

# HERMANN LOTZE'S CRITIQUE OF JOHANNES MÜLLER'S DOCTRINE OF SPECIFIC SENSE ENERGIES

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DOES EXPERIMENTAL PSYCHOLOGY follow Karl Popper's "logic of scientific discovery", advancing through falsification and refutation?<sup>1</sup> Or does it progress through puzzle-solving within a paradigm, as Thomas Kuhn characterized the "psychology of research"?<sup>2</sup> The case of Lotze's critique of Müller's doctrine of specific sense energies supports the Kuhn thesis. Even though Lotze's logical criteria did falsify and refute the Müller doctrine, the doctrine survived because of a quixotic allegiance to its paradigm by the scientific community, illustrated by this passage from a typical modern textbook:

In 1826, long before much was known about nerve impulses, the great physiologist, Johannes Müller, proposed a doctrine of specific nerve energies. The theory was that each sensory nerve had its characteristic type of activity so that the optic nerve would signal light and color, the auditory nerve the quality of sound, the olfactory nerve that of odor, and so on. This theory is vividly expressed by the statement, "If we could cross the auditory and optic nerves, we could see thunder and hear lightning."<sup>3</sup>

Woodworth and Schlosberg go on to repeat a standard fact supporting the theory that inadequate stimulation such as pressure on the right eyeball produces a dark disc in the left margin of the visual field. Then they give the standard criticism, that nerve impulses are fundamentally the same, and that sensory quality requires explanation by localization or by patterns, but certainly not by different kinds of nerve alone.

Now that we have stated the law as it is remembered today, let us compare its very first formulation. In 1826, at the age of twenty-five, Müller wrote in his first book, *Zur vergleichenden Physiologie des Gesichtssinnes des Menschen und der Thiere*: "We want to state right at the beginning the basic idea of all physiological investigation, not only of vision but of all the other senses, which we cannot repeat often enough, . . .

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<sup>1</sup> K. Popper, *The logic of scientific discovery*, London, Hutchinson, 1959.

<sup>2</sup> T. S. Kuhn, *The structure of scientific revolutions*, 2nd ed., Chicago, University of Chicago, 1970.

<sup>3</sup> R. S. Woodworth and H. Schlosberg, *Experimental psychology*, New York, Holt, Rinehart & Winston, 1954, p. 272. The authors perpetrated the error of referring to the doctrine of specific energies of the senses as "specific nerve energies". See W. Riese and G. E. Arrington, Jr., 'The history of Johannes Müller's doctrine of the specific energies of the senses: original and later versions', *Bull. Hist. Med.*, 1963, 37: 179ff. Cf. R. Weinmann, *Die Lehre von den spezifischen Sinnesenergien*, Hamburg and Leipzig, Voss, 1895.

that the energies of light, dark, and colour are not immanent in external things, . . . but in the visual substance itself."<sup>4</sup> Where did this notion come from? The favourite answer of Wundt and Helmholtz was Kant's epistemology. Both scientists thought it was a physiological attempt to find the conditions of knowledge *a priori*.<sup>5</sup> Be that as it may, their views are suspiciously characteristic of the 1870s and 1880s, a period of outspoken neo-Kantianism quite different from that of Müller. Incidentally, Wundt was critical of Müller's law and proposed a law of indifference of function of the nervous elements,<sup>6</sup> while Helmholtz favoured it but revised it to apply to specific fibres instead of specific nerves.<sup>7</sup>

The doctrine itself has two components which posterity has joined together: specificity and energy. Obviously "energies" did not refer to the substances whose convertibility was discovered by various scientists in the 1840s, and not defined until the 1850s by Lord Kelvin.<sup>8</sup> Probably the actual word came from either Purkynje, the admirer of Goethe whose writings on the subjective phenomena of vision were closely studied by Müller,<sup>9</sup> or from Magendie, who used the term in describing the sensibility of the nasal cavity.<sup>10</sup> The explanation of living activities by the ascription of dispositional properties, however, was older. In 1755, von Haller termed the property of muscles "irritability" and that of nerves "sensibility".<sup>11</sup> The concept came to be known as "excitation" when, in 1780, the Scottish physician John Brown put forward the theory in his *Elementa medicinae* that all disease could be explained and treated by raising or lowering the excitation of the body, and producing states which he termed *sthenia*, or tension, and *asthenia*, or relaxation.<sup>12</sup> This view was widely adopted because of its therapeutic simplicity and its polar nature by German physicians and *Naturphilosophen*, c. 1800.<sup>13</sup> Thus *naturphilosophische Medizin* was well represented

<sup>4</sup> J. Müller, *Zur vergleichenden Physiologie des Gesichtssinnes des Menschen und der Thiere*, Leipzig, C. Cnobloch, 1826, pp. 44–45.

<sup>5</sup> J. T. Merz, *A history of European thought in the nineteenth century*, New York, Dover, 1965, vol. 2, pp. 483–484.

<sup>6</sup> W. Wundt, *Grundzüge der physiologischen Psychologie*, Leipzig, W. Engelmann, 1887, pp. 336–339. For a comparison of Wundt's and Müller's views, see E. Montgomery, *Mind*, 1880, 5: 1ff.

<sup>7</sup> *Helmholtz's treatise on physiological optics*, ed. by James Southall, trans. from 3rd German ed., The Optical Society of America, 1924, vol. 2, pp. 143–146.

<sup>8</sup> T. S. Kuhn, 'Energy conservation as an example of simultaneous discovery', in M. Clagett (ed.), *Critical problems in the history of science*, Madison, University of Wisconsin, 1969, pp. 320–359. Cf. Merz, op. cit., note 5 above, vol. 2, pp. 98, 116. Thomas Young defined "Energy" as the product of the weight and the velocity squared c. 1800, and William Thomson (Lord Kelvin) distinguished another kind of "energy" as "the power to perform work" in 1892. Later these two kinds of energy were named kinetic and potential.

<sup>9</sup> J. Purkynje, *Beobachtungen und Versuche zur Physiologie der Sinne*, Prague, Calve, 1823, p. 73. Cf. V. Kruta, *J. E. Purkynje (1787–1869) Physiologist*, Prague, Academia Publishing House of the Czech Academy of Science, 1969, p. 37. Müller cites him in op. cit., note 4 above, pp. 61–62.

<sup>10</sup> F. Magendie, 'Le nerf olfactif est-il l'organe de l'odorat? Expériences sur cette question', *J. Physiol.*, 1824, 4: 170.

<sup>11</sup> A. von Haller, *A dissertation on the sensible and irritable parts of animals*, introduction by O. Temkin, Baltimore, Johns Hopkins Press, 1936, *passim*. The original Latin work was published at London, J. Nourse, 1755, being a translation from the French version of Haller's paper 'De partibus corporis humani sensibilibus et irritabilibus', *Comment. Soc. Reg. Sci. Göttingen*, 1753, 2: 114–158.

<sup>12</sup> J. Brown, *Elementa medicinae*. Edinburgh, C. Elliot, 1780, trans. by the author, *The elements of medicine*, London, J. Johnson, 1788.

<sup>13</sup> B. Hirschel, *Geschichte des Brown'schen Systems*, 2nd ed., Leipzig, Arnoldische Buchhandlung, 1850.

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among Müller's teachers at Bonn University around 1820, including the physiologists Christian Friedrich Nasse and Philip von Walther, Gottlob Kastner the friend of Schelling, and the botanist Nees von Esenbeck a friend of Goethe.<sup>14</sup>

Therefore Müller, in speaking of "energies", was using current conceptions of the vital activity characteristic of life; however, in the implication that these were "specific" to each sense he departed from the classic view of von Haller that *all* sensory nerves had the *sole* property of sensitivity, undifferentiated by sense.<sup>15</sup> Actually Müller did not employ the word "specific", but he clearly implied this when he wrote that "the optic nerve cannot even be affected without seeing itself luminous, the auditory nerve cannot be affected without sounding, the taste nerve not without tasting, *et cetera*."<sup>16</sup> In 1838, in his *Handbuch der Physiologie des Menschen*, he spelled this out further: all stimuli, whether chemical, mechanical, or electrical, give rise to a single kind of sensation in any given sensory pathway; conversely, the same stimulus applied to different senses gives rise to different sensations.<sup>17</sup>

Two formative experiences shed light on the origin of Müller's law, and they reflect his attitude towards experiment. By training under von Walther at Bonn and Rudolphi at Berlin, Müller was a physiologist and anatomist.<sup>18</sup> But by predilection he was a psychologist, and his teacher was Goethe; thus he wrote: "I have no second thoughts about admitting how very much I owe to the inducements of Goethe's colour theory, and can fairly say that without many years of studying it together with personal observation of the phenomena the present researches would not have arisen."<sup>19</sup> Goethe's theory of light was simply that light is white and cannot be split into colours.<sup>20</sup> But Goethe's method, unlike Newton's, was psychological, for it asked the subject to describe the visual phenomena directly, regardless of objective reality. It is no accident that Müller sent his first book and a grateful letter to Goethe, and even paid him a visit.<sup>21</sup> The combined influence of Goethe and the great comparative anatomist Rudolphi is evident in Müller's attitude expressed in his academic inaugural lecture in 1824 that "plain observation in anatomical investigation is far more splendid and superior to the reckless and often deceitful physiological experiment."<sup>22</sup> In the same lecture, Müller acknowledged that "a certain kind of experiment", the sectioning

<sup>14</sup> M. Müller, 'Über die philosophischen Anschauungen des Naturforschers Johannes Müller', *Arch. Gesch. Med.*, 1926, 18: 131–132.

<sup>15</sup> Von Haller, *op. cit.*, note 11 above, p. 24.

<sup>16</sup> Müller, *op. cit.*, note 4 above, p. 6.

<sup>17</sup> J. Müller, *Handbuch der Physiologie des Menschen*, Coblenz, J. Hölscher, 1834–1840, vol. 2, pp. 251–254, trans. by W. Baly as *Elements of physiology*, London, Taylor & Walton, 1842, vol. 2, pp. 1061–1064. The section referred to was first published in 1838.

<sup>18</sup> W. Haberling, *Johannes Müller. Das Leben des Rheinischen Naturforschers*, Leipzig, Akademische Verlagsgesellschaft M.B.H., 1924, pp. 42, 49–54.

<sup>19</sup> Müller, *op. cit.*, note 4 above, pp. 395–396.

<sup>20</sup> J. W. von Goethe, *Theory of colours*, trans. by C. L. Eastlake with notes, Cambridge, Mass., Massachusetts Institute of Technology Press, 1970, reprinted from London, J. Murray, 1840, pp. 100–118. Cf. *Helmholtz's Optics*, *op. cit.*, note 7 above, vol. 2, pp. 114–115.

<sup>21</sup> Haberling, *op. cit.*, note 18 above, pp. 97–98. Cf. *Goethes Gespräche. Eine Sammlung zeitgenössischer Berichte aus seinem Umgang*, enl. and ed. by W. Herwig, Zürich, Artemis Verlag, 1972, vol. 3, Pt. 2, 1825–1832, p. 372.

<sup>22</sup> J. Müller, 'Über das Bedürfniss der Physiologie nach einer philosophischen Naturbetrachtung', *Antrittsvorlesung*, 19 October 1824, reprinted as ch. 1, Müller, *op. cit.*, note 4 above, pp. 27–28.

of nerves, “leads to . . . *Urphenomena*”.<sup>23</sup> The second formative experience, therefore, was reading Magendie’s 1824 experiments on sectioning the olfactory, trigeminal, and optic nerves of a dog; Müller refused to believe Magendie’s contention that pricking the nerves afterwards did not produce smell, pain, and light, respectively.<sup>24</sup> The reason for Müller’s disbelief was his conviction, gained from Goethe’s subjective visual experiences and his own,<sup>25</sup> that light could be excited by internal as well as external causes. By this belief, which he stated as “the metamorphosis of the visual substance” in imitation of Goethe’s *Plant metamorphosis*, he meant that sensations are specific qualities of the nervous pathways all the way from the sense organ to the sensorium.<sup>26</sup>

It was Rudolph Hermann Lotze, sixteen years later, who first dared to challenge Müller’s assertion outright. He too was only twenty-five when he wrote in his first book, *Allgemeine Pathologie und Therapie als mechanische Naturwissenschaften*, in 1842:

It is false to claim with assurance that the higher sensory nerves always react to a stimulus exclusively by functional expressions, never by pain. The single experiment which seems to speak for the doctrine of specific nerve energy in a decisive way is the sectioning of the optic nerve, which as some claim is supposed to be accompanied not by pain but by a visual appearance. Around this one observation, if we want to be honest, the far-reaching doctrine of specific nerve energies has spread out, while supporting itself upon this sole analogy and repeatedly referring to it, it has established the two parts of its claim, that (1) every nerve reacts to inadequate stimuli by its functional expression, and (2) it also reacts exclusively by this.<sup>27</sup>

In effect, Lotze was defending Magendie; however, it is likely that he acquired his critical attitude toward Müller’s work from his three teachers at Leipzig University, Ernst Heinrich Weber, Alfred Wilhelm Volkmann, and Gustav Theodor Fechner, who were contemporaries of Müller. In 1834, Weber had patently ignored the theory in writing about hearing and touch.<sup>28</sup> In 1836, Volkmann objected in his book *Neue Beiträge zur Physiologie des Gesichtssinnes* that sensations and mind should not be separated, as Müller had done in writing about nerve energies, and that experience

<sup>23</sup> *Ibid.*, p. 26.

<sup>24</sup> F. Magendie, ‘De l’influence de la cinquième paire de nerfs sur la nutrition et les fonctions de l’oeil’, *J. Physiol.*, 1824, 4: 180. Müller did not cite this experiment until 1838 (*Elements*, op. cit., note 12 above, vol. 2, p. 1069), however he appears to refer indirectly to it in 1826 (*Gesichtssinnes*, op. cit., note 4 above, pp. 20–27). Another indirect reference to Magendie is found in J. Müller, *Über die phantastischen Gesichterscheinungen*, ed. by M. Müller, Leipzig, A. Barth, 1927, p. 20: “When a French physiologist has proven through experiment, therefore, to his own great astonishment, that the optic nerve has a so-called specific sensitivity for external light but no sense of touch for mechanical irritation, i.e., it senses no resistance, no pain, no warmth, then we wish this physiology only the advance that it realize how the optic nerve does not sense external things as resistance, but reacts to every external thing, to the knife as to the stimulus [of light], by luminance. If, however, the optic nerve is illuminated by every external thing no matter what, then no reasonable basis remains for it to sense pleasure and pain also. That entire investigation of the lack of a sense of pain in the optic nerve appears to [our] physiological conception as a mystification of the investigator.”

<sup>25</sup> *Ibid.*, *passim*; Goethe, op. cit., note 20 above, pp. 1–55.

<sup>26</sup> Müller, *Gesichterscheinungen*, op. cit., note 24 above, p. 23; J. W. von Goethe, *Versuch die Metamorphose der Pflanzen zu erklären*, Gotha, C. W. Ettinger, 1790.

<sup>27</sup> Rudolph Hermann Lotze, *Allgemeine Pathologie und Therapie als mechanische Naturwissenschaften*, Leipzig, Weidmann’sche Buchhandlung, 1842, p. 155.

<sup>28</sup> E. H. Weber, *De pulsu, resorptione, auditu et tactu: Annotationes anatomicae et physiologicae*, Leipzig, C. F. Koehler, 1834.

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was a factor in the recognition of external objects by newborn animals and persons with their sight newly restored after blindness.<sup>29</sup> And in 1838 and 1840, Fechner reported on subjective colours, complementary colours, and after-images without mentioning Müller's doctrine.<sup>30</sup>

Concurrent with his medical education, Lotze received a thorough grounding in philosophy under Christian Hermann Weisse.<sup>31</sup> As Eduard von Hartmann later remarked, "it is basically through the glasses of Weisse that [Lotze] saw Hegelian dialectic and Hegelian idealism."<sup>32</sup> In 1835, Weisse had published *Grundzüge der Metaphysik* styled after Hegel's *Wissenschaft der Logik*.<sup>33</sup> Its thesis was being, and its antithesis, thought; it differed in its synthesis, however. Instead of the "Absolute Idea", Weisse's synthesis was *Fürsichseyn*, "being for self", i.e., sensation, freedom, and "the postulation of oneself by specification".<sup>34</sup> Lotze came to similar conclusions in his medical dissertation in 1838.<sup>35</sup> The monad of Leibniz became for Lotze, as it been for Weisse, the best example of the emergence of sensation in an otherwise mechanistic world description. The monad had an active capacity "to specify itself", and a passive capacity to occupy space and submit to change.<sup>36</sup> Instead of Leibniz' attribute of mind, "perception", Lotze chose Weisse's term "specification", although he replaced it with "sensory quality" three years later in his first book, *Metaphysik*.<sup>37</sup>

Another important influence on Lotze's view of the nature of sensation was the Göttingen philosopher, to whose chair Lotze was called in 1845, Johann Friedrich Herbart. Herbart opposed idealism with his own brand of realism, and he substituted a "hairsplitting manner" for the grand strokes of the dialectic.<sup>38</sup> In his *Metaphysik* of 1828, Herbart took the example from Kant that "one hundred real coins contain not the least more than one hundred possible ones."<sup>39</sup> Lotze, in his *Metaphysik* of 1841, commented that "the possible (thought) hundred coins behave . . . neither as physical substances upon impact with other bodies, nor do they produce through their value a movement in the world; one buys nothing with them."<sup>40</sup> Herbart regarded

<sup>29</sup> A. W. Volkmann, *Neue Beiträge zur Physiologie des Gesichtssinnes*, Leipzig, Breitkopf und Härtel, 1836, pp. 18–20.

<sup>30</sup> G. T. Fechner, 'Ueber die subjectiven Complementarfarben', *Ann. Physik Chemie*, 1838, **44**: (120): 220–245, 513–535; 'Ueber eine Scheibe zur Erzeugung subjectiver Farben', *ibid.*, 1838, **45** (121): 227–232, 'Ueber die subjectiven Nachbilder und Nebenbilder', *ibid.*, 1840, **50** (126): 193–221, 427–470.

<sup>31</sup> M. Wentscher, *Hermann Lotze*, Heidelberg, C. Winter, 1913, pp. 24–30.

<sup>32</sup> E. von Hartmann, *Lotze's Philosophie*, Leipzig, W. Friedrich, 1888, pp. 25–26.

<sup>33</sup> C. H. Weisse, *Grundzüge der Metaphysik*, Hamburg, F. Perthes, 1835; G. W. F. Hegel, *Wissenschaft der Logik*, ed. by L. von Henning, vols. 3, 4, 5 in *Hegel's Werke*, Berlin, Duncker und Humblot, 1833–1834.

<sup>34</sup> Weisse, *op. cit.*, note 33 above, pp. 533, 561.

<sup>35</sup> R. H. Lotze, *De futurae biologiae principia philosophica*, Leipzig, Breitkopf und Härtel, 1838, reprinted in *Kleine Schriften von Hermann Lotze*, ed. by D. Peipers, Leipzig, S. Hirzel, 1885, vol. 1, pp. 1–25.

<sup>36</sup> *Ibid.*, pp. 22–25. Cf. Lotze's undated essay from this period, 'Pensees d'un idiotie sur Descartes, Spinoza et Leibnitz', in *Kleine Schriften*, *op. cit.*, note 35 above, vol. 3, pp. 558–566.

<sup>37</sup> R. H. Lotze, *Metaphysik*, Leipzig, Weidmann'sche Buchhandlung, 1841, p. 271.

<sup>38</sup> Hartmann, *op. cit.*, note 32 above, pp. 31–35.

<sup>39</sup> J. F. Herbart, *Allgemeine Metaphysik nebst den Anfängen der philosophischen Naturlehre*, 2 vols., Königsberg, A. W. Unzer, 1828–1829, vol. 1, pp. 73–74, citing I. Kant, *Critik der reinen Vernunft*, Riga, J. F. Hartknoch, 1790, p. 627.

<sup>40</sup> Lotze, *op. cit.*, note 37 above, p. 51.

the being of an object as determined by its reference to real qualities, while Lotze regarded it as determined by reciprocal relations to other objects.<sup>41</sup> Both opposed Hegel's identification of the qualities, which are thought, with the object, which exists, in the Absolute. By a similar line of argument, Lotze defined sensation as a kind of reciprocal relation between thought and object.<sup>42</sup> When one monad "specifies" another, when one individual "perceives" another, and when a higher power "prescribes" the ends of the universe, the meaning or value of sensation reduces to an ethical judgment.<sup>43</sup> Despite a realistic definition of sensation in the realm of being, Lotze conceded to it an idealistic definition in the realm of value.

Idealism and realism together were the groundwork of Lotze's philosophy; however he expressed them under the abbreviation of "occasionalism" in his scientific books which followed. In the *Allgemeine Pathologie*, he explained that "ideal qualities of sensitivity are incommensurable with the physical events which occasion them."<sup>44</sup> Neither the ideal event nor the real one need be neglected by the scientist. But it would be a mistake to understand them as reciprocal causes of one another, as Müller had done.<sup>45</sup> Lotze noted that the qualities of sensations are "a production of the soul according to its own laws, and do not depend at all on the nature of the physical stimuli except that these offer signals for the soul to create ideas."<sup>46</sup> A strict solution to the problem of the reciprocal effect between the soul and the body would have to go back to the origin of the concepts of matter, movement, and idea. However, the natural sciences need not reduce every single phenomenon to the true metaphysical relations which underlie it.<sup>47</sup>

The origin of Lotze's mechanistic conception of scientific explanation, as contrasted with his ideo-realistic views of the nature of reality, was his *Logik* of 1843.<sup>48</sup> Logic for Lotze did not comprise mental operations by which inferences are made in real thought; it consisted rather of the ideal forms of thought.<sup>49</sup> The qualities of sensation and the properties of objects were held apart, as empirical or metaphysical questions, from the marks of concepts, a logical question.<sup>50</sup> Recognizing that the classical figures of the syllogism (subsumption, induction, and analogy) were only ideal forms, Lotze nevertheless tried to make them refer to real particulars. He showed how mathematical inferences could serve to make specific the marks of the concept, either by substituting numbers, or forming proportions where quantification was impossible, or making equations.<sup>51</sup> For example, he described the event in which

<sup>41</sup> Herbart, op. cit., note 39 above, vol. 2, pp. 71–142; Lotze, op. cit., note 37 above, pp. 50–68.

<sup>42</sup> Ibid., pp. 278–290.

<sup>43</sup> Ibid., pp. 323–329.

<sup>44</sup> R. H. Lotze, *Allgemeine Pathologie und Therapie als mechanische Naturwissenschaften*, Leipzig, Weidmann'sche Buchhandlung, 1842, p. 150.

<sup>45</sup> Müller, *Handbuch*, op. cit., note 17 above, vol. 2, pp. 1382–1399. Cf. *Elements*, op. cit., note 17 above, vol. 2, pp. 553–569.

<sup>46</sup> Lotze, op. cit., note 44 above, p. 59.

<sup>47</sup> Ibid., pp. 56–57.

<sup>48</sup> R. H. Lotze, *Logik*, Leipzig, Weidmann'sche Buchhandlung, 1843.

<sup>49</sup> H. W. Blount, 'Logic, II. History', *Encyclopaedia Britannica*, 11th ed., New York, The Encyclopaedia Britannica Co., 1911, vol. 16, p. 915.

<sup>50</sup> Lotze, op. cit., note 48 above, p. 193.

<sup>51</sup> Ibid., pp. 190–213.

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undulations of light give rise to the colours of sensation as an inference from proportion: such a logical relation is a hypothesis about these natural phenomena which, if verified by experiment and quantified by mathematics, could become a natural law.<sup>52</sup>

Was Müller's doctrine such a natural law? Müller had generalized that all stimuli give rise to only one kind of sensation in a given sensory modality. Although obviously not quantifiable, this proposition rested heavily on the evidence of the "phantastic visual phenomena", which Müller assumed to come from inner stimuli to the specific fibres. Introducing a distinction between adequate and inadequate stimuli, Lotze put forth a hypothesis diametrically opposed to Müller's, that "every sensation-producing process in a nerve is always brought about by its definite adequate stimulus alone."<sup>53</sup> The optic nerve is stimulated by light, the auditory nerve by sound, and so on, always producing a normal sensation for that sense. On the other hand, the optic nerve can also be stimulated by congestion or fever, the auditory nerve by a blow to the head; Lotze's point was that these sensations resulting from inadequate stimuli were abnormal ones. Thus Lotze came to the ironic conclusion in 1842 that Müller's doctrine "is founded almost solely on pathological cases, and as it appears, not very securely."<sup>54</sup> He softened this verdict in 1848 and wrote: "One can say, therefore, that the theory of specific energy does not stand upon all that many facts; we are satisfied, without entering into the matter, with the result sufficient for our purposes that there are many sensations which come from unusual, namely inner, stimuli. These sensations belong to the class of usual ones for each nerve, irrespective of whether those inner stimuli, although unusual, were adequate to excite them, or if inadequate, have produced them by virtue of such a specific energy."<sup>55</sup>

It is noteworthy that Lotze used the term "*adäquater Reiz*" (adequate stimulus), in view of E. G. Boring's claim that C. S. Sherrington invented the term in 1906.<sup>56</sup>

How was this challenge to the doctrine received? At Berlin, where Müller's interest had again turned to comparative anatomy, there was no reply. However, his students Jacob Henle and Hermann Helmholtz continued to promulgate variations of the theory.<sup>57</sup> At Leipzig, E. H. Weber raised serious questions about the doctrine and presented a mass of contrary evidence in his 1846 article "Der Tastsinn und das Gemeingsgefühl".<sup>58</sup> Meanwhile in 1844, Lotze's friend and former teacher A. W. Volkmann, now at Halle, sided with Lotze, though not without reservations: "I believe with Lotze that this theory is opposed by very basic considerations, although

<sup>52</sup> *Ibid.*, pp. 205–206; 224–230.

<sup>53</sup> Lotze, *op. cit.*, note 44 above, p. 156.

<sup>54</sup> *Ibid.*, p. 152.

<sup>55</sup> R. H. Lotze, *Allgemeine Pathologie und Therapie als mechanische Naturwissenschaften*, 2nd rev. ed., Leipzig, Weidmann'sche Buchhandlung, 1848, p. 159.

<sup>56</sup> Lotze, *op. cit.*, note 44 above, p. 156. E. G. Boring, *A history of experimental psychology*, New York, Appleton-Century-Crofts, 1950, p. 87.

<sup>57</sup> J. Henle, *Allgemeine Anatomie*, Leipzig, L. Voss, 1841, pp. 739–753; H. Helmholtz, 'Ueber die Natur der menschlichen Sinnesempfindungen', a lecture delivered at his *Habilitation* as *ordentlicher Professor* on 28 June 1852, published with his *Habilitationsschrift*, 'Ueber die Theorie der zusammengesetzten Farben', 3 July 1852, 24 pp., Berlin, Gebrüder Unger, 1852.

<sup>58</sup> E. H. Weber, 'Der Tastsinn und das Gemeingefühl', in *Handwörterbuch der Physiologie*, ed. by R. Wagner, Braunschweig, F. Vieweg, 1846, vol. 3, pt. 2, pp. 507–511.

I would not turn it around and want to claim that 'each specific sensation is always brought about by a specifically determined stimulus and its changes.'"<sup>59</sup>

Lotze answered Volkmann in 1846 in an essay called "Seele und Seelenleben", where he explained that by stimulus he meant the entire state of the nervous system.<sup>60</sup> Volkmann had taken issue with a simple logical law, wrote Lotze, that equal conditions have equal consequences; hence, a certain state of the nervous system would always result in a certain sensation. Thus, the inception of Lotze's challenge to Müller was misunderstood in Halle, and it fell on deaf ears in Berlin and Leipzig.

It is worth pausing for a moment to consider this essay about the soul. Two hundred pages long, it dealt with the empirical nature of the soul (excluding free will, but including the phenomena of sensory quality, sensory localization, feeling, ideas, and the unity of consciousness), all of which the author attempted to relate to physiological conditions and the available explanatory principles of natural science. Wherever possible, it set forth hypotheses and theories for experimental investigation by a science of psychology as yet unfounded. For example, on the question of where the specificity of the senses originates, Lotze suggested two possible hypotheses: one was Volkmann's that some kind of correction apparatus limits a nerve to certain classes of sensations. Thinking that this was ruled out by the anatomical similarity of all nerves, Lotze preferred the other hypothesis of G. H. Meyer, that specific energies were only acquired habits in the nerves.<sup>61</sup> The latter hypothesis was more easily reconciled with the cautionary advice of E. H. Weber, who wrote: "One should not, it seems to me, overestimate the influence of the central organs with which the inner endings of the nerves connect in the origin of specifically different sensations, nor should one underestimate the influence of the auxiliary organs in the external endings of the nerves."<sup>62</sup>

Actually, Lotze had adopted the hypothesis from Weber that the structure of the peripheral sense organs allowed only a certain class of stimuli to affect each sensory nerve, whereas the structure of the nerves themselves was identical and could play no role in the specificity of sensation.<sup>63</sup>

As for the qualitative differences in sensation within a given sense, further explanation was called for. Volkmann had criticized Müller harshly here: "The observation satisfies me that the red light wave transmits another sensation than the blue, and a slowly oscillating string another tone than a rapidly oscillating one. Herewith the doctrine of specific excitability is shaken in its foundation."<sup>64</sup>

Lotze went even further, and suggested the "phantasy" that no qualitative differences could occur in the body which were not differences of magnitude, direction, duration, or a combination of these. This physical series of processes would release first the sensations of tone, gradually climbing to the sensations of colour. "Despite

<sup>59</sup> A. W. Volkmann, 'Nervenphysiologie', in *ibid.*, 1844, vol. 2, p. 521, citing Lotze, *Pathologie*, *op. cit.*, note 44 above, p. 164.

<sup>60</sup> R. H. Lotze, 'Seele und Seelenleben', in *Handwörterbuch*, *op. cit.*, note 58 above, vol. 3, pt. 1, p. 159; reprinted in *Kleine Schriften*, 2: 30-31.

<sup>61</sup> Lotze, *Handwörterbuch*, *op. cit.*, note 58 above, vol. 3, pp. 162-163, and in *Kleine Schriften*, *op. cit.*, note 35 above, vol. 2, pp. 32-35.

<sup>62</sup> Weber, *op. cit.*, note 58 above, vol. 3., p. 507.

<sup>63</sup> Lotze, *Pathologie*, *op. cit.*, note 44 above, p. 157.

<sup>64</sup> Volkmann, *op. cit.*, note 59 above, vol. 2, p. 522.



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the qualitative incomparability of both kinds of processes," concluded Lotze, "we find in contrast a proportionality, the further pursuit of which could secure for psychology a wealth of information."<sup>65</sup> This brilliant speculation, adhering to the mechanical principles of explanation developed in Lotze's *Logik*, was anticipated by Fechner's *Habilitationsschrift*, "Premises toward a general theory of organisms" in 1823 and confirmed by Fechner's announcement of the psychophysical law in the *Zend-Avesta* in 1851.<sup>66</sup>

Incidentally, I have found no indication by Fechner or by Lotze that Fechner's law owed anything to Lotze's proposal of a proportionality between the "mathematical differences" of nervous processes and sensation; yet I do feel that Lotze performed an important service for the scientific community when, in his major works, *Allgemeine Physiologie des körperlichen Lebens* in 1851, and *Medicinische Psychologie oder Physiologie der Seele* the year after,<sup>67</sup> he separated the physiological from the psychological issues for perhaps the first time in any language. The physiological issues turned on the nature of the nervous principle; Du Bois Reymond had revived the hypothesis that electricity was transmitted in the nerve medulla and insulated by the nerve sheath, while Rudolph Wagner, Albert Kölliker, and Volkmann had each described the cellular nature of the neural elements.<sup>68</sup> Admitting that an undulation theory of nervous conduction was as uncertain as an emission or electrical one, Lotze offered a preliminary hypothesis of an equilibrium of forces among the elements of the nerve, capable of disturbance by a stimulus and recovery by nutritional processes.<sup>69</sup>

In his *Medicinische Psychologie* of 1852, Lotze abandoned the viewpoint of the single nerve and traced the origin of a single sensation through six stages: external stimulus, inner sensory stimulus, nervous event, brain event, then the psychical impression in the soul, which may be unconscious, and finally the conscious sensory quality, such as a tone or a colour.<sup>70</sup> Compared with the "metamorphosis of the visual substance" in Müller's exposition of a quarter of a century before, this was a considerable advance. Müller's "energies" had given way to a proportionality between

<sup>65</sup> Lotze, *Handwörterbuch*, op. cit., note 60 above, vol. 3, pp. 167–168, and in *Kleine Schriften*, 2: 37–38.

<sup>66</sup> Fechner had proposed a quasi-logarithmic relationship between soul and body in his *Habilitationsschrift* in 1823, and he announced a logarithmic law to relate sensation and stimulus in 1851 and 1860. Cf. M. E. Marshall, 'G. T. Fechner: premises toward a general theory of organisms (1823)', unpublished MSS., at Carleton University, Ottawa, 1972. Lotze suggested a proportionality, but he remained sceptical of the logarithmic law even as late as 1880–1881 when, in his final psychology lecture course, he commented that the following question is still to be answered: "Why does this characteristic relation occur at all, and why does the sensation not grow quite simply in proportion to the stimulus, which would be much more natural. None of the established theories is satisfactory, but the most probable assumption is that in the transformation of external stimuli in neural excitations something goes on which requires the latter to increase much more slowly than the external stimuli grow." H. Lotze, *Grundzüge der Psychologie. Dictate aus den Vorlesungen*, Leipzig, S. Hirzel, 1881, p. 11.

<sup>67</sup> R. H. Lotze, *Allgemeine Physiologie des körperlichen Lebens*, Leipzig, Weidmann'sche Buchhandlung, 1851; R. H. Lotze, *Medicinische Psychologie oder Physiologie der Seele*, Leipzig, Weidmann'sche Buchhandlung, 1852.

<sup>68</sup> Lotze, *Physiologie*, op. cit., note 67 above, pp. 389–393.

<sup>69</sup> *Ibid.*, pp. 400–401.

<sup>70</sup> Lotze, *Psychologie*, op. cit., note 67 above, pp. 173–181.

three disparate processes: the stimulus, the nervous excitation, and the conscious sensation. Lotze also replaced the “specific” determination of these energies, which for Müller was nothing more than an ascribed disposition, with a review of the evidence for qualitative differences at each stage in the chain of sensation. The stimuli could be adequate or inadequate by degrees.<sup>71</sup> The nerves maintain a specific tension, analogous to a string stretched between two points: disattach it at either end, and it can no longer resonate.<sup>72</sup> Finally, the brain may be involved in the “vicarious sensations”, known to us as “synesthesias”, in which one sense sees, hears, smells, tastes, or feels for another.<sup>73</sup>

Despite its prominence in three books from 1842 to 1852, as well as in Wagner’s prestigious *Handwörterbuch der Physiologie*, Lotze’s critique went unmentioned by Wundt as well as by Weber, Fechner, Helmholtz, and Müller himself. Yet if the agreement on the part of E. H. Weber, A. W. Volkmann, and Lotze is any measure, the criticisms were justified and the Müller doctrine, as it stood, was wrong.<sup>74</sup> Why this neglect of a justified critique, and why the continued allegiance by Henle, Helmholtz, and others to an imperfect doctrine?

I suggest that an answer may be found in the Kuhn-Popper debate of the 1960s.<sup>75</sup> Logical criticisms and data difficult to digest, especially when they come from a philosopher-physician who was not an experimenter, are not sufficient to bring down a scientific theory, much less to bring about a scientific revolution. Rather, it seems to be the case that personal prestige such as Müller commanded, not to mention a fundamental improvement by Helmholtz, did succeed in maintaining the theory for a time.

Only in this century has the tide turned back toward Lotze. The Müller doctrine had become almost unassailable after Helmholtz replaced the specific sensory pathways with specific fibres within the senses.<sup>76</sup> In 1895, for example, von Frey proposed one kind of fibre for each of the four sensory qualities of touch—pressure, warmth,

<sup>71</sup> *Ibid.*, pp. 188–189.

<sup>72</sup> *Ibid.*, pp. 190–191.

<sup>73</sup> *Ibid.*, pp. 194–197. Cf. L. E. Marks, ‘On colored-hearing synaesthesia: Cross-modal translations of sensory dimensions’, *Psychol. Bull.*, 1975, in press.

<sup>74</sup> “In the final analysis, one arrives at the conclusion that the law of specific energies of the senses rested on an Aristotelian or metaphysical, rather than an anatomical or physiological, argument,” wrote W. Riese and G. E. Arrington, Jr., *op. cit.*, note 3 above, p. 182. Cf. R. Weinmann, *op. cit.*, note 3 above, pp. 39–42 and conclusion, pp. 95–96: “1. The facts of a specific reaction to any stimulus demand an explanation in the sense of Lotze. The mere use of ‘specific sense energies’ means the introduction of mysterious force principles: it means the renunciation of an explanation. . . . 2. The doctrine of specific energies would more accurately carry the name ‘doctrine of the different constitution of the physiological carriers of sensation’. . . . 3. The so-called new doctrine of specific energies stands in direct opposition to the key point of the parent doctrine. It also seems unjustified. . . . 4. The qualitative and quantitative rarity, the thoroughly abnormal character of the facts of the doctrine must be decisively emphasized. . . . 5. The doctrine of specific energies cannot serve as support for either the (unjustified) subjectivism of modern sensory psychology nor as empirical proof for the (justified) doctrine of the subjectivity of the secondary qualities. The doctrine of specific energies has solely physiological interest.”

<sup>75</sup> T. S. Kuhn, ‘Logic of discovery or psychology of research?’, and K. R. Popper, ‘Normal science and its dangers’, in I. Lakatos and A. Musgrave (eds.), *Criticism and the growth of knowledge*, Cambridge University Press, 1970, pp. 1–24, 51–58.

<sup>76</sup> See E. G. Boring, *Sensation and perception in the history of experimental psychology*, New York, Appleton-Century-Crofts, 1942, pp. 72–73.

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cold, and pain.<sup>77</sup> However, new techniques and data have since cast doubt upon such a simple one-to-one correspondence between psychological, physiological, and anatomical elements. Critics have suggested that the use of punctate stimuli elicited sensory specificity, whereas sensory fibres are actually much more "broadly tuned".<sup>78</sup> Thus pattern theory offers another way to interpret the data, by assigning qualitative differences to a pattern of responses across many neural elements.<sup>79</sup> In disguised form, perhaps, Lotze's critique and Müller's doctrine have come back to haunt the present generation of philosophers and scientists.<sup>80</sup>

<sup>77</sup> A. J. McKeag, *The sensation of pain and the theory of specific sense energies*, Boston, Mass., Ginn, 1902, p. 40; cf. pp. 45–69 for a review of the specific sense energy question at the turn of the century.

<sup>78</sup> R. P. Erickson, 'Stimulus coding in topographic and non-topographic afferent modalities: on the significance of the activity of individual sensory neurons', *Psychol. Rev.*, 1968, 75: 447–465.

<sup>79</sup> *Woodworth and Schlosberg's experimental psychology*, ed. by J. W. Kling and L. A. Riggs, New York, Holt, Rinehart, and Winston, 1971, pp. 179–181.

<sup>80</sup> Cf. U. Ebbecke, *Johannes Müller: der grosse rheinische Physiologe*, Hannover, Schmorl & von Seefeld Nachf., 1951, pp. 62–72, who reinterprets the Müllerian view in terms of a "point by point connection" between sense organ and the central cortical neurons; Ebbecke bridges the mind-body relation with the conclusion that "all these [cortical] centers, whose name 'center' is not to be taken literally, are themselves no longer sensory, their excitation is no longer experienced as sensation but as idea, ideo-sensorially or ideationally." In private communication with the author, Prof. Dr. Roths Schuh has commented that "if one investigates the sections in Johannes Müller's treatment having to do less with the specific sensory energies of the nervous tracts or fibres than with the corresponding central parts, then one can today still hold to Müller's conception." Cf. K. E. Roths Schuh, 'Spezifische Sinnesenergien', *Historisches Handwörterbuch der Philosophie*, ed. Joachim Ritter, Basle/Stuttgart, Schwabe, 1971ff (in press).