

**‘Clusters’ of Ideas. Social Interdependence and Emotional Complexity in David Hartley’s *Observations on Man* and Adam Smith’s *Theory of Moral Sentiments***

**I From Passion to Feeling**

My contribution to the topic of this conference – “Representations of Emotions” – consists of four hypotheses about debates in 18th-century moral philosophy:

My first hypothesis is that there is a strong interdependence between the nature of emotions and the way they are represented. I should here like to understand ‘representation’ in an obvious sense, i.e. as a technical term for sensory and neurophysiological processes. For it is not only since Descartes that epistemology has been accompanied by medical models attempting to provide a material basis for psychological phenomena. This is true quite independent of the arguments of the various philosophical schools.

I have spoken of ‘interdependence.’ On the one hand, emotions somehow seem to be influenced by the physiological channels of expression to which they are allotted – where, according to contemporary science, they get their energy from, how they connect with ideas, how they associate among themselves, what effects they produce in the mind, the body, and the sense organs. One feels in a different way depending on whether one locates the source of these feelings in the humours produced in the abdomen or in the nervous system weakened by advancing civilisation – to name the two significant options for the 18th century.

On the other hand, the history of these physiological illustrations recapitulates and assimilates the history of emotionality. However materialist the physiologists may portray themselves, they in fact invent physiological processes in order to base on them the actual emotional experiences that are typical of their period.

My second hypothesis is that it would be useful to distinguish between passion and feeling and that 18th-century society moves from a grammar of passions to a grammar of feelings. This is not just because classic passions

like anger, avarice, lecherousness, and hate might be stronger than the feelings in which the enlightened and sentimental 18th century indulged, but because there are formal reasons as well, or better: reasons that have to do with the logic of representation.

This leads me to my third hypothesis, namely that the 18th century saw a fundamental and momentous change in the ways emotions were represented, and not just in the kinds of feelings. The grammar of feelings differs in at least two respects from that of the passions: firstly, passions are simple qualities that can be categorised correspondingly while feelings are depicted as blends of diverse elementary emotions. Feelings possess a statistical quality that the passions of pre-Enlightenment – rhetorical – psychology do not have. Secondly, feelings, in contrast to passions, function reflexively, both with regard to other mental states and to the reactions of different people with different feelings.

My fourth hypothesis claims that these changes are caused by increasing social interdependence and that 18th-century psychology, just as other disciplines dealing with interdependence, seeks to convert this social interdependence into a similarly complex emotional arithmetic.

## II Theory of Associations

In the 18th century a subject became fashionable that before had only been pursued on the side, as a rhetorical sub-discipline. This is the theory of associations. Its flourishing can easily be attributed to the growing significance of its very object.

Rationalist rhetoric had split itself into two registers. As a communicative technique it strove to convey messages to the addressee as faithful as possible to the meaning intended by the speaker/sender. This transfer was conceived as a kind of copying of consciousness. Ideas take shape in the mind of the speaker, who couches them in adequate words which in turn cause equivalent ideas in the listener. Or alternatively, physiologically speaking: ideas are stored in the mind as images, they are engraved in the mind's matter. Since linguistic signs represent ideas, they can be used to reproduce these ideas without major transfer problems. In the mind of the listener they induce an equivalent process: they evoke ideas that leave their respective impressions.

This is the register of denotation. With its help abstract truths are communicated. However, ideas that are not supported by passions necessarily remain weak; they do not reach sufficient depth. In order to heighten the effect, thoughts have to be embellished, dressed up with emotional interest; they have to come alive in the mind's eye. This is achieved through an additional and complementary register, the register of connotation. Connotation, too,

establishes a relationship of copying, yet it does not reflect facts, states of affairs, but states of mind of the speaker/listener. Denotation outlines the picture, as it were, while connotation supplies the required colour. It does this by working with tropes and figures, by collecting stimuli elsewhere, by appealing to personal experience; in other words: by capitalizing on the listener's ability to associate.

Rationalism assumed a clear hierarchy between the two registers. Denotation makes use of connotation but keeps it under control – under the control of those who employ it in a rhetorically adequate way. Rationalist linguistic theory adopts a similar stance: a word's central denotative meaning governs its potential connotations. This is also exactly the paradigm on which psychological thinking was based at that time: it was assumed that the mechanism of the association of ideas allowed for every concept a number of other related concepts, but that did not seriously threaten the processing of the actual ideas.

All of that changed with 18th-century stylistics and psychology. Here, the theory of associations gains an evermore important place. It no longer confines itself to making plausible the stimulating or disconcerting contexts of communication. Rather, the theory of associations becomes aesthetically as well as epistemologically a key issue in the theory of perception. Enlightenment epistemologists can no longer recognise ideas as entities; they break them down into ever smaller elements. As a result the association of ideas plays a more and more important role. However, associations cannot be controlled as readily as the moulded images of calculating rhetorical operations. They are shaped biographically and thus, to an extent unknown until then, bring into play the individuality of the people involved. For that reason it becomes impossible to think of communication simply as an analogous transfer of contents of consciousness. The distance between author and reader becomes wider, their relationship more insecure, and it can no longer be guaranteed that the recipient will perceive the exact meaning the author wanted to communicate.

There were, roughly speaking, two options to react to this development: firstly, a policy of restriction with which to suppress the associative, individual, the subjective-incalculable, the surplus of the sign in comparison to the signified or, in a nutshell: the high-handedness of imaginative power let loose from its rational moorings. This is the 'conservative' approach. Secondly, the 'progressive' option, i.e. the effort to create communicative order out of the principles of the imagination and the associations themselves.

## III David Hartley and the Complexity of Ideas

I consider David Hartley and Adam Smith representatives of the second faction, regardless of their differences. Hartley's voluminous treatise *Observations on Man, His Frame, His Duty, And His Expectations* of 1749 is well-

known for its considerable influence on the English Romantic poets. Hartley grounds the whole moral and social universe on the theory of associations. The elementary constituent of this universe is sensation. "Sensations, by being often repeated, leave certain Vestiges, Types, or Images, of themselves, which may be called, Simple Ideas of Sensations."<sup>1</sup> Ideas are images of sensations, or, the other way round: in the mind, sensations turn into sensual ideas. They are transmitted through vibrations from the sense organs to the brain, where they exercise an unspecified mechanical influence on the soft matter, which preserves them in miniature format and enables retrieval by memory.

Of course the world of the senses is not made up of series of unconnected elementary sensations. When neural stimuli leave their "Types, or Images" in the mind, they interact with other vibrations, which leads to a modification of the transmitted sensory input. Thereby more complex and more heterogeneous data structures emerge. "Simple Ideas," says Hartley, "will run into complex ones, by means of Association."<sup>2</sup> He speaks of "clusters" of ideas and explains:

And, upon the Whole, it may appear to the Reader, that the simple Ideas of Sensation must run into Clusters and Combinations, by Association; and that each of these will, at last, coalesce into one complex Idea, by the Approach and Commixture of the several compounding Parts.<sup>3</sup>

Yet Hartley does not stop at this distinction between simple and complex ideas but combines it with a second distinction of sensory and mental impressions. Following Locke and his rejection of the traditional mind-body dualism, which presumed two entirely different sources and substances for the sensory and the mental, he derives intellectual ideas from the principles of the associations of ideas as well. For him, intellectual ideas are nothing more than combinations of simple, physical sensations. Both are distinguished only by their degree of complexity. About intellectual ideas Hartley says that it is their "very Essence [...] to be complex."<sup>4</sup> The old metaphysical dichotomy is dissolved into a hierarchy of complexity. As far as this is concerned, Hartley in fact speaks of a vision to be realised in the future, but that does not keep him from making quite light-hearted use of the new premises:

One may hope, therefore, that, by pursuing and perfecting the Doctrine of Association, we may some time or other be enabled to analyse all that vast Variety of complex Ideas, which pass under the Name of Ideas of Reflec-

<sup>1</sup> David Hartley, *Observations on Man. His Frame, His Duty, and His Expectations*, Two Volumes in One, Gainesville, Fla., Scholar's Facsimile & Reprints 1966 [1749], vol. I, 56; all further page references refer to this work.

<sup>2</sup> Op.cit., I, 73.

<sup>3</sup> Op.cit., I, 74.

<sup>4</sup> Op.cit., I, 56.

tion, and intellectual ideas, into their simple compounding Parts, *i.e.* into the simple Ideas of Sensation, of which they consist.<sup>5</sup>

Thus, Hartley turns the physiology of the senses into a kind of exercise in cybernetics *avant la lettre*. Increasing complexity generates entirely new qualities in the mind: abstract ideas. A purely quantitative parameter, a greater or lesser degree of complexity, is responsible for covering the distance between immediate sensations and the intellect. The more complex the formation of ideas, the more intellectual are the results because the mutual influence of the nervous vibrations represents a bodily activity that pushes the original sensory stimuli into the background. The increase in complexity thus produces 'higher' and more intellectual, even 'spiritual' frequencies for plain neurophysiological reasons:

When the complex miniature Vibrations are thus exalted in Degree, we are to conceive, that the corresponding complex Ideas are proportionally exalted, and so pass into intellectual Affections and Passions.<sup>6</sup>

This leads to two potential consequences, one of them looking backwards, so to speak, the other one forward-looking. On the one hand, it is possible to trace back the development of intellectual ideas and to decompose them into their sensory elements. Then good and bad parts can be separated – with the goal of better 'associative hygiene' and parallel moralization of thinking.<sup>7</sup> But, on the other hand, it is also feasible to encourage the process of association even further in order to widen the distance between the intellectual ideas and the simple sensations that are altogether confined to the body and the senses. This is due to the fact that enhanced association of ideas contributes, irrespective of the constitution of individual sensations, to the spiritualization of ideas. And Hartley is still bound to tradition insofar as he regards the body as the negative and the intellect as the positive pole on the scale of moral perfection.

This is nothing less than an early model of entropy. Association is, for Hartley, a means of blending physical traces of sensations beyond recognition and thereby generating purer mental states. With a 'trick' Hartley manages to turn the resulting moral gain effortlessly into a theory of happiness: he adds to his argument the axiom that on the one hand "the Pains be, in general, greater," but insists on the other that "our sensible Pleasures are far more numerous than our sensible Pains."<sup>8</sup> In other words: the effects of pain might be more acute, but "Pleasures" – which are distinguished from pain not qualitatively but merely by a lesser and therefore more tolerable intensity<sup>9</sup> –

<sup>5</sup> Op.cit., I, 75f.

<sup>6</sup> Op.cit., I, 80.

<sup>7</sup> Op.cit., I, 81.

<sup>8</sup> Op.cit., I, 83.

<sup>9</sup> "First then, The Doctrine of Vibrations seems to require, that each Pain should differ from the corresponding and opposite Pleasure, not in Kind, but in Degree only, *i.e.* that Pain should be nothing more than Pleasure itself, carried beyond a due Limit." Op.cit., I, 35.

are more frequent. Now, the more acutely unpleasant and moderately pleasing sensations are mixed, the more noticeable the quantitative dominance of agreeable sentiments becomes. This is, at least, what Hartley believes on the basis of his occasionally dubious emotional arithmetic. Painful and pleasurable ideas in their sum tend towards an average value above the arithmetic mean and thus lie within the, as it were, emotional profit margin.

If now the Ideas of these sensible Pleasures and Pains are associated together, according to all the possible Varieties, in order to form intellectual Pleasures and Pains, it is plain, that Pleasure must prevail [...]; and also, that when the several Parts of these complex Pleasures are sufficiently united by Association, the Pains which enter their Composition will no longer be distinguished separately, but the resulting mixed and complex Pleasures appear to be pure and simple ones, equal in Quantity to the Excess of Pleasure above Pain, in each Combination. Thus Association would convert a State, in which Pleasure and Pain were both perceived by Turns, into one in which pure Pleasure alone would be perceived; at least, would cause the Beings who were under its Influence to an indefinite Degree, to approach to this last State nearer than by any definitive Difference. Or, in other Words, Association, under the Supposition of this Corollary, has a Tendency to reduce the State of those who have eaten of the Tree of the Knowledge of Good and Evil, back again to a paradisiacal one.<sup>10</sup>

This argument is as complicated as it is daring. At any rate, it allows mankind to regain paradise by virtue of association. Aggregates of ideas obtained through blending reduce the amplitude between contrary emotions, step by step they even level out the difference between good and evil and restore man's harmony and inner purity that were lost with his original progenitors' Fall. Moreover, this emotional convergence is not restricted to the individual's inner life. It includes one's fellow men and, in the end, can be extended to humanity as a whole. In an ambitious theological speculation Hartley concludes "[t]hat Association tends to make ultimately similar; so that if one be happy, all must."<sup>11</sup> The physiological laws of association applied to the body politic, produces "pure ultimate spiritual Happiness"<sup>12</sup> everywhere.

For such confluent effects, be it within one body or between several bodies, the 18th century had a specific term: sympathy. This term originally stems from the *magia naturalis*; but in the social theories of the Enlightenment it acquires a meaning opposed to its magical heritage and psychological in the modern sense of the word. Hartley's argument makes clear that the potency of sympathy thus understood belongs to the category of feeling, not to the system of passions: it unfolds where solitary sensory stimuli in the associative network combine to form fuzzy overall pictures that generate states of mind, moods, and emotional entropy. The passions of the old psychology of types had been subject to the rules of mechanical and

<sup>10</sup> Op.cit., I, 83.

<sup>11</sup> Op.cit., I, 84.

<sup>12</sup> Loc.cit.

hydraulic causality. Sympathetic feelings obey different laws. They are based on the calculability of complexity, a phenomenon that also received attention in other disciplines at the same time: in Newtonian physics, which deals with long-distance effects, fluid forces in the atmosphere and mass integrals,<sup>13</sup> and in probability calculus, the beginnings of which belong to that era and which was no longer exclusively interested in singularities but also in properties of sets.

#### IV Adam Smith and the Interdependencies of Social Behaviour

In his *Theory of Moral Sentiments* (1759) Adam Smith devises a system that bases society's emotional cohesion on the concept and operations of sympathy. For a long time now scholars have asked how far this approach is compatible with that of his principal work, the *Inquiry into the Nature and Causes of the Wealth of Nations* that appeared seventeen years later, in 1776. In the former book, society depends on compassion, in the latter on selfish interest. There are grounds for assuming that both conceptions are dependent on each other, that the first one functions as a prerequisite of the second one; sympathetic stirrings and motivation of self-interest would then be complementary to each other rather than mutually exclusive. Smith has also been suggested as a source for the view of capitalism as parasitically feeding off social bonds that in their essence are of pre-capitalistic origin – the view that capitalism somehow utilizes an older and more primitive solidarity as a kind of raw material, which it uses up without being able to replenish it.<sup>14</sup>

In my opinion, however, such interpretations run the risk of underestimating the potential for rationalization and the modernity of sympathy as conceived by Smith. He identifies a mechanism in the concept of sympathy that modern system theory would call 'double contingency.' *Ego* cannot put himself in the position of *alter*, nor can *alter* be in *ego's* place. The distance between individuals cannot be bridged and can at best be diminished indirectly. The only means of doing this lies in the power of the imagination:

As we have no immediate experience of what other men feel, we can form no idea of the manner in which they are affected, but by conceiving what we ourselves should feel in the like situation. Though our brother is upon the rack, as long as we ourselves are at our ease, our senses will never inform us of what he suffers. They never did, and never can, carry us beyond our own person, and it is by the imagination only that we can form any conception of what are his sensations. Neither can that faculty help us to this any other

<sup>13</sup> On the spiritual affinity of Hartley's physiology with Newtonian physics cf. Martin Kallich's "Introduction," in David Hartley, *Various Conjectures on the Perception, Motion, and Generation of Ideas*, Los Angeles, University of California Press 1959 [1746].

<sup>14</sup> Cf. Helmut Dubiel, "Autonomie oder Anomie. Zum Streit über den nachliberalen Sozialcharakter," in Johannes Berger (ed.), *Die Moderne – Kontinuitäten und Zäsuren*, Göttingen, Schwartz 1986, 263-281; here 269ff.

way, than by representing to us what would be our own, if we were in his case. It is the impressions of our own senses only, not those of his, which our imaginations copy.<sup>15</sup>

This is a clear refutation of rhetorical models of transmission. Even the spontaneous stirrings of sympathy cannot, according to Smith, change anything about the mutual inaccessibility of individuals. This is also the reason why compassion will never be as strong as the original emotion. It works more like the (Burkean) experience of the sublime or even the traditional (Aristotelian) experience of pity and fear: the spectators are watching a drama that excites their passions, while in reality they have a secure place outside the action.

After all this, however, the emotions of the spectator will still be very apt to fall short of the violence of what is felt by the sufferer. Mankind, though naturally sympathetic, never conceives, for what has befallen another, that degree of passion which naturally animates the person principally concerned. That imaginary change of situation, upon which their sympathy is founded, is but momentary. The thought of their own safety, the thought that they themselves are not really the sufferers, continually intrudes itself upon them; and though it does not hinder them from conceiving a passion somewhat analogous to what is felt by the sufferer, hinders them from conceiving any thing that approaches to the same degree of violence.<sup>16</sup>

This toning down, however, does not only happen – and this is what makes Smith's conjecture interesting – to the observer of someone else's passions. The emotions of the observer reflect, via the same sympathetic channel, on the observed. In a social universe charged with mutual sympathy, recursive effects are produced: by sympathising with other people's sympathy, one's own emotions, too, are weakened.

This represents a second-order observation, the observation of the observer. The first observer sees in his fellow man a surge of passion that, by way of the imagination, he can apply to himself and thus can feel with reduced intensity. Yet the observed person for her part feels this reduction in the observer. Hence she gains a perspective on herself from the outside – a perspective, that is, that has followed the path of double dissociation. On this path, the intensity of the original emotion is replaced by a different, reflexive emotional state. While the primary passion was effective directly and with might and main, out of the to and fro of the observation of the observation there grows something completely different; and that is feeling. Smith painstakingly scrutinizes the interrelation between sufferer and spectator:

As they [the spectators] are continually placing themselves in his situation, and thence conceiving emotions similar to what he feels; so he is constantly placing himself in theirs, and thence conceiving some degree of that coolness about his own fortune, with which he is sensible that they will view it.

<sup>15</sup> Adam Smith, *Theory of Moral Sentiments*, Dugald Stewart (ed.), New York, Kelley 1966 [1853] [1759], 4; all further page references refer to this work.

<sup>16</sup> Op.cit., 22f.

As they are constantly considering what they themselves would feel, if they actually were the sufferers, so he is constantly led to imagine in what manner he would be affected if he was the only one of the spectators of his own situation. As their sympathy makes them look at it in some measure with their eyes, so his sympathy makes him look at it, in some measure, with theirs, especially when in their presence, and acting under their observation: and, as the reflected passion which he thus conceives is much weaker than the original one, it necessarily abates the violence of what he felt before he came into their presence, before he began to recollect in what manner they would be affected by it, and to view his situation in this candid and impartial light.<sup>17</sup>

Observation of someone else leads to self-observation, which is why the recursive effects of sympathy not only enhance the closeness between people but also the self-control of each individual. From this phenomenon Smith derives the concept of "self-command" which develops with "regard to the sentiments of the supposed impartial spectator," i.e. through the fiction of continually being looked at.<sup>18</sup> Every member of a sympathetically communicating group is always someone else as well, learning to see himself with someone else's eyes and to feel someone else's feelings. Smith outlines a system in which everyone has emotional shares, so to speak. These intertwining partnerships are, with expanding general multiplication and division of the self, of benefit to a universal pacification of emotional life.

Sympathy's capacity for ordering has yet another effect: the interrelation between individuals not only causes, as described, a weakening of emotions, but the channels for transmitting sympathy altogether exclude 'indecent passions,' emanating as they do from the body. Chiefly transmitted sympathetically are "those passions which take their origin from the imagination."<sup>19</sup> Mere bodily emotions provoke repulsion instead of compassion:

Such is our aversion for all the appetites which take their origin from the body: all strong expressions of them are loathsome and disagreeable. [...] The true cause of the peculiar disgust which we conceive for the appetites of the body when we see them in other men, is, that we cannot enter into them.<sup>20</sup>

Considerations such as these also play a role in the contemporary debates about the conditions for the imagination of passions on the stage. I will not go into that in more detail, however. To me, it seems more important in our context to look at the hidden kinship between Smith's concept of sympathy and Hartley's theory of associations. Both describe structures of interdependence – be they social or physiological – that result in the expulsion of the body from the imaginary sphere. Both do not discount interdependencies but programmatically strengthen them as they lead to a stable equilibrium.

<sup>17</sup> Op.cit., 23f.

<sup>18</sup> Op.cit., 386.

<sup>19</sup> Op.cit., 35.

<sup>20</sup> Op.cit., 34.

Both theories are about feedback effects which, for the authors, who are breaking new ground here, serve as starting points for novel techniques of control. Hartley allows nervous sensations to interfere to such a degree that their natural input, the original stimulus, completely disappears behind the process of interference.<sup>21</sup> In the closed associative sphere of the nervous system these external inducements can no longer be assigned a causal purpose. Adam Smith proceeds in analogous fashion, albeit with a more elaborate vocabulary. He juxtaposes sympathetic reactions in such a way that they mutually adjust down to a lowered but even level of emotional inclination or, as he puts it, "love."<sup>22</sup>

### V James Watt and the Principle of Mechanical Self-Regulation

One could devote a separate analysis to the occurrence and functioning of such feedback effects in contemporary economic theory, especially in the physiocrats and in Smith's own economic oeuvre.<sup>23</sup> Yet I would like to draw, in the form of mere speculation, a different parallel – indeed to the work of a contemporary and friend of Adam Smith's. I refer to James Watt and his famous steam engine. After all, its innovation was not the use of steam power. There had been more or less successful experiments with this before. Rather, Watt found solutions to two problems that his predecessors had failed to solve. Firstly, he brought together the two phases of expansion and condensation, the heating up and cooling down of steam in a single mechanical sequence. This was made possible because, secondly, he built the engine as a closed dynamic circle – apart from the supply and removal of the steam itself, of course – which phased itself and which had no need for regular intervention by the engineer.<sup>24</sup> This was achieved by Watt's dexterous use of feed-

<sup>21</sup> "If the Number of simple Ideas which compose the complex one be very great, it may happen, that the complex Idea shall not appear to bear any Relations to these its compounding Parts, nor to the external Senses upon which the original Sensations, which gave Birth to the compounding Ideas, were impressed. The Reason of this is, that each single Idea is overpowered by the Sum of all the rest, as soon as they are all intimately united together." Hartley, *Observations on Man*, 75.

<sup>22</sup> Smith, *Moral Sentiments*, 124.

<sup>23</sup> Cf. Albert O. Hirschman, *The Passions and the Interest. Political Arguments for Capitalism before its Triumph*, 20th Ann. Ed., Princeton, N.J., Princeton University Press 1997. Hirschman describes how passion of the older type could be used, in the form of capitalist interest, against itself and thus contribute to its own disciplinization.

<sup>24</sup> "The universally minded eighteenth century was interested in the overall view, in cyclic processes. Giambattista Vico, in his *Scienza Nuova* (1730) looks for cyclical processes in history: who knows the history of one people knows the history of all peoples. Parallel with this, there is a turning of awareness to cyclic processes in physics and to their utilization in practical life. Contemporaries found a most strong stimulus to their inventive fantasy in the gas-to-liquid, liquid-to-solid cycle and its reverse. The cyclic passage from water to steam and from steam back to water led the practical mind of James Watt, with a minimum of technical knowledge, to the invention of the condenser (1769), the function of which is to recondense water vapor after expansion to sub-atmospheric pressure. This supplied the missing link in the cycle, and the modern steam engine was made possible." Siegfried

back. It was provided by several valves which rhythmically opened or closed with the piston movement and thus alternately generate the required low and excess pressure in the cylinder and its surrounding containers. The construction's ingenuity lies in the fact that the same load arm which the piston presses upwards and which carries out the lifting, is simultaneously linked to the valves and controls their opening or closing<sup>25</sup> – a mechanical version of cyclical self-regulation.

Self-regulation, to use one of Hartley's expressions again, presupposes "mutual indefinite Implication" of all involved elements.<sup>26</sup> It entails that all possible states of a system can be transformed into each other. The difficulty, therefore, lies in recognizing and utilizing the common denominators of such contrasting dimensions as sensuality and spirituality, love and individuation, heating and cooling. In that sense I regard both the theory of associations and 18th-century social theory as spiritually akin to the machines constructed at that time.

All of the three models I have presented in a summary fashion deal with unstable forces. They share the fact that they use part of their system's energy to control and dampen the main process. They set going a dynamism that from a certain point onwards turns against itself and becomes, in a manner of speaking, the driving force behind its own deceleration. The consequences are dynamic homeostases – and this formula, which sounds paradoxical in retrospect, describes, in such disparate fields as psychology and mechanical engineering, an essential feature of the dawning industrial revolution.

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<sup>25</sup> Although here Watt had recourse to the preliminary work of other inventors as well. Cf. Conrad Matschoß, *Die Entwicklung der Dampfmaschine. Eine Geschichte der ortsfesten Dampfmaschine und der Lokomotive, der Schiffsmaschine und Lokomotive*, 2 vols., Düsseldorf, VDI-Verlag 1987 [1908], vol. I, 281ff and Hans L. Sittauer, *James Watt, Biographien hervorragender Naturwissenschaftler, Techniker und Mediziner* vol. 53, Leipzig, B.G. Teubner Verlagsgesellschaft 1989, sec 74 for a design of the 1776 steam engine.

<sup>26</sup> Which of course then had to be restrained. Quotation in Hartley, *Observations on Man*, I, 71.

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