sensorium through the solid and continuous capillamenta of the nerves". In the other direction,

> by a similar motion propagated from the sensorium through the solid capillamenta of the nerves, a certain substance in the muscles can be agitated and by that agitation dilated so as to contract the muscles and move the limbs. For the animal spirits (which they feign) can hardly be propagated easily, swiftly and copiously enough through the compact substance of the nerves to swell the muscles.[40]

People sweat when undergoing exertion, not because the movement of the muscles gives rise to the inrush of these spirits, but because of "a certain agitation of the parts of the body by which the muscles are kept distended, and when this ceases they grow flaccid". In the *Principia* itself, there was a reference in the General Scholium of 1713 to a "most subtle spirit" which

> pervades and lies hid in all gross bodies [by which] electric bodies operate to greater distances, as well repelling as attracting the neighbouring corpuscles; and light is emitted, reflected, refracted, inflected, and heats bodies; and all sensation is excited, and the members of animal bodies move at the command of the will, namely, by the vibrations of this spirit, mutually propagated along the solid filaments of the nerves, from the outward organs of sense to the brain, and from the brain into the muscles.

In the edition of 1713, the reader was to be disappointed in the expectation of any further analysis and Newton concluded that "these are things that cannot be concluded in a few words, nor do we have at hand a sufficient number of experiments by which to demonstrate & determine the laws of action of this spirit accurately, as ought to be done". Nevertheless, in Motte's translation of 1729, the spirit (after consultation with Newton) is called "electric and elastick", while "electrici & elastici" is to be found in Newton's hand

39 Ibid., vol. 1, pp. 369–70.

40 A R Hall and M B Hall (eds), *The unpublished scientific papers of Isaac Newton*, Cambridge University Press, 1962, p. 346.

in the margins of his own copy of the second edition of the *Principia*. The connection between electricity and life did not emerge late on in the evolution of his natural philosophy (as a number of commentators have suggested), and goes right back to his experiments in the early 1670s and probably even earlier.[41]

4. In the Image of God: the Metaphysics of Self-motion

The experimental project on the body, and the factuality of spontaneous motion were linked at the deepest level for Newton and they reappeared in a number of different contexts. For example, Dobbs has recently questioned the dating of the untitled manuscript which is now known by its first line "De Gravitatione et Aequipondio Fluidorum", moving it from its previous home in the early 1670s to the period of the *Principia* in the mid-1680s. If this is true, Newton's care in picking apart the allegedly atheistic implications of the metaphysics of Descartes can be linked to the vehement attack on the latter's vortices which made up a part of the second book of the *Principia,* while he probably did not fully jettison his own belief in vortices until his work on *De motu corporum* in the mid 1680s. *De gravitatione* may probably have been intended for publication in the originally conceived *Principia*. In any case, as a number of pieces of evidence attest, it was a crucially important document which was used again and again by Newton in the rest of his career when he formulated relevant metaphysical positions.[42]

In *De gravitatione*, Newton attacked Descartes' identification of body with extension as atheistic, and put forward a notion of space in which there were always a multitude of figures not disclosed to sight. For Newton, these objects *actually* existed, although they became visible only when God endowed them with sensible qualities (in the same way that dye made visible swirling figures in water). After an analysis of the notion of space, he considered the nature of body. He gave a voluntarist underpinning for the existence of bodies, viz., that they existed by Divine Will, and proceeded to argue that the power of God was such that he could have created bodies in an infinite number of ways. Nevertheless, we were not aware of the exact nature of bodies and could only infer this nature from our perceptions of them. Following this, he stated that he would investigate "a certain kind of being similar in every way to bodies, and whose creation we cannot deny to be within the power of God, so that we can hardly say that it is not body".[43]

[41] F Cajori (ed.), *Sir Isaac Newton's mathematical principles of natural philosophy and his system of the world*, 2 vols, London, University of California Press, 1931, vol. 2, p. 547. M B Hall and A R Hall, 'Newton's electric spirit: four oddities', *Isis*, 1959, **50**:473–6, p. 474; A Koyré and I B Cohen, 'Newton's "Electric & Elastic Spirit"', *Isis*, 1960, **51**:337. For other treatments of Newton's renewed interest in the electric spirit, see J L Hawes, 'Newton and the "Electrical Attraction Unexcited"', *Ann. Sci.*, 1968, **24**: 121–30; *idem*, 'Newton's two electricities', *Ann. Sci.*, 1971, **27**: 95–103; R W Home, 'Newton on electricity and the aether', in Z Bechler (ed.), *Contemporary Newtonian research*, Dordrecht, D Reidel, 1982, pp. 191–213, and *idem*, 'Force, electricity and the powers of living matter in Newton's mature philosophy of nature', in M Osler and P L Farber (eds), *Religion, science and worldview: essays in honor of Richard S. Westfall*, Cambridge University Press, 1985, pp. 95–117.

[42] Dobbs, op. cit., note 30 above , pp. 139–49, especially pp. 144–6. *De gravitatione* (CUL Add. Ms. 4003) is published in Hall and Hall, op. cit., note 40 above, pp. 90–156.

[43] Hall and Hall, op. cit., note 40 above, pp. 133, 136–8. See also M Tamny, 'Newton, creation, and perception', *Isis*, 1979, **70**: 48–59.

To get an idea of God's power, he considered the fact that all humans believed that they could move their own bodies "at will", while they also believed that all men "enjoy the same power of similarly moving their bodies by thought alone". This being so, God's power of moving bodies by will could be understood as being of a similar kind of action but infinitely greater and swifter; by "the sole act of thinking and willing" He could "prevent a body from penetrating any space defined by certain limits". Any such space made impervious to bodies would seem to be "truly body from the evidence of our senses (which constitute our sole judges in this matter)". If this "impenetrability" were transported according to certain laws, then it would "have shape, be tangible and mobile" and Newton did not see that it would "not equally operate upon our minds and in turn be operated upon, because it is nothing more than the product of the divine mind realized in a definite quantity of space". By definition, these sorts of bodies must be able to "excite various perceptions of the senses and the fancy in created minds, and conversely be moved by them . . .". The only problem with this schema, then, lay in the precise manner in which God imparted form to space. But this was reduced to the same problem of how we move our own bodies, "and nevertheless we do believe that we can move them". If we knew how we moved our own bodies, we might have some purchase on the larger problem. This was premissed on the analogy between God and man, and Newton argued that his analysis was designed to show that this analogy was much closer than previous Philosophers had realized—"that we were created in God's image holy writ testifies"—and in order that "God may appear (to our innermost consciousness) to have created the world solely by an act of will alone".[44]

If body were simply extension, as Descartes claimed, then this led to atheism and an unintelligible distinction between mind and body. Extension and thinking were not separate substances, for otherwise we would have to say that mind had no extension and so existed nowhere, and God would not "eminently contain extension within himself and thus [could] not create it". But in fact "if extension is eminently contained in God, or the highest thinking being . . . both may fit the same created substance". The sense organs of humans were implicit in the definition of body, and Newton claimed that Descartes was wrong in his belief that extension remained after all non-essential items like gravity, hardness and sensible qualities had been removed from the notion of body:

> For we may also reject that faculty or power by which [the sensible qualities] stimulate the perceptions of thinking beings. For since there is so great a distinction between the ideas of thinking and of extension that it is impossible that there should be any basis of connection or relation [between them] except that which is caused by divine power, the above faculty of bodies can be rejected without violating extension, but not without violating their corporeal nature.

It was not a question of an actual union of mind and body, since there were a number of bodies which were not united to minds, but concerned

[44] Hall and Hall, op. cit., note 40 above, pp. 138–41. In a slightly later manuscript he wrote that creatures shared "so far as possible the attributes of God (as fruit the nature of the tree and an image the likeness of man), and by sharing tend towards perfection, & to that extent God [can] be discerned in the more perfect creatures as in a mirror . . ."; cf. J E McGuire, 'Newton on space, time and God: an unpublished source', *Br. J. Hist. Sci.*, 1978, **11**: 115–28, p. 123.

a faculty in bodies by which they are capable of a union through the forces of nature. From the fact that the parts of the brain, especially the more subtle ones to which the mind is united, are in a continual flux, new ones succeeding to those which fly away, it is manifest that that faculty is present in all bodies.

This was not the final time that he deployed his work on self-motion in a different sphere. Although he continued to think about the union between soul and body and the physical causes of spontaneous motion, the research was made public only in an attenuated form in the Queries of the *Opticks* and as an empirical fact which pointed both to the shortcomings of a purely mechanical philosophy and to laws other than those expressed in the *Principia*.[45]

5. Active Principles and the Mechanical Threat

The practical investigation of the related powers of the will and of the imagination remained of prime importance for Newton throughout the rest of his life. Notoriously, he vacillated between attributing events in nature to the direct volitional power of God, and to secondary instruments such as "active principles" responsible for various phenomena such as biological and mineral growth. The power of self-motion was a third possibility which was sometimes separated from active principles, and sometimes accounted by him as an example of them. In the three major editions of his *Opticks* (1704, 1706 (the *Optice*) and 1717/18), he progressively inserted material on the reality of an all-pervasive aether, and the third and final set of Queries were those that most vigorously asserted its existence. But in the earlier Query 28, Newton followed the conjunction outlined in an earlier manuscript from the 1690s in which he had asserted that God "decre[ed] and rule[d] all things by means of his substantial presence (as the thinking part of a man perceives the appearances of things brought into the brain and thence rules its own body)":

How do the Motions of the Body follow from the Will, and whence is the instinct in animals? Is not the Sensory of Animals that place to which the insensitive substance is present, and into which the sensible Species of Things are carried through the Nerves and Brain, that they may be perceived by their immediate presence to that Substance? And these things rightly dispatch'd, does it not appear from Phaenomena that there is a Being incorporeal, living, intelligent, omnipresent, who in infinite Space, as it were his Sensory, sees the things intimately, and thoroughly perceives them, and comprehends them wholly by their immediate presence to himself . . .?[46]

This passage recalled his early researches, but was now linked to the programme of work on active principles which postdated the *Principia* of 1687. It had definitively covered the macroscopic laws determining gravity and force but there were a number of

[45] Hall and Hall, op. cit., note 40 above, pp. 143, 145–6. For the general problem of the relation between mind and matter in this period, see J Yolton, *Thinking matter: materialism in eighteenth century Britain*, Minneapolis, University of Minnesota Press, 1983.

[46] For the relatively common use of active principles in this period, see J Henry, 'Occult qualities and the experimental philosophy: active principles in pre-Newtonian matter theory', *Hist. Sci.*, 1986, **24**: pp. 335–81, and for the role of active principles in Newton's explanation of gravity, see *idem*, '"Pray do not ascribe that notion to me": God and Newton's gravity', in J E Force and R H Popkin (eds), *The books of nature and scripture: recent essays on natural philosophy, theology, and Biblical criticism in the Netherlands of Spinoza's time and the British Isles of Newton's time*, London, Kluwer Academic Publishers, 1994, pp. 123–48.

other areas such as magnetism to which the tools of the *Principia* could not be applied. In a passage which was intended for the *Optice*, Newton related the conservation of force by means of active principles to the visible decline of motion in the world: "Seeing therefore the variety of motion (w^{ch} we see) in the world is always decreasing, there is a necessity of conserving and recruiting it by active principles; such as are (the power of life & Will by which animals move their bodies with great and lasting force)". He added that "we meet with very little motion on the world besides what is (visibly) owing to these active principles, & the power of the will".[47]

This power was again linked closely to the positivistic stance adopted in *Principia* (in which Newton presumed to avoid disputes about causation and ontology by talking only of "phaenomena"), as well as to the new interest in active principles which had become the focus of interest in the *Opticks*. Another passage illustrates this well. Here he used the mysterious nature of the power of self-movement to assert that one could argue from the phenomenon of self-movement to the existence of active principles without the aid of "metaphysical arguments [which] are very slippery . . . We find in o^{r}selves a power of moving our bodies by o^{r} thoughts (but the laws of this power we do not know) & see y^{e} same power in other living creatures but how this is done & by what laws we do not know". From this example "& that of gravity it appears that there are other laws of motion (unknown to us) than those w^{ch} arise from Vis inertiae (unknown to us) w^{ch} is enough to justify & encourage o^{r} search after them. We cannot say that all nature is not alive". In other drafts from *c*. 1705, he stated that "Life & Will (thinking) are active Principles by w^{ch} we move our bodies, & thence arise other laws of motion unknown to us", concluding elsewhere that if there was

> an universal life and all space be the sensorium of a immaterial thinking being, who by immediate presence perceives things in it as that w^{ch} thinks in us perceives their pictures in the brain and whose Ideas work more powerfully upon matter than the Imagination of a mother works upon an embrio, or that of a man upon his body for promoting health or sickness, the laws of motion arising from life or will may be of universal extent.[48]

His public pronouncements on both the operation and methodological function of Divine or merely human will were kept to a minimum. In a Query (number 23) added to his *Optice* of 1706, he argued that we came across very little motion in the world except what was due to active principles or the Divine Will, although in the corresponding Query (number 31) in the *Opticks* of 1717/18, the reference to the Divine Fiat had disappeared. From 1704 he had directed Francis Hauksbee on a series of researches on electricity and

[47] J E McGuire, 'Force, active principles and Newton's invisible realm', *Ambix*, 1968, **15**: 154–208, pp. 169–70 (from CUL Add. Ms. 3970 fols 255^{r}–256^{r}).

[48] Ibid., pp. 171, 205 and 196 (passages from CUL Add. Ms. 3970 fols 620^{r}, 619^{r}, 244^{r} and 252^{r}). Newton was a preformationist who held that the embryo of the young is already present in the egg; "by the act of generation nothing more is done than to ferment the sperm of the female by y^{e} sperm of y^{e} male that it may thereby become fit nourishment for y^{e} Embriyo. ffor y^{e} nourishment of all animals is prepared by ferment & the ferment is taken from animals of the same kind, & makes the nourishment subtile & spiritual. In adult animals the nourishm^{t} is fermented by the choler and pancreatic juice both w^{ch} come from the blood." This passage occurs amongst the drafts for one of the Queries to the *Opticks* at CUL Add. Ms. 3970 fol. 235^{r}. For extended material on the heart, see ibid., fol. 652^{r}. See also P D Bowler, '"Preformation" and pre-existence in the seventeenth century: a brief analysis', *J. Hist. Biol.*, 1971, **4**: 221–44.

he turned to this as the best candidate for accounting for the principles and forces which were not covered by the *Principia*. In a draft Query 25 which was to have appeared in the 1717/18 *Opticks*, Newton saw the "very subtile, but active, potent, electric spirit" as just this mysterious and ubiquitous force:

> vibrations may be excited in the bottom of the eye by light & propagated thence through the solid capillamenta of the Optick Nerves into the sensorium for causing vision & the like of other senses The like vibrations may be also propagated from the brain through the solid fibres of the spinal marrow & its branches into y^e muscles for agitating & expanding y^e liquors therein & thereby contracting the muscles to cause y^e motions of animals. For liquors are expanded by heat & by consequence by the vibrating agitations of the spirit. If the agitations be of short continuance they expand the liquors without heating them. If lasting (as in running a race, or in supporting a burden without external motion of the body) they heat the body by degrees & at length excite sweat. This spirit therefore may be the medium of sense of animal motion & by consequence of uniting the thinking soul & unthinking body.[49]

His manuscript corpus contains a number of detailed statements about the possible causes of self-motion and this apparently irreducible power came to be of central importance in his fight with Leibniz. The latter had accused any nonmechanical explanations of phenomena like gravity as being either occult (such as Newton's concept of gravitational attraction) or miraculous, and had asserted (on the basis of a rare print of the *Optice* which Newton had done his best to suppress) that the Newtonian philosophy held that space was literally the sensorium of God. After a supposedly impartial committee of the Royal Society had decided in favour of Newton's right to priority in the invention of the calculus, he had a group of letters relating to the affair published in a form known as the 'Commercium Epistolicum'. In a letter to the Abbé Conti of 26 February 1716 he complained that Leibniz had not responded to this publication, and he replied to the metaphysical issues that were then being debated elsewhere in the correspondence which was nominally between Leibniz and Samuel Clarke. Leibniz, he wrote, "colludes in the significations of words, calling those things miracles w^ch create no wonder & those things occult qualities whose causes are occult tho the qualities themselves be manifest, & those things the souls of men w^ch do not animate their bodies". His main target was the Leibnizian doctrine of *Harmonia Praestabilita* which he condemned as miraculous and which he damned as contradicting "the daily experience of all mankind, every man finding in himself a power of seeing with his eyes & moving his body by his will".[50]

Clarke's public response to his patron's main enemy was in part the result of much background work by Newton, visible in a tortuous series of drafts of letters to Conti. In these Newton criticized his opponent's lack of empirical evidence for his own doctrine: "He pleads for Hypothetical Philosophy because there may happen experiments to decide w^ch of the Hypoteses are true, & yet almost all his Philosophy consists in Metaphysical Hypoteses such as never were and never can be decided by experiments . . .". For Newton, Leibniz's notion of God as an Intelligentia Supramundana was supposedly based on his

[49] CUL Add. Ms. 3970 fol. 241^r–v and 244^r. Compare with *Optice*, p. 343: "Nam admodum paullum Motus in mundo invenimus praeterquam quod vel ex his Principiis actuosis, vel ex imperio *Voluntatis*, manifesto oritur."

[50] Newton to Conti, in Hall, *et al.*, op. cit., note 17 above, vol. 6, p. 285.

desire to avoid a God who was the soul of the world, "and yet according to his Philosophy (that of Harmonia Praestabilita) the soul of man doth not animate his body". Moreover, Leibniz called the world God's watch, "& insinuates that it is the fault of the workman & not of the materials if a watch will at length cease to go, & in like manner that it would be God's fault if his watch should ever decay and want an amendment". By the same way of arguing, Newton continued, "a man may say that it would be God's fault if matter doth not think". Leibniz's scheme left a literally Godless creation, a notion that explicitly contravened Scripture and, according to Newton, Leibniz was angry at him "for saying that God is everywhere & that he is not far from everyone of us; for in him we live and move & have our being". In his correspondence with Leibniz, Samuel Clarke adopted identical positions to those of Newton.[51]

Clarke's response to Leibniz's first letter began with a statement of the Newtonian party line on the status of space and its relation to God, linking this "by similitude" to the way in which "the mind of man" sees images "as if they were the things themselves". Later, he argued that by "sensorium" Newton meant the *place* of sensation rather than the organs of sense themselves, while the soul in man was not present to all parts of the body but operated only "upon the brain, or certain nerves and spirits, which, by laws and communications of God's appointing, influence the whole body". In the more substantial two final letters to Leibniz, Clarke trotted out his master's opinion on the miraculous or deterministic nature of the mind-body system in Leibniz's scheme and lashed his opponent's system as "wholly taking away the very idea of liberty". Like God, humans remained active beings with their own principle of action, even when faced by two apparently indistinguishable choices.[52]

In the final letter, Clarke made clear the restrictive political and religious consequences of Leibniz's position and stressed the connection between the notion of free will and the responsible individual: "the true and only question in philosophy concerning liberty is, whether the immediate physical cause or principle of action be indeed in him whom we call the agent". On the other hand, Leibniz's philosophy "tends to make men be thought of as mere machines, as Descartes imagined beasts to be", and crucially, "by taking away all arguments drawn from phenomena, that is, from the actions of men, to prove there is any soul, or any thing more than mere matter in at all". If preestablished harmony were true, then "a man does not indeed see, nor hear, nor feel any thing, nor move his body, but only dreams that he sees, and hears, and feels, and moves his body".[53]

5. The Theological Politics of Self

In the England of the mid 1710s, liberty was a crucial political and philosophical issue. In the light of the forthcoming appearance of a new post-Stuart regime, Clarke worked hard to curry favour with the House of Hanover and to let people know that the doctrines

[51] CUL Add. Ms. 3968 fols. 591, 589, 587^r, 571^r and 436^v, cited in A Koyré and I B Cohen, 'Newton and the Leibniz-Clarke correspondence with notes on Newton, Conti and Des Maizeaux', *Archives internationales d'histoire des sciences*, 1962, **15**: 63–126, pp. 73, 74, 114 and 109.

[52] H G Alexander (ed.), *The Leibniz-Clarke correspondence*, Manchester, 1965, pp. 13, 21, 34, 51, 98.

[53] Ibid., pp. 99, 110, 116.

of the new King's resident Court philosopher were no better than that of the freethinkers and deists. In this context, the correspondence with Leibniz on the nature of liberty, divinity and kingship was of the utmost significance. In the face of renewed threats from the Pretender, a number of Whigs had moved closer to the court in their bid to stabilize the Hanoverian succession, and Steven Shapin has pointed out that the immediate political setting for Clarke's work was the rejection of traditional Whig views of a monarchy limited by law in favour of a more absolutist ruler who reigned by fiat. In addition to this, the recent experiences of William Whiston and Clarke, who had both been hounded for their antitrinitarian beliefs, meant that there was a great need for natural philosophers who were Court Whigs to prove that Newtonian theology was orthodox.[54]

The related issue of whether thought could be an essential property of matter—or had necessarily to be superadded to it by God—had come to the fore with the publication of John Locke's *Essay concerning human understanding* in the early 1690s, and was directly addressed (in a series of arguments which owed much to Newton) by Richard Bentley in his second Boyle Lecture (*Matter and motion cannot think*) of 1692. In his own Boyle Lectures of 1704–5, Clarke stressed the unbounded nature of God's will and attacked the notion that matter might have a principle of self-motion within itself. Only if activity was superadded to brute matter could God's power and the immortality of the soul be guaranteed; without freedom of the will, there was no such thing as moral responsibility and a society premised on such a deterministic view of man was doomed to collapse into anarchy. Although the requirements of different contexts coloured the precise way in which Clarke defended human, monarchical and Divine will, the *extent* of legitimate use of will which he accorded to these beings was highly unusual for a Whig thinker in the first decade of the eighteenth century. Despite the relative stability of his position between 1704 and 1716, it is correct to point out that Clarke's *specific* accounts of the domain of will were fashioned for local contexts. Yet although it may not be true that Newton wrote Clarke's side of the correspondence, this paper has pointed to what was perhaps a highly significant source of Clarke's writings.[55]

Almost the earliest work we have from the Newtonian corpus indicates how he tore pneumatological and physiological information from what he called "The excellent D^{r} Moore['s] booke of y^{e} soules immortality" to begin his project on the power of the imagination and the operation of the soul. This programme was summed up by his Aristotelian conviction that one could not begin to grasp how much in an act of

[54] See in particular S Shapin, 'Of gods and kings: natural philosophy and politics in the Leibniz-Clarke disputes', *Isis*, 1981, **72**: 187–215, especially pp. 201, 204–10; N Jolley, 'Leibniz on Locke and Socinianism', *J. Hist. Ideas*, 1978, **39**: 233–50, and Yolton, op. cit., note 44 above, pp. 10–20, 29–39.

[55] Shapin, op. cit., note 54 above, pp. 193, 210–11, 213–14, and Yolton, op. cit. note 45 above, pp. 38–43. For Clarke on freedom see J H Gay, 'Matter and freedom in the thought of Samuel Clarke', *J. Hist. Ideas*, 1963, **24**: 85–105. For 'Locke's suggestion', see Yolton, op. cit., note 45 above, pp. 14–28. For eighteenth-century reactions to Lockean conceptions of mind and body, see A Suzuki, 'Anti-Lockean enlightenment? Mind and body in early eighteenth- century English medicine', in R Porter (ed.), *Medicine in the Enlightenment*, Amsterdam, Rodopi, 1995, pp. 336–59. Locke uses exactly the same general argument as Newton regarding the relevance of understanding the physiology of self-motion to comprehending Creation; see *Essay*, Bk IV, ch. 10, sect. 19. As Martin Tamny has pointed out, the French translator of Locke's *Essay*, Pierre Coste, revealed after Newton's death that Newton himself had confessed to suggesting this argument to Locke; see Tamny, op. cit., note 43 above, pp. 48–9.

sensation—our only means of gaining knowledge about the outside world—derives from the soul or body unless one had a well-grounded understanding of their functions and operations. It was an experimental project which drew from a number of different tools in his intellectual armoury, which spanned the whole of his career, and which was expressed publicly as a conviction that self-movement proved both the reality of individual freewill and that there was more to comprehending the world than was demonstrated in the *Principia*. At stake was something which might have completed Newton's overall concern with uncovering the laws of nature through natural philosophy, and which by analogy would have pointed to an understanding of how God created and then existed with His world. Nevertheless, the fact that this medically-derived project was based on a series of private experimental researches which sought to explicate the mind-body relationship remained largely unknown to his contemporaries. Ironically, his rich physiological material could not fully be deployed by the physicians and philosophers who went on in the period following the publication of the *Principia* to use Newton's doctrines and authority to construct a "Newtonian" physiology.[56]

[56] McGuire and Tamny, op. cit., note 19 above, p. 340. Drawing from the reflections in the Queries of Newton's *Opticks*, George Cheyne, John Keill, William Derham and Henry Pemberton all developed theories of the physiology of self-motion in Newton's lifetime; for a good account of this see Yolton, op. cit., note 45 above, pp. 162–6. For the general medical use by physicians of the *Principia* and of other Newton material, see T M Brown, 'Medicine in the shadow of the *Principia*', *J. Hist. Ideas*, 1987, **48**: 629–48, A Cunningham, 'Sydenham versus Newton: the Edinburgh fever dispute of the 1690s between Andrew Browne and Archibald Pitcairne', in W F Bynum and V Nutton (eds), *Theories of fever from antiquity to the Enlightenment*, London, Wellcome Institute for the History of Medicine, 1981, *Med. Hist.*, Supplement no. 1, and the following articles by Anita Guerrini: 'James Keill, George Cheyne and Newtonian physiology, 1690–1740', *J. Hist. Biol.*, 1985, **18**: 247–66; 'The Tory Newtonians: Gregory, Pitcairne and their circle', *J. Brit. Studs.*, 1986, **25**: 288–311, and 'Archibald Pitcairne and Newtonian medicine', *Med. Hist.*, 1987, **31**: 70–83.