HOW THINKING BECAME WORK: THE MENTAL WORK PROBLEM IN NINETEENTH-CENTURY EUROPE

by

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B.A., The University of British Columbia, 2013

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

in

THE FACULTY OF GRADUATE AND POSTDOCTORAL STUDIES

(Science and Technology Studies)

THE UNIVERSITY OF BRITISH COLUMBIA

(Vancouver)

August 2016

Abstract

This essay examines the problem of mental work in nineteenth-century Europe. As intellectual occupations became part of the economy, different thinkers strove to understand the nature of mental work. Whether it was penning novels, performing experiments, managing accounts, or designing products, intellectual labour became a new form of life in the modern metropolis. The crucial question for late-nineteenth century thinkers was how one could anchor and measure the value of ideas. Although the question was economic in nature, the solutions involved resources drawn from across the human sciences, but in particular from political economy, physiological psychology, sociology and philosophy. I show that the mental work problem was bound up with the dissolution of the labour theory of value, and the shift in political economy towards psychology and consumption. Few observed this shift, and its connection to the mental work problem, as well as Georg Simmel. I show that Simmel's reflections on mental work led him to theorize the role of knowledge and intellectual work in the economy.

Preface

This thesis is entirely the original, unpublished, and independent work of the author, Jordan Howell.

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Acknowledgements

This thesis is the result of much mental work, a good deal of which is not my own. I would like to thank, Bob Brain, my supervisor, for his critical and generative engagement with my work, and for encouraging me to pursue this project; Alan Richardson, for his critical thoughts as a second reader, and especially for his ongoing mentorship; and Thomas Kemple, for commenting on an early presentation of this project, and for his interest and input in my project. I also owe much to the support of the UBC Science & Technology Studies community, including, but not limited to, John Beatty, Adam Frank, Alexei Kojevnikov, and Margaret Schabas. I would like to thank members of the Department of the History and Sociology of Science at the University of Pennsylvania for their feedback on an early draft, particularly Harun Küçük and Projit Mukharji.

My fellow graduate students did much to support this project. I am grateful to Benjamin Allard, Sarah Basham, Geoff Bil, Ken Corbett, Shoshana Deutsh, Silvia Moreno-Garcia, Michael Hare, Andrew Jones, Brent Lin, Stefano Pantaleone, and Jia Yu. I owe much to my closet friend, and comrade, Dexter Fergie, who made this project and my M.A. an unforgettable experience. Dexter was there, whether it was joining me as an auditor in a seminar on Postcolonial French Literature, even with a full schedule; reading drafts in late December; attending the William James Society meeting on a Friday evening; or spending the afternoon discussing this work at the pub.

Without the financial support of the Science and Technology Studies Graduate Program at UBC, and the Social Sciences and Humanities Research Council of Canada, this research would not have been possible.

Most of all I want to thank my family. My grandparents, Al and Heidi, graciously welcomed me into their home during the fall of 2014. Lauren, my sister, remained a constant source of inspiration. My parents, Kevin and Christine, have always been my most important mentors, and I am very grateful for their inestimable support. Raquel Baldwinson, my partner, helped me through the most difficult intellectual and personal challenges I faced this past year. She read several drafts, and discussed *many* iterations of this project with me. The dedication is a small thank you for her support.

For Raquel

Chapter 1: Introduction

I know that I shall die without spiritual heirs (and that is how it should be). Mine is like a cash legacy divided among many heirs, and each converts his share into whatever business suits *his* nature, in which the provenance from that legacy cannot be seen.
Georg Simmel**,** *Journal Aphorisms* (From *The View of Life*)

In summer 1879, Eugène Gley, a budding French physiologist, sat stiff at his desk. For fifteen minutes he could neither move his body, nor disrupt his breathing. Without the aid of pen and paper, Gley crunched a series of difficult multiplications. As he computed each equation, an inscription apparatus traced the duration, intensity and force of his mental work. To isolate the physiological concomitants of mental work, careful discipline of mind and body was of the essence. If emotions flooded the mind, or muscular work augmented the total work of the system, the experiment was compromised. Strict discipline of the will was imperative.[1]

By the 1890s, physiologists across Europe had demonstrated the effects of mental work on various physiological measures, including the pulse, the secretion of nitrogen and phosphorous, and the temperature of the body. Efforts to address the nature of mental work were not limited to the physiological laboratory, however. In 1899, Georg Simmel published an essay "Towards a Philosophy of Work" (*Zur Philosophie der Arbeit)* that attempted to grapple with what I call the mental work problem.[2] A year later, the problem of mental work became a crucial element in Simmel's *Philosophy of Money*. For Simmel, the prevalence of mental work in the modern metropolis – *geistige Arbeit* in German and *travail intellectuel* in French – represented a sea change in European social relations. Whether it was penning novels, performing

[1] Eugène Gley, "Étude expérimentale sur l'état du pouls carotidien pendant le travail intellectuel" (Phd Diss., 1881, Université de Nancy). Unless otherwise noted, all translations are my own.
[2] Georg Simmel, "Zur Philosophie der Arbeit," *Neue Deutsche Rundschau* 10 (1899): 449-63. In this case, the preposition "zu" is best translated as "towards", rather than "on" or simply as "The Philosophy of Work", given the preliminary, exploratory nature of the text.

experiments, managing accounts, or designing products, an increasing number of European city-dwellers engaged in tasks understood as nonmanual or mental work.

Although social histories have examined the rise of white-collar or intellectual work in late-nineteenth century Europe and America, my question is different.[3] My starting point is mental work as a problem of intellectual history.[4] The crux of the mental work problem in its nineteenth century formulation was how one could anchor the *value* of ideas. How did thinking produce real economic value, and how could this value refer to the material world of bodies and engines? The mental work problem is intimately linked to the transition of the source of value in political economy from labour and production to utility and consumption.[5] This, as I will show, was also Simmel's view.

As industrial capitalism radically reshaped social relations in nineteenth century Europe, humans, machines, and the economy increasingly became part of a single, productive system. Thermodynamics and the mechanical measurement of work presented a model through which all labour – human and machine – might be understood as an expenditure of energy.[6] In political

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[3] Jürgen Kocka, "The European Pattern and the German Case," in *Bourgeois Society in Nineteenth-Century Europe*, eds. Jürgen Kocka and Allan Mitchell (Oxford: Berg Publishers Limited, 1993), 3-39; Kocka, *Industrial Culture & Bourgeois Society: Business, Labour and Bureaucracy in Modern Germany* (New York: Berghahn Books, 1999); and *White Collar Workers in America: 1890-1940*, trans. Maura Kealey, (London: Sage, 1980).
[4]Not unlike the vision John Tresch articulates in "Cosmologies materialized: History of Science and History of Ideas," in *Rethinking Modern European Intellectual History*, eds. Darrin McMahon and Samuel Moyn (Oxford: Oxford University Press, 2014), 153-172. For examples of problem-based approaches in the history of science, see Jimena Canales, *A Tenth of a Second: A History* (Chicago: The University of Chicago Press, 2011); John Tresch, *The Romantic Machine: Utopian Science and Technology after Napoleon* (Chicago: The University of Chicago Press, 2012) and Elizabeth Green Musselman, *Nervous Conditions: Science and the Body Politic in Early Industrial Britain* (Albany: State University of New York Press, 2006). Although my approach is not social history, it is also not the analytical approach Alfred Sohn-Rethel takes to a similar problematic in *Intellectual and Manual Labour: A Critique of Epistemology* (London: Macmillan, 1978).
[5] For an incisive analysis of this shift, see Margaret Schabas, *The Natural Origins of Economics* (Chicago: The University of Chicago Press, 2006), esp. 124-141.
[6]For the development of this thesis, see Anson Rabinbach, *The Human Motor: Energy, Fatigue and the Origins of Modernity* (Los Angeles and Berkeley, University of California Press, 1990) and also Philip Mirowski, *More Heat*

economic terms, the mechanical measure of work helped complete a unified theory of labour. A crucial site of this transformation was the physiological laboratory. Physiologists began to apply instruments used to measure machine work to organic bodies, which demonstrated that the expenditure of energy presented a common currency – the key to a unified theory of labour – between machine and bodily work. As intellectual activities increasingly had become a driving force in the economy, the question became whether one could treat thinking in the same way. The extension of this research program to the mind did not signify, as Simmel noted, "merely proletarian spite and fundamental depreciation of intellectual achievements."[7] On the surface, the physiological measurement of mental work promised a unified conception of labour, which signified the possibility of economic liberation for socialists and rational management for factory owners.

Simmel admitted that, in the future, mental work might be understood in mechanical terms. At the turn of the century, however, he dismissed a mechanical interpretation of mental work as a "scientific utopia". For Simmel, the physiological measurement of mental work revealed the protean nature of work in the modern metropolis. Mental work was thus not reducible to an expenditure of energy. Though contemporaries drew comparisons between *Philosophy of Money* and Marx's *Capital*, Simmel's analysis of mental work, as I demonstrate, turned Marx's framework on its head.[8] Knowledge was now the base, and intellectual work the obverse of a capitalist system fuelled by consumption, rather than production.

Than Light: Economics as social physics: Physics as nature's economics (Cambridge: Cambridge University Press, 1989).

[7] Georg Simmel, *Philosophy of Money*, trans. David Frisby and Tom Bottomore (New York: Routledge, 2004), 414.

[8] For the reception of *Philosophy of Money*, see David Frisby, *Georg Simmel,* (London: Routledge, 2002), 80-82. Rudolf Goldscheid drew an extensive comparison, and claimed that "Simmel's work contains a supplementation of Marx's life work such as has hitherto not existed in social science, even in any attempts at such," Rudolf

Chapter 2: Head and Hand: the Making of Mental Work

Conceptions of work in nineteenth century European political economy differed significantly from eighteenth century ones. In *The Wealth of Nations* (1776), for instance, Adam Smith elaborated on the productive implications of the division of labour applied to manual work. In his oft-repeated example of pin-making, ten men, each given a task "accommodated with the necessary machinery," might make forty-eight thousand pins in a day. Whereas separately, "and without any of them having been educated to this particular business," it would have been difficult for them to make one.[9] For Smith, the division of labour did nothing more than "fine-tune the balance of the economy," an equilibrium model Smith had taken from his earlier works on astronomy.[10] Machines, in Smith's account, were not independent entities in the division of labour; they served to "facilitate" and "abridge" human work. [11] Technology was thus a refinement of the division of labour. In other words, machines did not work, people did.

Manual human work was also the only form of productive work. The work of the philosopher, doctor or lawyer, is unproductive, since it "does not fix or realize itself in any permanent subject, or vendible commodity, which endures after that labour is past, for which an equal quantity of labour could afterwards be procured."[12] In the class of unproductive workers, Smith ranked "churchmen, lawyers, physicians, men of letters of all kinds; players, buffoons,

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Goldscheid, 'Jahresbericht über Erscheinungen der Soziologie in den Jahren 1890-1904," *Archiv für systematische Philosophie* 10 (1904): 397-8, in Frisby, *Georg Simmel*.

[9] Adam Smith, *Inquiry into the Nature and Causes of the Wealth of Nations*, vol. 1 (London: William Pickering, 1995), 8-9.

[10] Wise, M. Norton and Crosbie Smith. "Work and Waste: Political Economy and Natural Philosophy in Nineteenth Century Britain (I) – (III)," *History of Science* 27-28 (1989-1990): 393.

[11] Smith, 420-421.

[12] Adam Smith, *Inquiry into the Nature and Causes of the Wealth of Nations*, vol. 2 (London: William Pickering, 1995), 3.

musicians, opera-singers, opera-dancers, &c."[13] The work of this class, "like the harangue of the orator," wrote Smith, "perishes in the very instant of production."[14] The view of machines, bodily work, and especially mental work, was to change substantially over the course of the long nineteenth century.

As industrially savvy savants increasingly saw the motive power of steam as the driving force of Britain's Industrial Revolution, the steam engine came to represent a progressive, dynamic social order in which machines and intelligence played a constitutive role. Nowhere was this shift clearer than in Charles Babbage's *Economy of Machinery of Manufactures*.[15] The efficiency of factory operation always impressed Babbage, a Cambridge Wrangler who moved between social, scientific, and industrial circles. Babbage presented a vision of political economy that joined machine, manual and mental work in a sprawling system of production. Both knowledge and machines would play powerful roles in this future progressive social order.

In Babbage's vision, intellectual work acquired heightened significance. As the production of knowledge and other goods became increasingly sophisticated, it became crucial to organize efficiently different degrees of skill in a hierarchy of labour. Babbage found inspiration for this view of work in the labours of Gaspard de Prony, who had shown in his production of logarithmic tables in Revolutionary France that a large parcel of "mental work" might be reducible to, or representable as, handwork. As Lorraine Daston observes, Prony's "project

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[13] Ibid., 3.
[14] Ibid., 3-4.
[15] For themes of surveillance and the shifting meaning of intelligence, see Simon Schaffer, "Babbage's Intelligence: Calculating Engines and the Factory System," *Critical Inquiry* 21 (1994): 203-227. For Babbage's place in the history of rationality, see, Paul Erickson et. Al. *How Reason Almost Lost Its Mind: The Strange Career of Cold War Rationality* (Chicago: The University of Chicago Press, 2013), and for the broader context of Babbage's work in relationship to formalization and mathematics, see William Ashworth, "Memory, Efficiency, and Symbolic Analysis: Charles Babbage, John Herschel, and the Industrial Mind," *Isis* 27 (1996): 629-653, and "The Calculating Eye: Baily, Herschel, Babbage and the Business of Astronomy," *British Journal of the History of Science* 27 (1994): 409-441.

joined the loftiest flights of analysis and the crudest rules of arithmetic."[16] For Babbage, this provided the model for a more general social structure.

Prony parcelled his mental workers into three strata. At the top of the pyramid were management-oriented savants who organized the calculating system. According to Babbage, Prony would have been a member of this first class. The second class required training in analysis and the ability to provide the simplest components of the problem at hand to a third class of number crunchers. For Babbage, the mental work of this *tiers état* was so base that "it may almost be deemed mechanical." [17] This was the factory mode of production applied to knowledge making, with its capitalists, managers and labourers all assuming a position within the social hierarchy. The efficiency of the model justified its social stratification, particularly in the case of the lowest class:

> It is remarkable that nine-tenths of this class had no knowledge of arithmetic beyond its two first rules which they thus called upon to exercise, and these persons were usually found more correct in their calculations, than those who possessed a more extensive knowledge of the subject.[18]

The overall process would thus be most efficient if savants steered clear of any rote calculations. Prony's genius, for Babbage, consisted in the appropriate application of skill-to-task: it both saved "the loss arising from the employment of an accomplished mathematician in performing the lowest processes of arithmetic," while also cheaply securing lowly workers with no

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[16] Daston, "Enlightenment Calculations," 194.
[17] Babbage, *On the Economy of Machinery and Manufactures (*London: Charles Knight, 1832), 157.
[18] Ibid., 156-157.

mathematical expertise, who were apparently better at rote calculations.[19] This double savings was the result of expertise in industrial management.

Rational management, for Babbage, consisted in applying the principles of analysis to the problem solving apparatus' organization. Analysis "becomes continually more necessary at every step of our progress, and must ultimately govern the whole of the applications of science to the arts of life."[20] In Babbage's vision, the savant is charged with refashioning the social order to accord with the precepts of analysis. The production of knowledge is thus ordered according to a hierarchical division of labour. This was not simply Babbage's vision; it was also the Analytical Society's more general social programme.[21] In their view, intelligence and scientific discovery were no longer the domain of a single savant, but the product of a well-ordered system, visible only to the rational manager.[22] This was the brilliance of Prony's tables. To streamline the production of scientific knowledge, idiosyncratic ways of thinking had to be strictly regulated according to the requirements of analysis.[23]

In its most abstract form, analysis was a generalization from the technique of reasoning in mathematics to all other domains. Just as algebraic symbols permit "trains of reasoning, which, from their length and intricacy, would resist forever the unassisted efforts of human sagacity," analysis, understood abstractly as a division of any problem into its simplest constituent parts, permitted solutions to intractable problems of social and epistemic order.[24] Thus, the equation of

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[19] Ibid., 162.
[20] Ibid., 316.
[21] The Analytical Society was originally a group of Cambridge students, lead by Babbage, who promoted the use of Lagrangean analysis over more traditional geometrical methods of proof. In 1819 it was renamed the Cambridge Philosophical Society.
[22] Schaffer, "Babbage's Intelligence".
[23] Green Musselman, esp. 37-41.
[24] *Memoirs of the Analytical Society* (Cambridge: Deighton & Sons, 1813), i. For more on analysis in Babbage's philosophy, see William Ashworth, "Memory, Efficiency and Symbolic Analysis."

analysis with efficient rational management provided Babbage and the Analytical Society with the recondite rhetoric it needed to justify its social program.

In Babbage's vision, dividing the mind into tasks of management and computation allowed the latter to be standardized and even mechanized. Again, this meant purging particular thought processes of their creative and intelligent powers; this was the aspiration of Babbage's difference engine, launched in the summer of 1822. The difference engine mechanized Newton's polynomial approximation of complex functions.[25] The theoretical concept of the difference engine *showed* that mental work was in principle mechanical, in that it required movement without direction. In this way, mental work could be disciplined and regulated as manual labour. In traditional artisanal forms of work, workers had a degree of control over the value and style of their labour, as workers controlled and regulated skill.[26] But the worker-machine assemblages of the factory, in which everything was open to view, were more amenable to rational valuation and measurement in a nineteenth-century political economy that understand value in terms of labour.

Since labour was the source of all value, in Babbage's view, a good manager could ensure that the owners of the means of production received their fair share of the economic pie. Thus, economic efficiency depended upon a more precise interpretation of the division of labour. As Babbage explained,

> We have seen, then, that the effect of the *division of labour*, both in mechanical and mental processes, is that it enables us to purchase and apply to each process precisely the quantity of skill and knowledge which is required for it: we avoid employing any part of

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[25] Since the successive differences of a polynomial function can be shown to be a constant, a table of values can be computed as a series of successive additions (and subtractions). The idea was similar to Prony's, except that machines performed the arithmetic of the lowest class.
[26] Schaffer, "Babbage's Intelligence," 214.

the time of a man who can get eight or ten shillings a day by his skill in tempering needles, in turning a wheel, which can be done for sixpence a day.[27]

For Babbage, knowledge or intelligence functioned as a measurement of the value of labour within a hierarchical system. Knowledge, like any product, could be evaluated in terms of the labour invested in it, which connected knowledge and labour in manufacturing and the production of knowledge. "The cost of any article, even knowledge, "may be reduced in its ultimate analysis to the quantity of *labour* by which it is produced." [28]

For Babbage, material commodities were subject to "the forces of molecular attraction, which cease at sensible distances; or that of gravity, which decreases rapidly with the increasing distance from the point of origin." Not so for knowledge. Scientific knowledge, like capital, seemed to obey a limitless capacity for accelerated expansion. As Babbage mused, "the further we advance from the origin of our knowledge, the larger it becomes, and the greater power it bestows upon its cultivators, to add new fields to its dominions."[29] For Marx, the seemingly magical properties of capital derived from primitive accumulation. In Babbage's view, knowledge wedded to industrial practice could propel society upwards.

Intellectual work was at once above natural political economy in the case of the rational manager, and within its purview in the case of the number cruncher. The power of intellectual work was like that of the steam engine, categorically different than lowly manual labour. As Babbage presaged, "the experience of the past, has stamped with the indelible character of truth, the maxim that 'knowledge is power'. It not merely gives to its votaries control over the mental

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[27] Babbage, 201.
[28] Babbage, 125.
[29] Ibid., 315. On the question of the progress of science and the science of progress, see Simon Schaffer, "The Nebular Hypothesis and the Science of Progress," in *History, Humanity and Evolution: Essays for John C. Greene*, ed. James Moore (Cambridge: Cambridge University Press, 1989), 131-164.

faculties of their species, but is itself the generator of physical force."[30] Knowledge, the product of mental work, had acquired the properties of the forward-chugging steam engine, rather than those of the static balance. Quite literally, knowledge was for Babbage a kind of capital, or even money. In more abstract terms, knowledge had acquired a progressive, temporal character. Not only could it be generated at an ever-increasing pace, it could also stimulate economic growth.

If the engine metaphor provided a way to imagine the place of knowledge in a progressive society, Babbage's widely read *Economy of Machinery and Manufactures* also worked to cement a new place for machines in the division of labour. In Babbage's view, in contrast to Smith's, machines were not merely extensions of human work in the division of labour, but productive generators of knowledge/power. Indeed, machines were the embodiment of knowledge wedded to industrial practice, since they represented the accumulation of mental work. As Simon Schaffer observers, the place of intelligence in manufacturing became crucial. Instead of machines as "abridgements" and "facilitators" of human work, as Smith had reckoned, human work for Babbage and Andrew Ure had become the abridgment of the machine.[31] This new understanding of the machine was particularly important for Marx, who cited Babbage's categorization of machines in his 1845 excerpt notebooks.[32] In the case of the analytical engine, Babbage imagined a calculating machine capable of foresight and adaptation, which pushed the work of machines even closer to the work of the mind.

[30] For an elaboration on Babbage's concept of knowledge in the wider intellectual milieu, see Wise and Smith, "Work and Waste," 411-436.
[31] Schaffer, "Babbage's Intelligence," 223.
[32] For a detailed account of Marx's reading of Babbage, see Amy Wendling, *Karl Marx on Technology and Alienation* (London: Palgrave Macmillan, 2009), 182-192.

Equally important was the role of machines as regulators and invigilators of human work.[33] For Babbage, it was of the utmost importance to determine a "ready and certain mode of measuring the quantity of work done by the workmen."[34] "One of the most singular advantages we derive from machines," wrote Babbage, "is the check it affords against the inattention, idleness, or the knavery of human agents" in the act of observation.[35] For Babbage, the pedometer represented an ideal way to count the steps traversed by a workman, since any human observation would be liable to err. In Babbage's description of the manufacturing process, machines represented the ideal observer of work. They promised accurate and precise measurements of work, crucial to apportioning the inputs and outputs of any economic system.

Though Babbage's prophetic vision of a knowledge-driven economy would not pick up steam in Europe until the late-nineteenth century, it nevertheless provided an articulation of the place of knowledge, the body, and the machine in a new social order. Shortly after it hit the press, the *Economy of Machinery and Manufactures* sold 3000 copies, and was translated into French, Italian and German.[36] Central to Babbage's account of intellectual work was a kind of dualism between higher forms of work, which were certainly not mechanical, and the lower thought processes, which were representable in mechanical terms. Babbage was keen to show that certain kinds of calculations could be reducible to symbolic strings that, in principle, might be *implemented* mechanically, as the difference engine suggested. However, this did not suggest that *all* thinking was mechanical. The question was how one could account for the value of the

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[33] For more on this theme, see Schaffer, "Babbage's Intelligence" and Ashworth, "The Calculating Eye".
[34] Babbage, 256.
[35] Ibid., 39.
[36] It also served as the basis for J.S. Mill's analysis of the material dimensions of political economy, and Marx also quoted Babbage at length, working initially from Édouard Biot's French translation of the work, recording 73 excerpts from *Economy of Machinery and Manufactures*—see Anthony Hyman, *Charles Babbage: Pioneer of the Computer* (Princeton: Princeton University Press, 1983), 122.

higher forms of intellectual labour within the labour theory of value. On this matter, Babbage kept mum, though he did lament the poor pecuniary compensation he had received from publishers for his own mental work. If our own world suggests that the answer to this problem may be ever more complicated machines, capable of increasingly sophisticated "thought" processes, late-nineteenth century political economists looked in a different direction. To them, the most promising solution consisted in new ways of measuring work – even mental work – as a mechanical force.

Chapter 3: Tracing Out the Tender Mechanism

As writers, scientists, artists, designers, managers and entrepreneurs began to populate the modern metropolis, the need to understand the relationship between the value of intellectual and manual work became a pivotal problem in political economy. How might one quantify the contribution of industrial designers, engineers, scientists, and even artists to the economy? The most promising solution to the problem, circa 1880, consisted in the physiological measurement of mental work. As Simmel observed,

> The energy that the organism must expend upon the thought of this content as a cerebral process is, in principle, just as calculable as that necessary for muscular exertion… Mental labour would then be dealt with on the same footing as manual labour, and its products would enter into a merely quantitative balancing of value with those of the latter. [37]

In the physiological laboratory circa 1880, a question of economic and epistemic significance emerged: could thoughts be rendered into the thermodynamic language of force, and measured as physical movement? If so, energy promised to be the common element that united heterogeneous forms of work. In this section, I show how new instruments of regulation and measurement, alongside old ideas of surveillance and observation, shaped attempts to address the mental work problem in late-nineteenth century Europe.

In 1874, William Stanley Jevons, the British logician and political economist speculated, "the time may come, it almost seems, when the tender mechanism of the brain will be traced out, and every thought reduced to the expenditure of a determinate weight of nitrogen and

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[37] Simmel, *Philosophy of Money*, 421-422.

phosphorous."[38] Jevons made this materialist speculation in his *Principles of Science*, though the "reduction" of every thought to a determinate expenditure of energy implied solving at once a philosophical and economic problem. Jevons understood all labour, including mental work, as an expenditure of energy—negative utility.[39] For Jevons, this expenditure of energy was accompanied by pain, which increased in proportion to time. As he defined it, "Labour… is *any painful exertion of body or mind undergone with the view to future good.*"[40] Though Alfred Marshall wrote in his 1890 *Principles of Economics* that "the physiological basis of purely mental work is not yet well understood," it was clear to him that mental work could be understood in psychophysiological terms.[41] The measurement of mental work depended upon the coalescence of the dynamic understanding of work in political economy with the mechanical standard for work developed by French engineers.[42]

Undergirding the history of engineering in France was the shared economic, physiological and mechanical meanings of the concept of *travail*. Charles Augustin Coulomb, an engineer tasked in the 1760s with organizing engineering projects at a colonial outpost in

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[38] William Stanley Jevons, *The Principles of Science*, 735-6, quoted in Philip Mirowski, *More Heat Than Light*. For Jevons work in the context of the emergence of marginal utility theory and the dissolution of naturalism, see Margaret Schabas, *The Natural Origins of Economics* (Chicago: The University of Chicago Press, 2006), esp. 124-141.

[39] William Stanley Jevons, *Theory of Political Economy* (London: Macmillan and Company, 1871), 167-170. For a more extended discussion see Mirowski, *More Heat than Light*, 218-219.

[40] Jevons, *The Theory of Political Economy, 164*.

[41] Alfred Marshall, *Principles of Economics* (London: MacMillan, 1890).

[42] For an elaboration of these themes, see in particular Robert Brain, "The Graphic Method: Inscription, Visualization, and Measurement in Nineteenth-Century Science and Culture" (PhD thesis, UCLA, 1996), 48-163; François Vatin, *Le travail: Economie et physique, 1780-1830* (Paris: Presse Universitaires de France, 1993) and "Le «travail physique» comme valeur méchanique (xviii[e] – xix[e] siècles): Deux siècles de croisements épistémologiques entre la physique et la science économique," *Cahiers d'histoire* 110 (2009): 117-135; Lorraine Daston, "The Physicalist Tradition in Early Nineteenth Century French Geometry," *Studies in the History and Philosophy of Science* 17 (1986): 269-296. Heinz Otto Sibum, "Reworking the Mechanical Value of Heat: Instruments of Precision and Gestures of Accuracy in Early Victorian England", *Studies in the History and Philosophy of Science* 26 (1995): 73-106. For a more situated look at the French context, see John Tresch, *The Romantic Machine: Utopian Science and Technology after Napoleon* (Chicago: The University of Chicago Press, 2012).

Martinique, worked to devise a standard of human labouring force. Coulomb's understanding of mechanics was closely linked to practical applications, in contrast with the rational mechanics of savants such as Pierre-Simon Laplace.[43] Much like Babbage in the 1830s, Coulomb looked to put the knowledge of practical mechanics in the service of industry.[44]

In his *Mémoire sur la force de l'homme*, Coulomb imagined how one could consider human work as a mechanical problem. For Coulomb, human work could be represented as a ratio of effect to fatigue; the engineer's task was to maximize this ratio. Coulomb defined the useful effect, or the ratio of effect to fatigue, as the total amount of work a labourer could do, taking two losses into consideration.[45] In the case of a worker lifting an object up a flight of stairs, one must be careful to subtract the work the labourer must do lifting his own body, and the fatigue mounting as the action is repeated. On the one hand, there was a simple mechanical dimension to Coulomb's problem. But as François Vatin observers, the crucial point is how much work a worker can produce in a day. In other words, the problem also had a physiological and economic dimension.[46] In a mechanical sense, Coulomb's account of work is rather crude: how was one to account for the mechanical work done in moving an object horizontally? If a worker lifts a weight and carries it 100 metres, there is, in the purely physical sense of work, no work done after the weight has been lifted. French engineers such as Navier and Poncelet would criticize Coulomb for this imprecision, and sought new ways to develop an economically and mechanically viable conception of work.[47]

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[43] Vatin, 38.
[44] Ibid., 40.
[45] Ibid., 47.
[46] Ibid., 48.
[47] Brain, "Un étalon," 74.

But for mid-century political economists such as Babbage and Jevons, it was the spirit of Coulomb's work that mattered. Jevons cited Coulomb's discussions of work, which he borrowed from Babbage as paradigm examples of how they thought political economists should think about human work in a practical sense. Jevons even set out to conduct his own experiments on the economic dimension of the physiological aspects of human work, understood as a mechanical problem.[48] Yet back in France, the next generation of *polytéchniciens* were developing more precise ways to measure work.

In the 1830s, Jean-Victor Poncelet and Arthur Morin, two *anciens élèves* of the École polytechnique, looked to develop an instrument that could capture work as a movement, particularly in the case of engines. Previous instruments, such as Francis Bolton and James Watt's indicator diagrams, could measure the output of an engine, but only statically. To develop a proper measurement of work, one needed to be able to capture the ebbs and flows of the engine as they varied in time. In other words, until the 1830s, there was no instrument capable of capturing the dynamic motive force of the engine, the paradigmatic economic and physical machine of early-Industrial Europe.

Poncelet and Morin's solution consisted in bringing together the spring dynamometer's measurement of force with a circulating disc, upon which a stylus could trace the output of force. For Morin, the "sensibility of the instrument must be proportional to the intensity of the efforts to measure"; one must be able to "obtain the effort exerted at each point of space traversed by the

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[48] Michael V. White, "The Moment of Richard Jennings: the Production of Jevons' marginalist economic agent," in *Natural Images in Economic Thought: Markets Read in Tooth and Claw*, ed. Philip Mirowski, (Cambridge: Cambridge University Press, 1994), 207.

point of application of the effort."[49] What Morin and Poncelet looked to achieve was a dynamic *monnaie méchanique* – a mechanical currency or money. Such a machine promised both industrial and epistemological virtues, since, as Morin wrote, "the indications provided by the instrument must be obtained in a manner independent of the attention, of the will, or of the prejudices of the observer."[50] For Morin, this provided a natural standard for the measurement of labouring force, a crucial problem at the nexus of theoretical political economy and practical engineering. Abstract problems of fluid dynamics could be treated as physical movements represented in the form of a curve.

If Morin and Poncelet succeeded in developing a mechanical standard of work, it was Herman Helmholtz who, in the 1840s, imagined how this mechanical standard could be applied to organic bodies. As Robert Brain and Norton Wise demonstrate, Helmholtz reckoned the dynamometric instrument used to measure engine force could be applied to measure muscle force.[51] In other words, in theory, the complexities of human physiological movement could be represented as a mechanical movement. Helmholtz's myograph became a staple instrument in physiology, and led to myriad experiments on bodily forces in time.[52] Étienne-Jules Marey, a physiologist and Helmholtz's colleague across the Rhine, called for the extension of "this

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[49] Arthur Morin, *Notice sur divers appareils dynamométrique. Propres a mesure l'effort ou le travail développé par les moteurs animés ou inanimés et par les organs de transmission du movement dans les machines* (Paris, 1839), 29-30, quoted in Brain, "The Graphic Method," 1996, 139.
[50] Ibid., 139.
[51] Robert Brain and M. Norton Wise, "Muscles and Engines: Indicator diagrams and Helmholtz's graphical methods," in *The Science Studies Reader*, edited by Mario Biagioli, 51-66. New York: Routledge, 1999.
[52] Henning Schmidgen, "The Donders Machine: Matter, Signs, and Time in Physiological Experiment, ca. 1865" *Configurations* 13 (2005), 211-256; and Schmidgen, *The Helmholtz Curves: Tracing Lost Time*, trans. Nils F. Scott (New York: Fordham University Press, 2014). As Schmidgen notes, "The Helmholtz curves mark the beginning of an extended lineage of psychophysiological research machines that, in different contexts and by making use of different instruments and procedures, explored the gap between stimulation and contraction, the interval between stimulus and response, and the discontinuity between sensation and movement" in *The Helmholtz Curves*, 7.

graphic inscription of work whenever mechanical forces are in play."[53] Inscription apparatuses, such as Helmholtz's myograph, became tools that produced a mechanical standard of value – work – that could be applied to muscles and engines. They were indispensible tools in the emerging European science of work.[54]

Crucial to the study of work was the emerging science and social philosophy of thermodynamics. Outside of specific contexts in physics, thermodynamics was above all a kind of social accounting system. In the thermodynamic vision of the world, nature was a vast machine that could be made to churn out mechanical work. Both bodies and engines were instruments in this vast accounting system, which put a premium on directing energy towards productive ends.[55] As Anson Rabinbach observers, Hemholtz thought the value of human work "was determined more by the force expended than by the skill involved, which is a product of 'time and trouble'. A machine, even when it executes work adeptly, can always be produced in quantity; human skill is valuable only where it cannot be replaced by machines. In physical or mental labor, however, the quantitative side of work, or "yield", is entirely comparable to that of a machine."[56] In the materialist, deterministic world thermodynamics envisaged, social or mental activity was frequently thought to be reducible to exchanges of energy. Indeed, the ambiguity between "work" in the colloquial economic sense and the more precise physical sense was crucial.[57] Increasingly in the physiological laboratory, however, such ambiguities were removed when complex organic movements were represented in the same form as machine movements.

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[53] Etienne-Jules Marey, *La méthode graphique en sciences expérimentales* (Paris: Masson, 1878) quoted in Brain, "Ontology of the Questionnaire," 662.
[54] Rabinbach, 137-143.
[55] Ibid., 46.
[56] Ibid., 60.
[57] Miroswski, *More Heat than Light*, 130-132.

The metaphor of the body as an engine appeared plausible in the physiological laboratory and industrial factory, spawning new laboratories and research programmes into the science of human work. In 1902, Ernest Solvay established the Laboratoire d'Énergetique Solvay, to pursue research meant to capture "physio-energetic value" of human activity "by means of the same unit"—energy.[58] Solvay and others were keen to translate psychological and physiological phenomena into energetics. During the First World War, many of these projects were extended to colonial contexts to meet the demands of wartime labour.[59] Popular as the extension of the metaphor to the mind was, it proved to be a red herring for the totalizing social philosophy of energetics.

This materialist social philosophy had deep roots in France. As Coulomb's colleague, Antoine Lavoisier, speculated in 1789,

> We can know, for example, how much weight in pounds the efforts of a person who recites a discourse, of a musician who plays an instrument corresponds to. We could even evaluate what there is mechanical in the work of a philosopher who reflects, of the *homme de lettres* that writes, of the musician that composes. These effects, considered purely moral, possess something of a physical and material nature, which allows them to be compared with what manual work [*ce que fait l'homme de peine*]. It is not without some justice that the French language has confused under the common term *travail* the

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[58] Ernest Solvay, *Note sur des formules d'introduction à l'énergetique physio- et psycho-sociologique*, Institut Solva. Travaux de l'Institut de Sociologe. Notes et Mémoires (Brussels, 1902), 14, quoted in Rabinbach, *The Human Motor*, 137.
[59] See Laura Levine Frader "From Muscles to Nerves: Gender, "Race" and the Body at Work in France 1919-1939," *International Review of Social History* 44 (1999), and Elisa Camiscoli, *Reproducing the French Race: Immigration, Intimacy, and Embodiment in the Early Twentieth Century* (Durham: Duke University Press, 2009), 51-75.

> efforts of the mind as those of the body, intellectual work [*travail du cabinet*] and wage work [*travail du mercenaire*].[60]

If such reflections amounted to little more than materialist vitriol in the late-eighteenth century, physiologists such as Gley looked to demonstrate, with Republican zeal, their timeless truth. Indeed, Gley did not fear the philosophical implications of his work, and cited Lavoisier's passage as its most provocative implication.

But the first physiologist to devote significant attention to the measurement of mental work was Angelo Mosso. Mosso, from Italy, had worked with the eminent French physiologists Claude Bernard and Etiènne-Jules Marey. The question for Gley and other psychophysiologists was how to translate thought into movement. That is, how to extend the metaphor of the motor to the mind, with crucial implications for the materialist philosophy that sought to represent *all work* as mechanical movement.

At his laboratory in Turin, Angelo Mosso conducted a series of experiments on a "peasant" named Bertino.[61] What made Bertino the ideal subject was an injury to the cranium, which permitted the measurement of the brain's pulse. Mosso applied a washer of gutta-percha, with a small opening to Bertino's cranial wound (figure 3.1 and 3.2).[62] To measure the pulse of the forearm, Mosso employed an adapted plethysmograph, which he called the hydrosphygmograph (figure 3.3). It was this double apparatus that made possible the

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[60] Antoine Lavoisier, *Oeuvres*, t. 2 (Paris: Imprimerie Impériale), 697.
[61] Angelo Mosso, *On The Circulation of Blood in the Brain,* trans. Christine Nockels Fabbri. Oxford and New York: Oxford University Press, [1880] 2014, 46-47.
[62] Gutta-percha was a household item in Nineteenth century, and came from a tree in South Asia that the Malays called taban. Due to Werner Siemens engineering work, Gutta-percha became the main insulating technology for telegraph wires. See John Tully, "A Victorian Ecological Disaster: Imperialism, the telegraph and Gutta-Percha," *Journal of World History* 20 (2009): 564. Crosbie Smith and M. Norton Wise, *Energy and Empire: A Biographical Study of Lord Kelvin* (Cambridge: Cambridge University Press, 1989), 446.

comparative measurements of cerebral and forearm pulse, as the submerged limb in water mimicked the pressure conditions of the brain in the cranial casing (figure 3.2 and 3.3). This was the division of head and hand reproduced within the physiological laboratory.

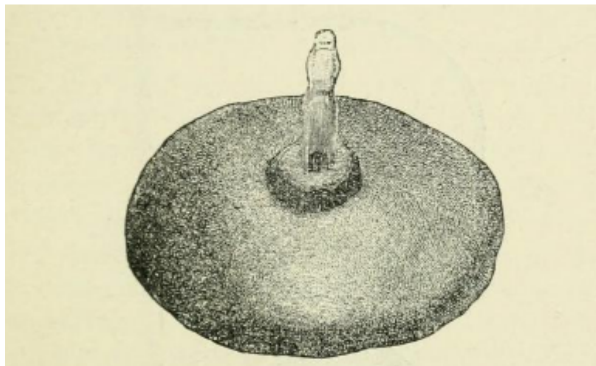

Figure 3.1. Washer of Gutta-Percha. From Alfred Binet, *La fatigue intellectuelle* (Paris: Schleicher Frères, 1898), 69.

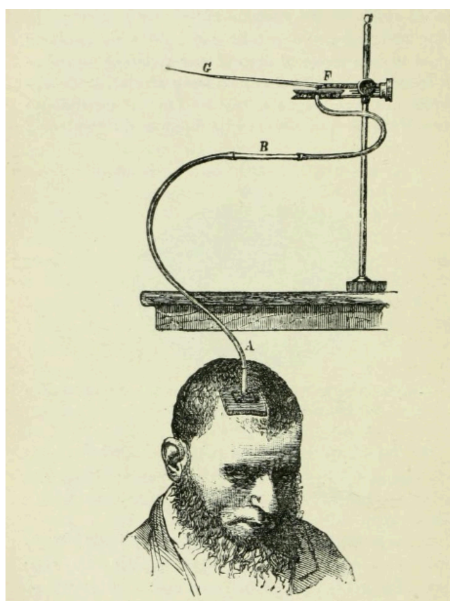

Figure 3.2. Apparatus Attached to Bertino’s Cranial Wound. From Alfred Binet, *La fatigue intellectuelle* (Paris: Schleicher Frères, 1898), 70.

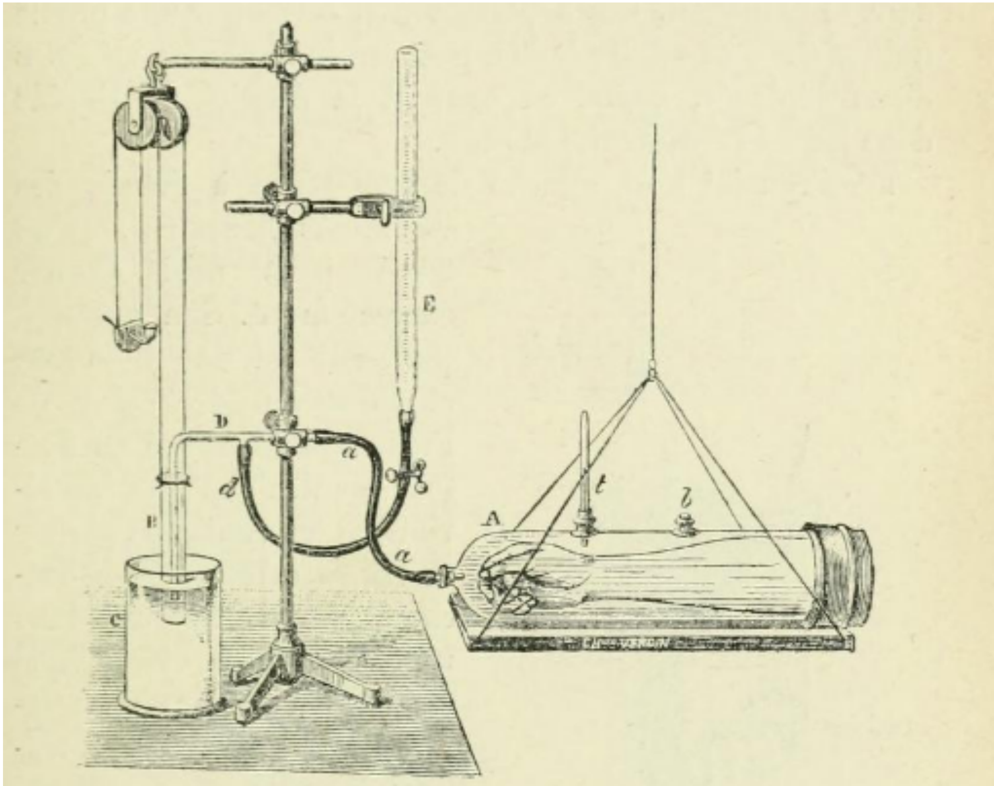

Figure 3.3. Plethysmograph to Measure Pulse of Hand. From Alfred Binet, *La fatigue intellectuelle* (Paris: Schleicher Frères, 1898), 63.

As important as the complex inscription apparatuses invented and employed in the physiological laboratories of the late-nineteenth century were, the experiment was impossible without the moral discipline required to isolate and measure mental work. In important respects, the work of the laboratory resembled that of Babbage's ideal factory, both from the top down, and from the bottom up.

On many occasions, Mosso admonished Bertino for lifting a finger, which immediately corrupted the experiment. Mosso was even less impressed with the guilt Bertino felt afterwards, the effect of which could be observed in the graphical recordings. In the age of mechanical objectivity, this embodied the classic contrast between the "patient, indefatigable, ever-alert machines" and "workers whose attentions wandered, whose pace slackened, whose hands trembled."[63] Once the experimental manager had achieved a balance in the human-machine assemblage, the ability to read the results was crucial.

Mosso described the results when his subject was asked to compute the product of eight and twenty-two. "At the start of the mental task," wrote Mosso, "one clearly sees the amplitude of the pulsations and the cerebral volume increase."[64] In one of Mosso's successful experiments, the pulse of hand and head diverged significantly during a period of mental work (figure 3.4).

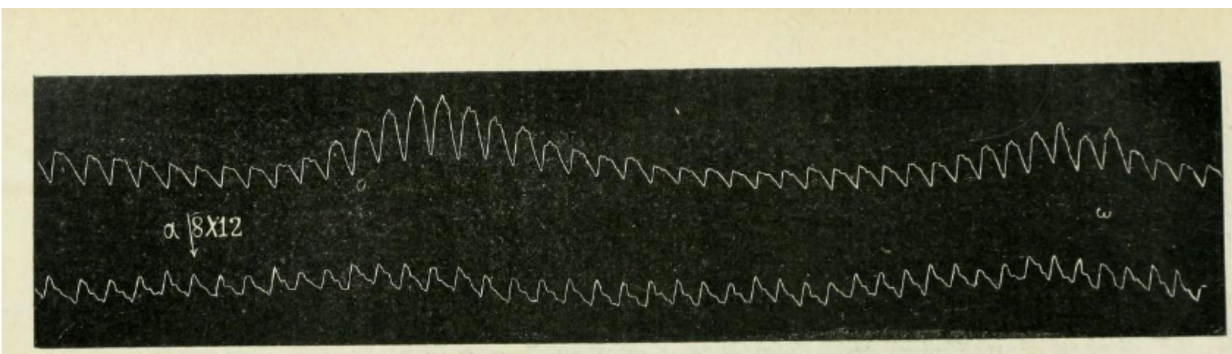

Figure 3.4 Pulse of Head and Hand During Mental Work. From Alfred Binet, *La fatigue intellectuelle* (Paris: Schleicher Frères, 1898), 78.

In his review of Mosso's work, Gley wrote that the advantage of the graphic method applied to physiology consisted in the idea "that these movements are naturally susceptible to being represented by lines: these lines evidently give the duration, force, intensity, regularity,

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[63] Daston and Galison, *Objectivity* (New York: Zone Books, 2006),123.
[64] Mosso, 67.

and thanks to the special dispositions in the instrumentation, the form of the movements."[65] Mosso succeeded in showing, according to Gley, that there was a correlation between the difficulty of mental work and the modification of the cerebral pulse. Thought was thus imagined like a muscle lifting weight: the more difficult the mental work, the more mental energy expended. In Mosso's experiments, "the work of thought" had been translated into the mechanical language of nature.[66] By no accident, this echoed the muscle-mind analogy in political economy that Jevons and later Alfred Marshall expounded.

Though Gley admired Mosso's work, he and others quickly became aware of an acute problem, resembling the experimenter's regress.[67] While Mosso could observe whether or not Bertino lifted a finger, he had to depend on the results of the experimental setup to determine if Bertino's emotions had flooded the mind. As observer of the experimental setup, Mosso was above all a manager who had to ensure the proper working of the human-machine assemblage. He could use both an unusual trace of the curve or signs on Bertino's face to ensure a controlled result, but faced an epistemological gap relating to Bertino's sentiments. There was thus a crucial way in which Mosso had violated Morin and Babbage's standard, as the frailties of human observation crept into the physiological laboratory. To accept Mosso's results, one had to depend both on his credibility as a manager, but also upon his ability to read the subjectivities of his object of study—Bertino. Gley looked to solve this problem in a series of auto-experiments in 1881.

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[65] Gley, Eugène. Review of Angelo Mosso's *Sulla circolazione del sangue nel cervello dell'uomo* (1880), in *Revue philiosophique de la France et de l'Étrangére* (1884): 198.
[66] For a historical and philosophical account of how this was viewed ontologically, see Brain, *The Pulse of Modernism*, 21-23. For a conceptual account, see Bruno Latour, *Laboratory Life*, 51.
[67] See the introduction and subsequent case studies in Harry Collins and Trevor Pinch, *The Golem: what everyone should know about science* (Cambridge: Cambridge University Press, 1993), 1-3.

In 1880, Gley was a doctoral student in physiology under Henri-Étienne Beaunis at the University of Nancy. His thesis work took up the question of mental work that Mosso had begun a year earlier. Gley had hoped he would be the first to trace the mechanical force of mental work, though he had spent that time navigating the bureaucracies of French higher education. He was thus doubly motivated to improve upon Mosso's results. "You will say that I have violated the great principle of the physiological method," wrote Gley, "according to which one must only experiment on objectively observable subjects."[68] Here Gley was echoing not just a key norm in the tradition of physicalist physiology, but also in the use of inscription apparatuses to measure work. This paradox highlighted the nature of Mosso's problem managing Bertino. While inscription apparatuses may have inscribed the objective movements of thought, there was no sure way to determine Bertino's state during the measurement. There seemed to be peculiar semantic distinctions between states of *real* mental work, and simply emotional fluxes, to which the inscription apparatus was blind. Thus, Gley looked to turn a methodological objection into a virtue, as he knew his readers would "certainly not deny that [he] had been better placed than any man in the world to appreciate the subjective state during which the traces are recorded."[69]

Gley summarized his reorganization of Mosso's experimental apparatus, with crucial epistemic implications:

> In this particular case, it is true the observing subject incorporates himself into the experiment, but he does not observe the results of the experiment. It was the recording apparatus that inscribed my observations.[70]

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[68] Eugène Gley, "Étude expérimentale sur l'état du pouls carotidien pendant le travail intellectuel," (Phd Diss., 1881, Université de Nancy), 32.
[69] Ibid., 31.
[70] Ibid., 32.

Gley's own self-monitoring thus became a crucial element *within* the experiment, though the epistemological burden of observation was transferred to the mechanical apparatus. This particular rhetoric turned the problem of subjectivity into a controllable variable within the experiment, leaving the crucial epistemological work to the indefatigable machine. Thus, if one could buy into the virtue and discipline of the physiological experimenter, objectivity was assured. This legerdemain ensconced, as we have seen, the very real intuitive and analytical readings of the graph that accompanied the experimenter's reporting of the results.[71]

Mind quiet, body still, Gley measured the difference between states of mental work and repose for thirty days (figure 3.5 and 3.6). To do this, he used a sphygmograph – pulse-writer – to measure the pressure, force, and rate of blood flow through the internal carotid artery. Mental work, for Gley, consisted in either geometrical proofs, careful reading of a philosophical text, or a series of multiplications. Gley's sphygmograph recorded an increase in the pulse's frequency, intensity and form during periods of mental labour.

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[71] Brain, *The Pulse of Moderism*, 23-24.

N°s d'ordre.	Date.	Genre de travail.	Durée du travail.	Nombre de puls. par minute. Repos.	Travail.	Différence.
1	31 août......	Philosophie.	15 minutes.	70	72	2
2	9 septembre.	—	— —	78	81	3
3	10	—	— —	73	75	2
4	11	—	— —	68	70	2
5	19	—	— —	74	77	3
6	20	—	— —	75	77	2
7	20	—	— —	73	76	3
8	22	—	— —	82	82	0
9	23	—	— —	77	77	0
10	24	—	— —	80	82	2
11	29	—	— —	72	75	3
12	30	—	— —	75	77	2
13	1er octobre..	—	— —	76	79	3
14	5	—	30 —	80	81	1
15	6	—	— —	79	81	2
16	7	—	— —	77	78	1
17	8	—	— —	78	81	3
18	9	—	— —	76	78	2
19	14	Géométrie...	10 —	78	84	6
20	15	—	20 —	76	77	1
21	19	—	30 —	76	79	3
22	21	—	40 —	75	77	2
23	24	—	50 —	72	77	5
24	14 novembre.	—	60 —	75	80	5
25	15	Philosophie.	10 —	79	79	0
26	16	—	5 —	81	82	1
27	17	Calcul......	4 —	75	76	1
28	18	Géométrie...	5 —	71	74	3
29	19	Calcul.....	5 —	79	82	3
30	19	—	5 —	77	81	4

Figure 3.5. List of Mental Works and Corresponding Changes in Pulse. From Eugène Gley, "Étude expérimentale sur l'état du pouls carotidien pendant le travail intellectuel" (Dissertation, Université de Nancy, 1881), 42.

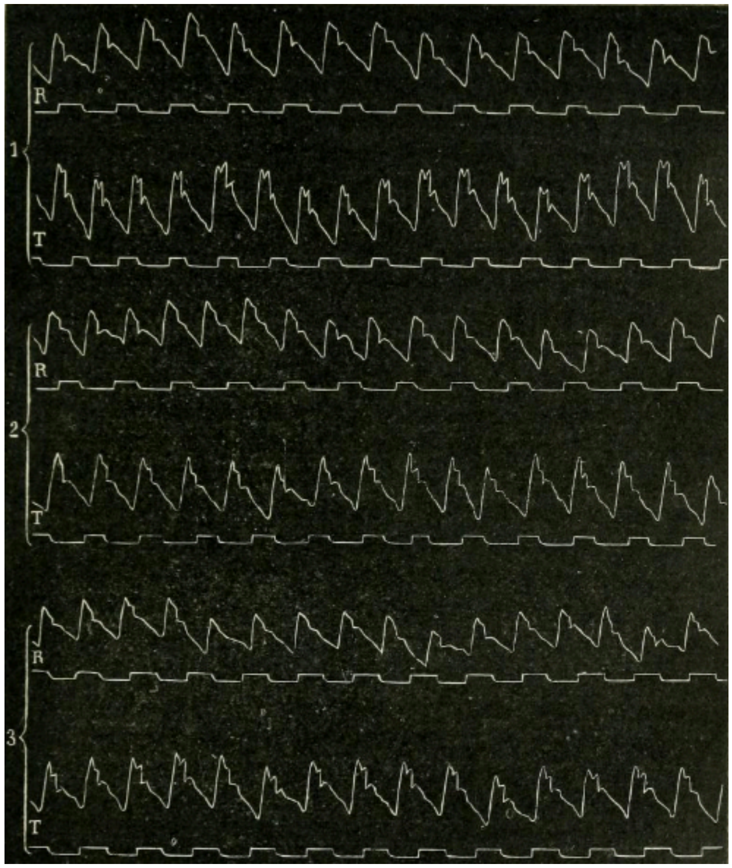

Figure 3.6. Comparison of Carotid Pulse During Mental Repose and Mental Work. From Alfred Binet, *La fatigue intellectuelle* (Paris: Schleicher Frères, 1898), 79.

The rapport between mental and muscular work was evident to Gley, and others interested in the physiological measurement of mental work. As Gley wrote,

> The muscular act, for example, needs to be maintained by the circulation of blood, but by reaction it favours this circulation and makes it faster, such that the production of work is

facilitated. And so thought, which needs blood to be maintained, determines by reaction the increased afflux of blood necessary for its production.[72]

For Gley, this showed that thought was a dynamic, mechanical force, with an intensity and duration. What inscription accomplished was a naturalization and abstraction of thought. If the apparatus is understood as a tool in the chain of reference adding new properties to thought and cleansing it of old ones, here was thought abstracted from the body and its broader milieu.[73] The objective translation of thought into a force with intensity and duration evidenced the view that thought was work, a measurable expenditure of energy. Although it was unclear how such measurements of work related to economic work, there was at least evidence that thought participated in a materialist economy of forces. In other words, it seemed plausible the expenditure of energy undergirded all labouring activity. To those trained in physiological experiment, the graph provided, "the condensation of laborious, step-by-step procedures into an immediate *coup d'oeil.*"[74] The graph showed that the intensity of mental effort translated into a greater flow of blood to the brain, which suggested an increased force.

The results of the measurement of mental work attracted much attention. William James considered the relationship between thought and blood flow to be an interesting one, though he lamented the philosophical claims these "phosphorus philosophers" derived from the work. Yet the analogy of thought as work appealed to James. As he wrote in "The Feeling of Effort," it is

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[72] Gley, "État du pouls", 59.
[73] For apparatuses and the chain of reference, see "Circulating Reference: Sampling the Soil in the Amazon Forest," in Bruno Latour, *Pandora's Hope: Essays on the Reality of Science Studies* (Cambridge: Harvard University Press, 1999).
[74] Lorraine Daston, "On Scientific Observaiton," *Isis* 99 (2008), 108. For example, see the difference between Gley's table (figure 3.5) and the curves (figure 3.6).

through mental effort that thought, "it could be said, is doing "work" upon the system."[75] "Work," wrote James, "is defined in mechanics as a movement done against resistance, and your will meets with a resistance which it has to overcome by moral effort."[76] Herman Helmholtz thought Mosso's results marked an important scientific breakthrough: "Mosso obtained a fundamental and significant result for the physiology of the brain and for psychology… the amplitude of the pulse in the brain produces itself instantly at each effort of intellectual attention."[77] The 1888 edition of *The Encyclopaedia Britannica* noted Gley's results, which demonstrated the "doctrine that the brain is the organ of the mind," even if it denounced the coarseness of Gley's method. All at once, the measurement of mental work seemed to evidence scientific materialism, and to solve a longstanding problem in political economy.

In the third edition of his *Theory of Political Economy*, which appeared in 1888, William Stanley Jevons addressed the problem of "the highest kinds of labour," which had been left out of earlier editions:

> It may be added that in the highest kinds of labour, such as those of the philosopher, scientific discoverer, artist, etc.., it is questionable how far great success is compatible with ease; the mental powers must be kept in perfect training by constant exertion, just as a racehorse or an oarsman needs to be constantly exercised.[78]

In this model, mental effort was formally analogous to muscular effort. This schema implied that the relationship between the strength of the mind was correlated with the "highest kinds of labour," much like a racehorse. Knowledge, as Babbage had claimed, was indeed power.

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[75] James, "The Feeling of Effort," 30.
[76] Ibid., 30.
[77] Herman von Helmholtz, translated by Alexandre Métraux, "Un rapport inédit sur divers travaux d'Angelo Mosso," *Philosophia Scientiae* 3 (2013), 206-207.
[78] William Stanley Jevons, *The Theory of Political Economy*, 3rd edition, (London: MacMillan, 1888), 182.

More than Jevons, The French economist and *homme d'affaires*, André Liesse, merged Babbage's hierarchical division of labour with the results of the measurement of mental work. Liesse was the chief disciple of Jean-Gustave Courcelle-Seneuil, a close reader of English political economy, who in turn appeared as an important reference in Jevons' writings on labour. Courcelle-Seneuil was the first to translate Mill's *Principles of Political Economy* into French, a text that, as noted above, dovetailed with Babbage's *Economy of Machinery and Manufactures*.

Liesse frequently acknowledged his debt to Babbage, and recapitulated the hierarchical division of labour applied to mind:

> If there is an inequality of muscular force between men, there is maybe an inequality still more accentuated of mental power, more disciplined in the civilized than in the savage. What's more, the inequality of powers offers in the division of labour a much greater specialization than muscular work, properly speaking.[79]

Despite Liesse's considerations of work from the "scientific" and "economic" points of view, Liesse's appeals to mental power reveal the degree to which any reference to physiology had broken down. Physiologically speaking, there was scant different between a computer's calculations and the pontifical flights of reason. This did not belie the scientific legitimacy of the oeuvre, however. Vilfredo Pareto, an Italian engineer and economist best known for his contributions to early neoclassical economics, called Liesse's work "one of the best works of political economy published in France in many years." This was not a disparagement of French political economy, but rather a true appraisal of Liesse's intellectual effort. While most works

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[79] André Liesse, *Le travail au point de vue scientifique, économique et sociale* (Paris: Guillamin and Co., 1899), 105-106. Jevons also echoed this sentiment in the *Theory of Political Economy*, 182.

on *le travail* were full of "declamations and commonplaces," this work, argued Pareto, "dealt with the question from a scientific point of view."[80]

More so than Babbage, Liesse was concerned with identifying and theorizing the faculty most important to the highest levels of economic production.[81] Man was, in Liesse's vision, above all else, a *machine à penser* (thinking machine). Attention, for Liesse, was the most precious intellectual power.[82] Attention corresponded directly to the intensity of mental effort: whether it was surveillance or hunting game, or perhaps managing an experimental apparatus, more mental effort meant quite simply more work done. For Liesse, this explained the entrepreneur's handsome remuneration. The entrepreneur's titanic will and capacity for mental effort literally moved markets. "In the middle of the division of labour," wrote Liesse, "he is an all-organized being, a center of formation."[83] If *most* humans were the organs of machines in Babbage's systematic vision of political economy, the rational manager – here the entrepreneur – was the prime mover.[84]

Liesse's writings echo the real paradox of mental work in the late-nineteenth century. In a rough sense, mental effort was an observable physiological process. Just like muscular work, mental work increased the pulse; it produced physiological waste; and it required a gradual *échauffement*.[85] As the physiologists had shown, it *looked* like mental work. In the case of nervous fatigue, which indelibly led to conditions such as neurasthenia, the bodily effects of

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80 Vilfredo Pareto, *Écrits épars*. *Oeuvres completes: T. XVI* (Paris: Librairie Droz, 1974).
81 This was also an important concern of Alfred Marshall in his 1890 *Principles of Economics*, which quickly became the dominant economics textbook in Britain.
82 Liesse, 111.
83 Ibid., 118.
84 For the role of the rational manager in Babbage, see Schaffer, "Babbage's Intelligence," 223.
85 Ibid., 103.

mental work were obvious.[86] Yet there was no correspondence between this physiological activity and the "power" of which Liesse and the physiologists spoke. Indeed, in Gley's 1900 review of the literature on physiological psychology, he retreated significantly from the project's earliest ambitions:

> In employing this term [travail intellectuel] it is necessary to avoid any misunderstanding. The word *travail* in mechanics has a precise sense: it is the product of a force by a given distance in the direction of the force. In this sense it would be absurd to speak of *travail intellectuel.* This is why I've tried as much as possible in this book to employ the words *intellectual activity.*[87]

If such ambitions seemed absurd to Gley circa 1900, they had been the motivation for his work twenty years earlier. Paradoxically, the closer mental work was pushed to manual work in physiology, the further the mind was pushed from the body. How was one to explain the titanic value of the work of the entrepreneur if not on a model of the expenditure of energy? Just as the labour theory of value had invaded the domain of mental work, there seemed to be no way to reduce the heterogeneous forms of mental work to a simple mechanical problem. This problem occupied a central place in Simmel's discussion of labour in his essay, "Towards a Philosophy of Work," and received an even more detailed treatment in *Philosophy of Money*. In what follows, I examine Simmel's framing of the problem and its place in the broader history of the mental work problem.

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[86] The question of fatigue was indelibly linked to widespread cultural worries about neurasthenia and degeneration. See Joakim Radkau, "Die wilhelminischen Ära als nervöses Zeitalter," *Geschichte und Gesellschaft* 20 (1994): 211-241; Daniel Pick, *Face of Degeneration: A European disorder, 1848-1918* (Cambridge; Cambridge University Press, 1989); Anson Rabinbach, *The Human Motor*.
[87] Eugène Gley, *Études de psychologie physiologique et pathologique* (Paris: Félix Alcan, 1903), 7. Indeed, Gley had himself turned his attentions principally towards research in endocrinology and physiological feedback mechanisms, and is best known as the discovery of the parathyroid gland (Gley glands).

Chapter 4: Conclusion

The language of mental effort and mental power implied that mental work was brainwork. It imagined a way to unify heterogeneous forms of labour as expenditures of energy. Energy was thus the ticket to a unified theory of labour. For Simmel, this promised practical and theoretical gains as immense as the existence of money, since it provided a *concrete* standard of value rooted in productive human activity. This was especially crucial for a world that understood money increasingly as a standard of *subjective* value. It also promised to determine the balance between production and fatigue. Yet for Simmel, the fundamental relationship between labour and energy was misguided. When one abstracted from the idiosyncrasies of disparate forms of work, "what remains left over in no way corresponds to the physical concept of energy—as a tempting analogy might suggest—which in its quantitative invariateness, can sometimes appear as heat, electricity, as mechanical motion."[88] This "tempting analogy" had motivated the physiological interpretation of the mental work problem, as we have seen.

It is important to note that Simmel did not think the analogy between energy and labour was wrong. But by 1900, the changing nature of work made it increasingly untenable. The increasing importance of the intellectual professions changed the nature of work itself, making a unified theory of labour implausible, though perhaps not impossible in the future. If it had been true in the past that "the more superior the position of individuals, both socially and intellectually, the more their existence is based on the work of those down the scale," the situation had become reversed. The extension of economic activity to include intellectual or

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88 Simmel, *Philosophy of Money,* 421.

white-collar workers, particularly scientists, engineers, designers, financiers, and entrepreneurs, meant that the days of peasants supplying the upper classes with goods were numbered.

In turn-of-the-century capitalism, “the needs of the subordinate masses are satisfied by large enterprises which have engaged countless scientific, technical, and managerial energies of the upper strata in their service.”[89] Work was part of the ethos of the bourgeoisie, as intellectual workers earned prestige through scientific, engineering and management labours. Politics and science increasingly became “vocations”, as Max Weber’s lectures and work implored.[90] As the mode of production became increasingly systematized, or as Simmel called it, objectified, intellectual labour became the lifeblood of the new economy. As Simmel observed, “the eminent chemist who reflects in his laboratory upon the description of dyed colours is working for the peasant woman who buys the most colourful scarf at the haberdasher.”[91]

In turn, this meant that the alienation and division of labour Marx observed in the case of manual labour had been extended to the mind. Indeed, Simmel observed precisely the same situation: “the immense division of labour in science, for instance, results in a situation in which only very few scholars are able to procure for themselves the prerequisites for their work; innumerable facts and methods have simply to be accepted from outside as objective materials, as the intellectual property of others that is to be used for further research.”[92] Babbage’s vision of the role of intellectual work in a progressive economy had increasingly become social reality.

Simmel’s observations of the growing significance of intellectual work compliment historical analyses of the emergence of white-collar work, and the increasing power and presence

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[89] Simmel, 463.
[90] Thomas Kemple, *Intellectual Work and the Spirit of Capitalism: Weber’s Calling* (London: Palgrave Macmillan, 2014), 189-207. See also: Robert Brain, “Ontology of the Questionnaire”.
[91] Simmel, *Philosophy of Money*, 463.
[92] Ibid., 461.

of the bourgeoisie in European life.[93] In his social study of workplace relations in the Siemens factory between the 1840s and the 1870s, Kocka charts the path of Werner Siemens' original telegraph-manufacturing business in Berlin to a full-scale factory.[94] Kocka observes a distinct break in workplace organization in the 1870s, as "at more or less the same time, a technical sales office and the first laboratory were set up."[95] The design office was particularly crucial. Design work, which had formerly been much more intimately connected to manual labour, now stood outside of the site of production, performed by men in suits. One of these men was Friedrich von Hefner-Alteneck, whose path-breaking engineering design work was integral to the development of the firm.[96] This signified, in Kocka's view, the complete separation of manual from nonmanual labour. The separation of the design office, the opening of industrial laboratories, and the growth of the sales office meant that intellectual labour quickly became the interface between the factory and the economy, which by the late-nineteenth century, became centered in the metropolis. If the nature of work had changed, so to had the nature of the economy.

For socialists, the goal of labour money had been a more socially just economic system in which labour determines prices. Practically speaking, it required the *use* value or utility of

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[93] Jerrold Siegel, *Modernity and Bourgeois Life: Society, Politics, and Culture in England, France and Germany since 1750* (Cambridge: Cambridge University Press, 2012). See also Jürgen Kocka and Allan Mitchell, *Bourgeois Society in Nineteenth-Century Europe* (Oxford: Berg, 1993)—in particular, Jürgen Kocka, "The European Pattern and the German Case," 3-39.
[94] As Kocka notes, the German term "*Manufaktur*" is distinct from "*Fabrik*." Whereas the former signified "a large-scale centralized industrial enterprise with some division of labour, with a labor force largely on a contractual basis, but with no machinery," the latter signified "a large-scale centralized industrial enterprise with an increasingly developed division of labour, a labor force largely on a contractual basis, and at least some kind of machinery in the form of either power machines (mainly steam engines) or machine tools. In that sense, "*Fabrik"* was closer to Babbage's use of "manufacture." See Jürgen Kocka, "From Manufactory to Factory: Technology and Workplace Relations at Siemens, 1847-1873," in *Industrial Culture & Bourgeois Society: Business, Labour, and Bureaucracy in Modern Germany*, trans. Belinda Cooper, (New York: Berghahn Books, 1999), 1.
[95] Kocka, *Industrial Culture and Bourgeois Society: Business, Labour, and Bureaucracy in Modern Germany* (New York, Berhahn Books, 1999), 19.
[96] Ibid., 19.

objects to form a constant with the "relation of labour time applied to them."[97] Such a "rationalized and providential" economic order, as Simmel called it, would be possible only if "the immediately essential, unquestionable basic life necessities are produced."[98] However, the growth of what one of Simmel's contemporaries, Thornstein Veblen, called "conspicuous consumption," meant that the economic order was anything but rational.[99]

The world of *Capital* had been turned on its head, both in terms of the nature of work and of consumption.[100] Manual work had been the driving force of the mid-nineteenth century economic order, and production the source of value. Yet by the late-nineteenth century, it seemed that mental work had become a driving force, and consumption the source of value. Few works captured the changing nature of consumption better than Émile Zola's *Ladies' Paradise* (*Au bonheur des dames)*, a fictional yet ethnographic account of a pivotal late-nineteenth century development: the department store. To Zola, the department store appeared as the new engine of the economy:

> There was the continuous roar of the working machine, an oven-full of customers crammed together in front of the departments, stunned by all of the merchandise, then thrown to the till. All of this organized and ordered with mechanical rigour—a population of women passing into the force and logic of the gears.[101]

True, the metaphor of the engine suggested that the rational order of the shopping centre had supplanted that of the factory. Yet the strong associations between femininity and irrationality,

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[97] Ibid., 430.
[98] Ibid., 431.
[99] Thornstein Veblen, *Theory of the Leisure Class* (New York: Funk and Wagnalls, [1899] 1967).
[100] For a development of this theme, see Rosalind Williams, *Dream Worlds: Mass Consumption in Late Nineteenth-Century France* (Los Angeles, University of California Press, 1982).
[101] Emile Zola, *Au Bonheur des dames*, in Rougon-Macquart., ed. A. Lanoux, H. Mitterand, (Paris: Gallimard, 1964), 402.

consumption and subjectivity, married to the masculine metaphor of the engine, suggested the undoing of liberal rationality.[102] The growth of the metropolis and with it spaces of consumption meant that production had increasingly given way to consumption as the source of value. This meant that economic value was increasingly psychologized, and removed from the concrete activity of labour. But for Simmel, the consumer economy and the increasing heterogeneity of work—particularly mental work—were two halves of the same coin.

If labour and production had grounded the economic world of the mid-nineteenth century in nature, the consumer economy of the metropolis and its crowds of intellectual workers seemed increasingly to stand on their own. As money became the only standard of value in the metropolis, economic relations were increasingly psychological ones.[103] It is tempting to place Simmel alongside early marginalists, who placed "economics entirely in the domain of the mental," claiming that "all prices were said to be reducible to the feelings of pleasure and pain at the margin."[104] For Simmel, whose early essay "Psychology of Money" had become *Philosophy of Money*, money was more than a subjective measure of value. Simmel's fundamental concern, as he admitted in the preface to *Philosophy of Money*, much to the displeasure of his colleague Gustav Schmoller, was philosophical.[105]

Although Simmel did not reject a psychological theory of value, he recast the mental work problem as a philosophical problem analogous to the problem of money. As Simmel often

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[102] For extensive developments of these themes, see Carl Schorske *Fin-de-Siècle Vienna* (New York: Vintage Books, 1981), and Deborah Silverman, *Art Nouveau in Fin-de-Siècle France: Politics, Psychology and Style* (Berkeley & Los Angeles: University of California Press, 1989).
[103] Walter Benn Michael's, "The Gold Standard and the Logic of Naturalism" *Representations* 9 (1985).
[104] Schabas, 136.
[105] For an important interpretation of Simmel's *Philosophy of Money*, see Nigel Dodd, *The Social Life of Money* (Princeton: Princeton University Press, 2014), 29. For whether Simmel's work was philosophical or economic, see Frisby, *Georg Simmel*, revised ed., (London: Routledge, 2002).

noted, there was an intimate relationship between knowledge and money, intellectualism and the money economy. Money presented an important philosophical problem because it was a technology of separation and connection. It brought the romantic closer to nature, but also made him feel an inevitable distance between himself and nature. This was the inherent tension in money between separation and synthesis. For Simmel, "there was no more striking symbol of the completely dynamic character of the world". It was the "*actus purus*" – the god of the modern world, "the vehicle for a movement in which everything else that is not in motion is completely extinguished."[106]

Essential to *Philosophy of Money* is money's agency. It had facilitated the increasing specialization of work, which had produced objects – typewriters, telegraph networks, vending machines, steam engines – that were then themselves agents in the mode of production.[107] Indeed, for Simmel, money was the object *par excellence*, the purest example of technology. Money had enabled the separation of the intellect from the body, most concretely in the division of mental and manual work. Yet it had also produced new connections, as "only by the means of money is it possible for a German capitalist and also a German worker to be actually involved in a ministerial change in Spain, in the profits of African gold mines, and in the outcome of a South American Revolution."[108] As Nigel Dodd has remarked, Simmel's views of money cannot be reduced to a negative view of "alienation" of subject from object; money also produced new

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[106] Simmel, 517.

[107] For Simmel, the relationship between the mental worker and the typewriter captures, by synecdoche, the general relation between the intellectual worker, objectivity and the division of labour. The pen, like the artist's brush, remained an undifferentiated tool that functioned as an extension of human activity rather than as an independent *object*. The typewriter, however, which was itself the concentration of intellectual work, became an agent in the production of a text. This meant that writing "can now abandon this form in favour of mechanical uniformity," which had two benefits. It avoids revealing "the most personal element" of handwriting, but also puts in relief the "pure content" of the text rather than its written form.

[108] Ibid., 482. For the transformation in experiences of space, see Stephen Kern, *The Culture of Time & Space: 1880-1918*, 2nd ed. (Cambridge: Harvard University Press, 2003).

worlds of connection otherwise impossible, such as the city. Part of the value of mental work, then, was that the intellect and the metropolis were more concretely connected to vast networks of commerce. Whereas the intellect was increasingly isolated from any contaminants in the physiological laboratory, the production of knowledge was, more than ever before, connected to communities of scholars, modes of production, and networks of communication. This was why, as Simmel observed, it was "more important, however, and at the same time more concealed" to see that mental work "extends much more into the whole of life and is surrounded by a much wider periphery of mediated relationships than is manual labour."[109] So while mental work was being divided from the body, it was being more concretely connected to the economy and the global world.

This interconnectedness explained the value of mental work. Simmel described the place of mental work in the emerging global world:

> The highest stages of education require less effort for every step further than the lower stages, and yet at the same time produce greater results. Just as the objectivity of money permits 'work' that is ultimately relatively independent of personal energies… the separation of the results of intelligence from its process, cause these results to accumulate in the form of concentrated abstractions, so that, if only one stands high enough, they may be picked like fruits that have ripened without any effort on our part.[110]

Just as Babbage had imagined, the intellect now stood at the top of a hierarchy of labour. But from another vantage point, the intellect at the top was merely a product of the accumulation of other forms of work. If the division of manual work had permitted the accumulation of capital,

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[109] Ibid., 423.
[110] Ibid., 447.

the division of mental work permitted the accumulation of knowledge, the capital of the metropolis. Knowledge, in this sense, was the product of any mental work. In Simmel's view, typewriters, telegraph networks, and vending machines were the concentration of large amounts of work, both mental and manual.

As much as intellectual workers and consumption signalled an important shift in socioeconomic relations, they remained still economically marginal in the late-nineteenth century. Born in the urban heart of Berlin, at the corner Leipziger- and Friedrichstrasse, one could not have been more metropolitan than Simmel. If mental work, money and the metropolis were the essence of Simmel's life, they remained inaccessible to most. Though the late-nineteenth century signified an unprecedented expansion of global capitalism through empire, mental work remained insignificant compared to manual work. It was not until the mid-twentieth century that mental work became a dominant form of work in global capitalism. By then, the problem of mental work had become a concentrated abstraction, a "cash legacy" that would become the problem of knowledge-producers in the knowledge economy. [111]

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[111] Fritz Machlup, *The Production and Distribution of Knowledge in the United States* (Princeton: Princeton University Press, 1962). See William Rankin, "The Epistemology of the Suburbs: Knowledge Production, and Corporate Laboratory Design," *Critical Inquiry* 36 (2010).

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