6

Material-cerebral plasticity, fluid ontology: the case of animal spirits [1]

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Abstract : Animal spirits – the messengers of the body, as Mandeville called them – cross domains such as neuroscience, literature, culture, and economics. Additionally, they are not a neutral concept. On the one hand, the history of neuroscience tends to claim that it was the *abandonment* of animal spirits which allowed experimental neuroscience to emerge. In contrast, more culturally oriented historians of ideas see the spirits as 'freed' from a linear scientific development, as agents of fluidity and dynamism, whether strictly as regards models of the brain and nervous system, or of matter and life overall. Animal spirits then seem to be a key case, or at least a particularly vivid case which calls for 'historical cognitive science' analysis or 'historical neurophilosophy', as some have proposed. For they testify to a tension between two models of the brain, both at the time of Willis et al., and now: a more *mechanistic* picture of brains (the brain is a mere lump of inert substance and/or a fully mechanistic system) and a more *dynamic* picture of the brain as self-transforming and malleable (plastic, in current parlance), as I have described elsewhere with reference to Diderot's image of the brain as a 'book which reads itself'. In this paper I seek to reconstruct this dynamism and to show how it related to a dynamic form of materialism.

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> "I don't pretend to account for the Functions of the Brain. I never heard of a System or a Philosophy that could do it"
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> (Mandeville, *A Treatise of the Hypochondriack and Hysterick Diseases*, 1730, p. 137).

Animal spirits are a popular object of study for humanists and an embarrassment to positivist historians of neuroscience, and depending on their degree of Whiggishness, to science-friendly specialists of early modern philosophy. How is it, they ask, that a respectable figure of mechanistic natural philosophy like Descartes, for whom everything material could be explained in terms of size, shape and motion, also allowed for such perverse entities as

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animal spirits, flowing through the nerves and bearing information[2]? For Descartes, animal spirits come from a rarefied portion of the blood and are mechanistically described as "extremely small bodies which move very quickly, like the jets of flame that come from a torch"; they traverse the body through "little threads or tubes"[3], in a process which Gary Hatfield has nicely described as a "mechanical sensory–motor feedback loop" ("The *Passions*", 17)[4]. Such mechanical processes play an important role in the mental life of the human or animal in which they occur. Descartes uses animal spirits to explain sensation, the use of images in memory, emotional states, and both voluntary and involuntary motion of the muscles (Hatfield, "The *Passions*", 16). However, this gives rise to an important question concerning the relation of mind and body: the use of animal spirits as a kind of corporeal extension of mental processes, or the material basis thereof, raises the question of whether or not they are the primary feature used to explain mind-body interactions; are they somehow mini-minds, animated portions of matter? In the language of Thomas Willis, the animal spirits impart to the parts of the body containing nervous fibers, "a motive or sensitive feeling of force" (*Practice,* 103)[5]. We shall return below to this issue of the potential materialism inherent in the animal spirits doctrine.

Scholars who approach the issue from the standpoint of the history of neuroscience tend to produce narratives in which it was the *abandonment* of animal spirits which allowed

[2] Descartes embraces animal spirits although he *should not have done so* given his mechanistic system, which should ontologically rule out such entities: "It would have made for clarity had Descartes and others discarded the phrase 'animal spirits', since it was difficult to disinfect the words of connotations wholly at variance with the assumptions of their physiology" (Balz, 54, in Sutton, 21). Of course the spirits can also be justified within such a system, e.g. by explaining their circulation mechanically (the animal spirits are "the subtlest parts of the blood and hence can be filtered into the pineal gland through pores too fine to admit anything larger": Gaukroger, 22). But this still does not address the question of their 'agential' and/or 'intentional' properties (nor, which is not my central concern, the fact that this still leaves them 'unobserved').

[3] "Ce sont des corps très petits et qui se meuvent très vite, ainsi que les parties de la flamme qui sort d'un flambeau" (*Passions of the Soul* I, § 10, AT XI, p. 335 / CSM I, p. 332). See also the Letter to Newcastle of April 1645, AT IV, p. 191 (not in CSM).

[4] "The machine is powered by blood that is impelled to the brain from the boiler-like heart... The most active particles of the blood push their way into the arteries of the brain, where the subtlest particles are filtered out to form the animal spirits, a fluid that is distributed from the centrally located pineal gland to the motor nerves, which are tubes that form the mass of the brain and (in some cases) lead to the muscles... The flow of spirits from the gland is controlled by four factors: patterns of openings created in the brain by sensory stimulation; the innate plumbing of the brain; alterations in brain plumbing due to previous patterns of stimulation; and the character of the spirits themselves, as sent up from the heart" (Hatfield, "The *Passions*", 17).

[5] Willis, *The Anatomy of the Brain* (1666), Ch. XIX, in Willis, *Practice of Physick*, p. 103 (note that the pagination of each work is independent, in this collection): "Animal Spirits are procreated only in the Brain and Cerebel, from which they continually springing forth, inspire and fill full the medullar Trunk: (like the Chest of a musical Organ, which receives the wind to be blown into all the Pipes) but those Spirits being carried from thence into the Nerves, as into so many Pipes hanging to the same, blow them up and actuate them with a full influence; then what flow over or a bound from the Nerves, enter the Fibres dispersed every where in the Membranes, Muscles, and other parts, and so impart to those bodies, in which the nervous Fibres are interwoven, a motive and sensitive or feeling force".

experimental neuroscience to emerge, in favor of the study of animal electricity, itself of course consigned to a short career; animal spirits, on this view, are a transition point on the way to a real scientific study of the nervous system (Clower, Eadie, Glynn, Smith). This point of view goes back at least to T.H. Huxley's famous essay on automata and animal minds of 1874, where he declares, "With the progress of research, the term 'animal spirits' gave way to 'nervous fluid,' and 'nervous fluid' has now given way to "molecular motion of nerve-substance" (207). Remaining within the parameters of a history and philosophy of neuroscience, Georges Canguilhem sought to roll back this wave of anti-spirited positivism in his defense of Thomas Willis contra Descartes, in his 1955 *La formation du concept de réflexe aux XVII*^{ème} *et XVIII*^{ème} *siècles*, ironically going against his own celebrated methodological recommendations to avoid 'presentism' at all costs. One of Canguilhem's goals in this work was to 'roll back' the authoritative narrative in which Descartes was the first great scientific student of the nervous system, in a kind of cumulative process of conceptualization and discovery leading to modern experimental neurophysiology. But Canguilhem is still operating within a consideration of scientific validity[6]. What happens when we seek to build a conceptual apparatus with the spirits included in the toolbox?

One approach, which is admirably pluralistic compared to the linear narratives mentioned above, treats animal spirits as an instance of hybrid, transgressive or nomadic scientific concepts; they become an object for a more hybridity-friendly history of science[7], a "go-between" object par excellence, the "internuncii" or messengers of the body, as Mandeville called them, belonging to a "Middle Nature" in Helkiah Crooke's language a century earlier: animal spirits are ontological go-betweens, connecting the realms (Mandeville, 156, 165;

[6] For example, Canguilhem influentially spoke out against the category of the precursor in the history of science: "by replacing the logical time of truth relations with the historical time of their invention, one aligns the history of science on science itself . . . and one creates the artefact, the false historical object called the precursor" (*Études d'histoire et de philosophie des sciences*, p. 19). To be sure, in the reflex book he is not naïvely making Willis a precursor of Sherrington or other twentieth-century pioneers of neurophysiology; yet he seems to argue for the former's worth in terms of a posterior scientific validation.

[7] The preeminent practitioner of this approach, creating a kind of cultural and metaphorological history of the neurosciences, was G.S. Rousseau: see e.g. his articles "Discourses of the Nerve" and " 'Brainomania': brain, mind and soul in the long eighteenth century". On the idea of nomadic concepts as applied to the history of biology in a slightly sharper sense, see J. Surman, K. Stráner and P. Haslinger's Introduction to their special section on 'Nomadic concepts in the history of biology'. The present story would look different if we were presenting a cultural history of the animal spirits, which often tends to focus on literary works (as in G.S. Rousseau's studies); and such a story would in turn differ from a strictly 'experimentalist' history, with vivisected dogs and frogs. The present narrative is philosophically focused, albeit not in an internalist sense.

Crooke, 428)[8]. Of course, other entities in the history of science can and have been studied as 'go-betweens' or as 'epistemic objects', like force or æther. But as we shall see below, animal spirits exhibit additional properties besides being mediators (Wolfe "the organism"), or interesting constructs (Rheinberger) .

In that sense, my interest is different: it is less to emphasize their scientific pertinence and more to stress their conceptual power (as go-betweens, as devices of fluidity) and ontological service performed for materialism. In addition to their function as go-betweens and/or as epistemic constructs, animal spirits, as I emphasize here, are intriguing because on the one hand so many wish to deny their existence – both as positivistically inclined historians of science and as 'actors', such as William Harvey – and on the other hand they clearly perform a function of 'vitalizing' and/or 'dynamizing' matter, thus with ontological implications. Somewhat surprisingly given his otherwise characteristic eclecticism compared to then-nascent forms of medical mechanism, Harvey was suspicious about spirits: "Opinions are so various and conflicting on the nature of these and the state in which they exist in the body – whether distinct from the blood and solids or conjoined with them – that they serve as a common refuge for ignorance" (Willis, *Harvey*, 232)[9]. But this suspicion could take much stronger forms, which should not be surprising if we consider both the 'go-between' function of the spirits and, more importantly in this context, the way in which they lend agency to matter. It has (quite reasonably, if a bit teleologically) been asserted that Willis overturned Cartesian dualism regarding the pineal gland, since on his account, animal spirits are both a material production (of brain activity) and a material cause of ideas (Houdé, Mazoyer, Tzourio-Mazoyer, 9).

Like a kind of Tom Thumb, I want to follow the spirits – their 'lead' – as they indicate a kind of heretical undercurrent in materialism. To be precise, the vision of brain-mind relations which employs animal spirits is (or can be, at least) characterized by a degree of *plasticity* not ordinarily seen in such theories. Let me clarify and propose some distinctions. Materialism can broadly be distinguished into two families of theories: one which focuses on the nature of the world or universe as material, along with every entity within it, and another, more local, which focuses on the identity between brain and mind, cerebral processes and mental

[8] Gail Kern Paster comments that the animal spirits could not be so easily dismissed in early modern anatomy and physiology, precisely given their 'messenger' or 'go-between' function: "As properties animating, even defining the living body, they, like soul, eluded the anatomist; but unlike soul, they mattered to his work because they were thought responsible for some of the body's most important structures of visible and behavioural difference, inside and out" ("Nervous tension," p. 113).

[9] Citing Harvey's Second letter to Riolan, *in Exercitationes duae anatomicae de circulatione sanguinis* (1649), p. 66.

processes. Of course, from deliberate misreadings of Locke on thinking matter to post-Baylean reflections on animal minds, all the way to Diderot's linking of a vital matter theory in which sensitivity is a general property of matter and a vibrating-string account of the nervous system, there were a number of theories which linked or blended the two[10] – a shift in the concept of matter could imply (or alternately, could be connoted by) a shift in the concept of the brain. Here I focus on a variant of the second kind of materialism, that concerned with brains and the nervous system, via the concept of animal spirits.

Spirits challenge a solidist ontology. They sound unreasonable – to William Harvey, as we saw above, but also to some eighteenth-century vitalists (although not all). The Montpellier vitalist Théophile de Bordeu argued against their existence in his 1742 medical thesis *De sensu generice considerato*; curiously enough, especially for someone who was not an amateur in matters of physiology, Bordeu seems to have been influenced by Voltaire's deflationary (but really, lazily skeptical) position on animal spirits[11]. Voltaire wrote that one uses the term 'animal spirits' or 'vital spirits' to signify "that which one has never seen, and which generates movement and life"; he adds, in rather archaic terms, that they are "probably a subtle fire" (Voltaire, "Esprit", 975)[12]. Those of us who are inclined to think typologically or taxonomically might be tempted to produce classifications of authors (and practitioners) according to whether they accept or reject the existence of animal spirits. Such a classification in fact is not very edifying: some materialists well into the eighteenth century, like Mandeville (as I discuss below), defended their existence; some vitalists rejected it; some gave explicitly experimental arguments to support this rejection, while others argued on a more conceptual basis[13].

[10] On the former, see my "Boundary crossings. The Blurring of the Human/Animal Divide as Naturalization of the Soul in Early Modern Philosophy", and on the latter, my "Sensibility as vital force or as property of matter in mid-eighteenth-century debates".

[11] On Voltaire's influence on Bordeu, see Boury, *La philosophie médicale de Théophile de Bordeu*, chapt. 14. Bordeu's commentator Gardanne reiterates the critique and equates the belief in animal spirits with iatromechanism, which makes sense if we bear in mind the relation between a strictly mechanical 'delivery process' through systems of tubes, and a set of animate properties possessed by the spirits, something both Descartes and Boerhaave, among others, put forth (*Eloge historique de Bordeu*, 6). A late figure of Montpellier vitalism, Jean Charles Marguerite Guillaume de Grimaud, whose medical thesis on irritability was published only under his initials ('D.G.') at Montpellier in 1776, includes in this work a long section against animal spirits (*Essai sur l'irritabilité*, 27n.-35n.), with a more 'conceptual' than 'experimental' focus. Grimaud is rather blunt: "Assurément personne n'a vu ces esprits" (28).

[12] Voltaire plays a typically ironic game with the question of their existence or inexistence.

[13] George Cheyne devoted a chapter of his important work on 'depression', *The English Malady*, to the 'existence of animal spirits' (chapter IX) – really their inexistence, as he runs through multiple proofs of their inexistence.

More interestingly as regards their ontology, several less-known eighteenth-century texts problematize the ontology of animal spirits without denying their existence, by insisting that even if they cannot be sensed or experienced directly, their existence can be intellectually certain[14]. Francesco Panese cites one author, Pourfour du Petit, who reflects on the 'degree of materiality' of the animal spirits, almost literally in those terms. In addition, Panese also discusses Alexander Stuart's experiments on the nervous system of frogs, which experimentally 'prove' the existence of an active property in the nervous fluid; Stuart then comments that the name of this property matters less than its existence, and acknowledges that 'spirits' is a somewhat unfortunate terminology since it conveys something other than material (Panese, 24, 28)[15]. It may be a worthwhile endeavor for the history of neuroscience (albeit too conceptually oriented for present-day trends which gravitate towards social and/or cultural history of science) to compare and typologize these more or less spirits-friendly positions, including in terms of their diverse, more or less experimental foci, but as I said, my concern is less with their existence or inexistence *per se*, and more with their effect on an ontology (*a fortiori*, materialist ontology).

The spirits do not just perturb the simplicity of mechanism, as we saw with Descartes, who had stated quite clearly, "what I am calling 'spirits' here are merely bodies: they have no property other than that of being extremely small bodies which move very quickly, like the jets of a flame that come from a torch"[16], but also that of materialism, if they are small material particles which possess 'movement and life', or "motive and sensitive force" (Willis, *Practice* 103)[17]. Yet this perturbing can, conversely, be a possible source of ontological fluidity: if animal spirits are incorporated into the materialist ontology, they allow for a kind of material '*agentivité'*, to use Panese's phrase[18]: an inherent form of agency.

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[14] Eg Jamert in the seventeenth century, cit. Panese, "Les "esprits animaux" au défi de l'expérience" (19).

[15] Curiously, Théophile de Bordeu's medical thesis of the same year, *De sensu generice considerato*, also contains an extended experimental refutation of the animal spirits hypothesis; there is material here for further comparative study!

[16] Descartes, *Passions of the Soul*, I, § 10, AT XI, p. 335 / CSM I, p. 331.

[17] F. Panese cites the article "Eréthisme" from the *Encyclopédie* in a different context, and it contains, almost a century later, much the same equation of the spirits with the principle of activity in the body: they are described as "the principle of action of all the organs of the human body" (d'Aumont, "Eréthisme", 906a).

[18] In discussion at the Animal Spirits conference, Fondation Hardt, Geneva. In a tour de force paper on epistemological issues in early modern 'neurophysics', Alexandre Métraux notes the same issue, which he presents as the question how the spirits communicate their information: energetically? semiotically? semio-energetically? And so forth (Métraux, "Impure Epistemology and the Search for the Nervous Agent", p. 75). In his *Philosophy and memory traces* (another tour de force), John Sutton cites John Wright as asking a version of what I've called the positivist question, why did the animal spirits concept survive as long as it did? and answering in what I see as another phrasing of the same idea of 'mindedness' or 'agency', "perhaps the real explanation of [spirits theory's] resilience to experimental refutation lay in the need […] to assign psychological functions to physiological processes" (178).

Given their materiality – but a special kind of materiality – I suggest that animal spirits are a dividing-point between two forms of materialism: a more mechanistic materialism in which matter, but also the brain, is a mere lump of inert substance, *à la* Henry More, for whom the brain was a mere "Cake of Sewet or Bowl of Curds," a "poor silly contemptible Knob" unfit to perform our cognitive operations (More, *Antidote*, 37, 40)[19], and a more dynamic materialism in which matter, but also the brain, is self-transforming and malleable (plastic, in current parlance); what the title of this paper refers to as "fluid ontology"[20]. As thinkers such as Mandeville show, a vision of the brain that incorporates animal spirits can enable a particularly dynamic picture of materialism. To be sure, a picture of the nervous system (or of the body-brain-nervous system interface) that appeals to these "tiny messengers" is itself ontologically neutral with regard to materialism. But a materialist project to understand the specificity of the brain (rather than simply detailing a metaphysics of matter overall) will be significantly modified if it takes spirits into account – rather than viewing the brain as a structure of which we might draw up a blueprint. Authors such as Georg-Ernst Stahl noticed that if animal spirits were allowed to play a genuine (real) explanatory role, they put the foundational character of the soul in danger: after all, animation should only be explainable by, and traceable to, the *anima* – something Leibniz disagreed with, preferring the animal spirits hypothesis (Clericuzio, 73)[21]. Bishop Berkeley saw the problem quite clearly when, among his various anti-materialist warnings, he spoke against "they . . . who hold the soul of man to be only a thin vital flame, or system of animal spirits," and thereby make the soul "perishing and corruptible as the body"(Berkeley, 87). Berkeley insisted on the non-materiality of our cognitive life: it is "evident that bodies, of what frame or texture soever, are barely passive ideas in the mind, which is more distant and heterogeneous from them than light is from darkness" (*ibid*.)

How do we get to an 'animal-spirited materialism'? Let us turn briefly back to Willis, before moving to his student John Locke, and into the eighteenth century with Bernard Mandeville

[19] On More's approach to animal spirits (which appears in his exchange with Descartes), see Martine Pécharman's paper in this volume.

[20] With echoes of late 1980s 'Theory', e.g. Stengers and Prigogine, Serres, and vulgar Deleuzianism, where everything is always in flux, or fluid, or chaotic, or metastable, or autopoietic, or folded, or nomadic …

[21] Leibniz supports their existence contra Stahl (which shows that commitment to animal spirits is not per equated with being a materialist or not, even if Stahl thinks so): see Duchesneau, *Leibniz – le vivant et l'organisme*, (149). The full text of the debates between Leibniz and Stahl has recently been made available in English for the first time, in François Duchesneau and Justin E. H. Smith's edition, *The Leibniz-Stahl Controversy*.

and Denis Diderot. The first major statement of a 'spirited' vision of the brain running counter to visions of the brain as passive and indeed matter as passive overall, was Thomas Willis', in which spirits were part of an iatrochemical framework[22], notably in his celebrated *De Cerebri Anatome* of 1664. Willis described complex cognitive processes such as memory and imagination in terms of the operation of animal spirits localised to different parts of the nervous system, largely based on comparative anatomy. Spirit is an active principle, and the animal spirits represent spirit in its lightest and most perfect form, the result of complex processes of fermentation within the blood and the matter of the brain: "Spirits are Substances highly subtil, and Ætherial Particles of a more Divine Breathing, which our Parent Nature hath hid in this Sublunary World, as it were the Instruments of Life and Soul, of Motion and Sense, of everything" (Willis, *Discourse on fermentation*, 3)[23]. Willis used the language of distillation and generally favored a more 'qualitative' approach to animal spirits, whereas for Descartes, animal spirits differed from the rest of the blood only in their mechanical properties (the properties of their constituent particles), which is to say, in quantitative terms. In contrast, in Willis they are "the outcome of a qualitative transformation: the separation and exaltation of a volatile salt"(Clericuzio, 68)[24]. Despite propelling the brain to the fore, however, he does not specifically worry about the *status* of the brain as a problem, nor about its cultural 'inscription' or embeddedness. However, his emphasis on fluids, fermentation, the chemistry of life, and the mobility of animal spirits cannot be understated in terms of a yet-unwritten history of brain plasticity.

Recall Henry More's "poor silly contemptible Knob"; similarly, John Hancock, in his 1706 Boyle Lecture attacking Willis, described the brain as a lump of matter "of a clammy and unactive Nature and Substance; [which] seems as far as we can judge of it to be a *meer passive Principle*, as to the Acts of inward Sensation and Intellection" (Hancock, 243). More also insisted rather predictably that "Brains have no Sense," as they are not an active

[22] On the 'vital spirit' background for the 'animal spirits' concept in its iatrochemical presentation such as in Willis see the classic paper by Antonio Clericuzio, "The Internal Laboratory".

[23] Also: "it appears from what hath been already said, that the blood is it self the matter out of which the animal Spirits are drawn; and that the Vessels containing and carrying it every where through the whole compass of the Head, are like distillatory Organs, which by circulating more exactly, and as it were subliming the blood, separate its purer and more active particles from the rest, and subtilize them, and at length insinuate those spiritualized into the Brain and its Appendix. Concerning this matter to be distilled, there is care taken, and indeed by the best means, that is stock or provision may be still supplied in fit quality and due quantity" (*Cerebri Anatome*, Ch. 9, "Shews by what provision, and in what places of the Head the Animal Spirits are begotten").

[24] Clericuzio draws attention to a passage from *Cerebri Anatome* exactly on this point that Pordage left out of the English translation (81, n. 115). See overall chapter XIX of *De Cerebri Anatome* (*The Anatomy of the Brain*).

principle; additionally, the diversity of psychological faculties we experience (imagination, reason, memory, etc.) could not correspond to different parts of the brain, which would then be so many "Individual Persons" in the brain (More, *Antidote*, 37, 39; 38). Robert Boyle (*Works*, vol. VI, 741) sounded as if he was directly responding to More when he noted in the *Christian Virtuoso* that "there must be in the brain ... far more of mechanism than is obvious to a vulgar eye, or even to that of a dissector"; this "seemingly rude lump of soft matter" which looks almost like "so much custard" in fact has "strange things performed in it, ... partly by the animal spirits it produces…". Animal spirits are not the only possible indicator of the brain's dynamism, but they are the choice one in this context. Other models, whether overlapping with that of animal spirits or fully distinct from it, sought also to articulate a kind of animation in matter. For instance, Albrecht von Haller did not think animate properties resulted from the spirits but rather from the nerves, which were not mere tubes carrying the spirits but were irritable themselves (Verbeek, 292)[25]. Whether the issue is animal spirits, the irritability of muscles or sensitivity as a core property of the nervous system, the distinction between a model privileging transmission, adaptation and mobility, and one focusing strictly on brain architecture, correspondences, or localization extends well beyond early modern England!

The *Kampfpplatz* of the brain in the above examples, taken from Henry More *et al*., is not yet that of materialism *per se* (although interestingly, More seems to have been the first author to employ the term 'materialism' or to be precise, 'materialist' in English, in a hostile manner, of course[26]); the issue is how much dynamism, activity and agency can be allowed to such a "clammy lump" of matter. Conversely, my second set of examples of plasticity-friendly visions of the brain in Locke (and Sterne) are also not directly concerned with being for or against materialism (my final examples, Mandeville and Diderot, do belong to that coloration). But the articulation of brain plasticity that we see taking shape is an important step in that direction – an important step towards allowing these 'messengers' to expand materialist ontology.

For materialism to take interest in brains and their functioning, non-materialist authors were needed: Malebranche's extensive investigation of psychology but also, indeed, animal spirits,

[25] See also the letter from Charles Bonnet to Haller of 16 August 1754, in which Bonnet asks Haller about the difference or similarity between animal spirits and 'electric fluid', with respect to irritability (Sonntag, ed., *The correspondence between Albrecht von Haller and Charles Bonnet*, p. 44).

[26] Henry More seems to have introduced the term into English philosophical language in his 1668 *Divine Dialogues*; in the cast of characters, he described the character Hylobares as "A young, witty, and well moralised Materialist" (*Divine Dialogues*, p. 5-6). See Bloch, "Sur les premières apparitions du mot 'matérialiste'".

was influential including in the form of uncredited excerpts in clandestine manuscripts such as *L'Âme matérielle*[27]; in the present, necessarily partial overview, it is Locke, and then Laurence Sterne who recognize the cerebral materiality involved, not just in the regular processes of mental life, but in its plasticity[28].

A concern with cerebral plasticity including the role of the animal spirits is manifest in Locke's often-unnoticed comment that forms of mental pathology which are usually traced back to behaviors (e.g. being frightened in childhood by stories of goblins), are in fact co-constituted by such behaviors *and* by their imprint in the brain, *qua* "Trains of Motion in the Animal Spirits"[29]:

> Custom settles habits of Thinking in the Understanding, as well as of Determining in the Will, and of Motions in the Body; all which seems to be but Trains of Motion in the Animal Spirits, which once set a going continue in the same steps they have been used to, which often treading are worn into a smooth path, and Motion in it becomes easy and as it were Natural (Locke, *Essay*, II.iii.6).

Granted, Locke is not the most obvious candidate for early intimations of brain plasticity, given his explicit 'bracketing-off' of naturalistic considerations concerning the brain and mental activity which position the *Essay* as a non-materialist work: he clearly stated that he would not provide "Physical Consideration of the Mind" (Locke, *Essay*, I.i.2), including "by what Motions of our Spirits, or Alterations of our Bodies, we come to have any Sensation by our Organs, or any *Ideas* in our Understandings; and whether those *Ideas* do in their Formation, any, or all of them, depend on Matter, or no" (I.i.2). Yet Locke was willing at times to consider that "the Constitution of our Bodies," "the make of our animal Spirits" and the "Temper of the Brain" are involved in the workings of mental processes such as remembering (*Essay*, II.x.5). Once again, while bracketing off the issue, he nevertheless acknowledged that "the Constitution of the Body does sometimes influence the Memory; since we oftentimes find a Disease quite strip the Mind of all its *Ideas*, and the flames of a Fever, in a few days, calcine all those Images to dust and confusion, which seem'd to be as lasting, as if graved in Marble" (II.x.5). If not outright materialism, what is hinted at here is nevertheless a kind of skeletal (or perhaps phantomatic) neurophilosophy.

But Locke is not the only non-materialist author to hint at the receptivity and malleability of the brain. Another such intimation of plasticity and invocation of spirits, closer to what will be our final example with Diderot, is Sterne's *Tristram Shandy*, a work which influenced

[27] On Malebranche's 'neuropsychology', see Sutton, *Philosophy and Memory Traces*, chapter 3; on *L'Ame matérielle* see Wolfe and van Esveld, "The Material Soul".

[28] On the animal spirits in Sterne's *Tristram Shandy*, see Guillemette Bolens' contrbution to the present volume.

[29] See Sutton, "Carelessness and Inattention", for further discussion.

Diderot's prose endeavours. *Tristram Shandy* is famous, among other things, for its literary appropriation and usage of animal spirits, which yields a dynamic materialism of matter-mind relations. But the title character also describes an associative mechanism whereby, when arriving in Lyon, he cannot help thinking about a story of two Lyonnais lovers he had read in his youth, "a sweet æra in the life of man, when (the brain being tender and fibrillous, and more like pap than anything else…)"; he cannot avoid this recollection because the cultural-associative event of reading about them had modified his brain anatomy: "There is a soft æra in every gentle mortal's life, where such a story affords more *pabulum* to the brain, than all the *Frusts,* and *Crusts,* and *Rusts* of antiquity, which travellers can cook up for it" (Book 7, chapter XXXI)[30]. This "sweet" or "soft" æra is one where there is an interaction between cerebral architecture and mental stimuli, including those provided by cultural sources.

So far I have discussed two visions of the brain, one stressing its passivity (including, for the sake of preserving the immaterial autonomy of the person, free will, the soul etc.; what I referred to earlier as 'agency') and another its dynamicity. Animal spirits, in Willis, Locke and Sterne, testify to the malleability of the brain-mind, or its plasticity in other terms. What does this have to do with materialism? Two final examples will hopefully illustrate how this vision of cerebral plasticity flows into, or is taken up and appropriated in a novel species of materialism: Mandeville and Diderot.

Bernard Mandeville's wonderful dialogue work, the *Treatise of Hypochondriack and Hysterical Diseases* (1711, revised 1730) is among other things[31] a sustained discussion of mind-body interactions in cases of mental disorders of different kinds. It is here that Mandeville – or rather Philopirio, the materialist character and *analogon* for Mandeville given what is stated about his biography – brings in the spirits, which he nicely calls the '*internuncii*' of the body (156, 165; i.e., the messengers). The other participant in the dialogue, Misomedon, is skeptical:

> How do you know that there are Animal Spirits at all? The Nerves, through which they are supposed to flow, are not hollow, made like Pipes, as Arteries, Veins, Lympheducts, Lacteals and other Vessels, that are contrived to convey Liquids: They are solid Bodies, like Strings or Cords made up of many lesser Strings: No Liquid is found in them, nor have they any cavity to contain it. Therefore this Business of the Animal Spirits is only a Dream (135).

[30] I'm grateful to Jess Keiser for discussion of this passage; see Sutton, *Philosophy and memory traces* (208).

[31] I do not discuss here its brilliant 'social critique' of medicine as a power discourse, or its extremely unusual sensitivity to gender politics.

Philopirio replies that there are many things, the existence of which cannot be demonstrated *a priori*. He then proceeds to a series of analogies: microscopes enable us to see infinitely small vessels in insects; we know our hairs are actually hollow; there is a fluid within muscular fibres, as we also know from cooking! Hence it is "more than probable" that nervous threads, like other fibres, be hollow (135). Further, Philopirio argues that the existence of spirits *has* been demonstrated, and spends a page on the heat of the blood; how could the brain be affected by substances we ingest organically, if not by means of "volatile particles originally derived from the Blood" (136). And this hypothesis is widely shared by ancients and moderns (138). Misomedon grants him some of this, but insists that phenomena such as pain and sensation in general are more clearly explained in terms of the relations between solid parts (including motions transmitted by vibrating chords) than by assuming the existence of animal spirits (137). Philopirio also insists on the *variety* of animal spirits, complaining that most philosophers and physicians think of them as uniform particles. He discusses for example the effect of opium on the spirits, i.e. on our mental state, and disagrees with Willis that it has a harmful effect (236). As regards their 'messenger' or further, their character as an ontological go-between, Philopirio also speaks of the "most exquisite Functions of the Spirits," the "Nicety of their Performance" and the "Swiftness of the[ir] Execution," "the transcendent Subtility of those airy velocious Agents, the chief and immediate Ministers of Thought"; "officiating between the Soul and grosser Spirits of the Senses," they always have "Access to her invisible self" (161).

Crucially, when Mandeville asserts certain core elements of materialism – thought takes place in the brain, etc. – he ties this position to the existence of animal spirits. (I don't focus on the related question of their 'observability' or 'inobservability' here.) Following some intuitions of John Sutton, we can see this as a 'vitalized' materialism in which the features of the organic are not reduced to the features or properties of inanimate, mechanically specifiable bodies. Mandeville's *embodied* materialism is concerned with the interrelations and interactions between body, mind and brain: "I can as easily conceive the Stars without a Sky as Memory without a Brain" (160), not with some 'pure physics' vision of materialism (including a Hobbesian one). Here, a recognition of plasticity is articulated with an embodied materialism. A comparable articulation occurs in Diderot, although his central metaphor in dealing with the brain is not animal spirits but … a book.

Diderot's reflection on brains, minds, nerves and plasticity occurs across a variety of writings, including novels, scientific commentary, and plain 'philosophy', as in the *Rêve de*

D'Alembert (1769; unpublished in his lifetime), which introduces scientific speculations with metaphysical ramifications. But it is in his late manuscript on 'physiology', in fact a kind of natural-philosophical handbook for materialism, the *Éléments de physiologie* (written in the 1770s-1780s and unpublished in Diderot's lifetime), that we find the most explicit statement of cerebral plasticity. It occurs in a chapter on memory, in the third and last section of the manuscript, dealing with "phenomena of the brain." Diderot presents several extremely lyrical cases of recalling landscapes in nature and landscapes in painting, and then almost abruptly turns to cerebral-material explanations of such phenomena, with a striking image:

> In order to explain the mechanism of memory we have to treat the soft substance of the brain like a mass of sensitive and living wax, which can take on all sorts of shapes, losing none of those it received, and ceaselessly receiving new ones which it retains. There is the book. But where is the reader? The reader is the book itself. For it is a sensing, living, speaking book, which communicates by means of sounds and gestures the order of its sensations; and how does it read itself? By sensing what it is, and displaying it by means of sounds[32].

There are prefigurations of this image of the brain as a book. In his 1755 *Essai de psychologie*, Charles Bonnet spoke of the "mechanism of the brain" which could be read by an "Intelligence" which would be familiar with all of its details, sounding rather like a Laplacean demon; Bonnet added that this intelligence would read the brain "like a book" (vol. 8, 2). But Bonnet's conception is not plastic like Diderot's, who emphasizes the self-transformative (we might say 'self-organized') character of the brain. Contrast, for instance, the language used to describe much the same situation by an author who was in many respects very close to Diderot, namely La Mettrie:

> The cause of memory is entirely mechanical … and depends, it seems, on the proximity of the corporeal impressions of the brain, which are the traces of successive ideas; the Soul cannot discover one trace or idea without recalling the others which customarily accompanied it[33].

As La Mettrie says, it is an "entirely mechanical" process. From Descartes to Willis, and onwards into adumbrations of an embodied materialism with Mandeville and Diderot, we

[32] "Pour expliquer le mécanisme de la mémoire il faut regarder la substance molle du cerveau comme une masse d'une cire sensible et vivante, mais susceptible de toutes sortes de formes, n'en perdant aucune de celles qu'elle a reçues, et en recevant sans cesse de nouvelles qu'elle garde. Voilà le livre; mais où est le lecteur? C'est le livre même. Car ce livre est sentant, vivant, parlant ou communiquant par des sons, par des traits l'ordre de ses sensations, et comment se lit-il lui-même? en sentant ce qu'il est, et en le manifestant par des sons" (*Éléments de physiologie*, in Diderot, *Œuvres complètes*, vol. XVII, p. 470). Note that I am not presenting Diderot as a partisan of animal spirits: joining his voice to what was by then a majority view, he considers the belief in such entities as madness (I thank an anonymous reviewer for this reminder). But the ways of plastic materialism (i.e. how fluidity enters its ontology) are mysterious.

[33] " La cause de la mémoire est tout-à-fait mécanique . . .; elle paroît dépendre de ce que les impressions corporelles du cerveau, qui sont les traces d'idées qui se suivent, sont voisines; et que l'Ame ne peut faire la découverte d'une trace, ou d'une idée, sans rappeller les autres qui avoient coutume d'aller ensemble" (*Traité de l'âme*, ch. 10, in in La Mettrie, *Œuvres*, vol. I, p. 172-173); cf. *L'Homme-Machine*, in *op. cit.*, vol. I, p. 98.

have seen grapplings with the question – both experimental and conceptual, indeed ontological – of how a purely material (and perhaps mechanical) system can possess 'mind'-like properties: maximally, a form of agency, and minimally, "motive and sensitive force". Notice the absence of a fluid, self-transforming vision of the brain in La Mettrie's presentation, in contrast to Diderot's (and to the others presented above). Further, this fluidity can color, not just the vision of the brain but of the overall ontology – blurring the sharpness of the distinction I suggested at the outset, between materialism as a claim about the world and fundamental states of matter, and materialism as a claim about brain and mind. There are different materialist strategies of 'hyper-plasticity' here, which can turn animal spirits, not just into a go-between entity between realms, but into a kind of ontological category of their own, opening onto a new philosophy of nature.

If Willis or Mandeville had let their portrayals of the animal spirits wander into a further-ontologized arena in which they explained and/or colored more and more of the ontology itself, we would have arrived at something comparable to Diderot's account of the brain as a self-reading, self-organizing book, since his image is directly related to his overall concern, indeed obsession, with sensitivity as both a key feature of the nervous system and (here is the ontologization) as a key feature of matter itself *in esse* (Wolfe, "Sensibility"). Something like this occurs e.g. in Sade, who simply equated animal spirits with the electric fluid in the nerves (whereas many authors complain about the obscurity of the former in contrast with the scientific rigor of the latter, including 'vitalists' such as La Caze[34]), in order to emphasize the specifically hedonistic dimension of their plasticity (to use our term): all of our sensations are caused by the 'disturbances' (*ébranlements*) in this fluid, it is the "seat of pleasure and pain," "the only soul" (i.e. the only type or understanding of soul) that "modern philosophers allow for"; indeed, Lucretius himself "would have reasoned better" (doubtless in his notion of a material soul) had he known of this fluid (Sade, vol. 1, 575)[35].

To conclude, if we follow these tiny messengers, they lead us to

(i) a revised picture of the possibilities of early modern and Enlightenment materialism in

[34] "Tous les effets qu'on a attribués jusqu'ici aux esprits animaux dans le jeu de l'économie animale, se déduisent beaucoup plus simplement & plus clairement des propriétés reconnues du fluide électrique, que de toutes les suppositions vagues qu'on avoit été contraint de faire, pour établir la nature & les propriétés de ces esprits animaux" (La Caze, *Idée de l'homme physique et moral*, 78). Thanks to Marco Menin for calling my attention to this passage. For further discussion of Montpellier vitalist attitudes to animal spirits see D. Boury, *La philosophie médicale de Théophile de Bordeu*.

[35] Sade, *Aline et Valcour*, in *Œuvres*, I, p. 575. On the Epicuro-Lucretian idea of a 'material soul' in early modern clandestine thought, see Wolfe and van Esveld, "The Material Soul".

dealing with the brain and its plasticity, building on the real conceptual fertility of animal spirits that Sutton has described (*Philosophy and memory)*, not 'trapped' in a linear scientific development, but precisely messengers, agents of transmission which enable Willis (but also Sterne) to articulate brain models characterized by fluidity and dynamism rather than by passive matter;

(ii) a heretical picture of empiricism contrasting with the official programmatic pronouncements of a Locke or a Hume, when they claim that they entirely bracket off physical and physiological considerations in their study of the mind (Sutton, "Carelessness") - animal spirits turn out to have crept back in;

(iii) an equation or articulation of spirits, plasticity, and vital materialism as an ontology (the "ontological service" performed for materialism by the spirits, as I put it earlier) – including as an ontology of the brain, which is granted properties that pencils and clocks, but also kidneys and livers, do not seem to possess.

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