Realism without tears I

Realism without Tears I:
Müller's Doctrine of Specific Nerve Energies

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1 Introduction

Johannes Peter Müller (1801–1858) was the most influential physiologist of the first half of the 19th century, due both to his original contributions, especially in the areas of reflex action, sensation, and comparative embryology, and to his textbook, *Handbuch der Physiologie des Menschen* (1833–40). The single idea most strongly associated with Müller is the "Doctrine of Specific Nerve Energies," articulated in Book V of his *Handbuch* in 1840.[1] The fundamental idea behind the Doctrine is that the direct objects of sensation are the activities of sensory nerves, *not* qualities external to the body. This Doctrine serves as a foundational principle in both the neurophysiology of sensation and the psychology of perception; historians have identified it as a precondition for the "visual culture of modernity" (Crary 1990); and it has had profound influence in philosophy, providing the crucial link between Herbart's realist interpretation of Kant and the "operationalized" Kantianism of Helmholtz (Hatfield 1990; Lenoir 2006), as well as motivating the epistemology of a number of late 19th century neo-Kantians, including Liebmann and Lange (Edgar 2015). The shadow cast by Helmholtz across the early 20th century ramified the influence of the Doctrine into the philosophy of science, where its structuralist implications echoed through the work of Hertz, Schlick, Cassirer, and beyond.

In the science of perception, the importance of the Doctrine cannot be overstated. Although there are questions of priority about its tenets, it was given its fundamental codification by Müller. Boring (1950) argues that Helmholtz's theories of hearing and vision, Hering's theory of vision, and theories of "sensory spots in the skin" all depend critically on Müller's theory as they "were suggested explicitly by [it]" (81–2). In fact, a survey of Boring (1942) makes clear that far more of the science of perception than just these particular theories rests upon the Doctrine, as it motivated specific research programs on all aspects of sensation, as well as heralding the shift toward the study of localized sensory centers in the brain (1942, 72*ff*, 610; 1950, 88–9). The Doctrine continues to be cited in standard textbooks on perception (e.g. Goldstein 2006) and to appear in contemporary research papers as both a fundamental principle and an object of continued empirical support (e.g. Namer and Reeh 2013; Nadel et al. 2012).

Nevertheless, the Doctrine has also been sharply criticized, and its philosophical significance contested. Although heavily influenced by the Doctrine, Cassirer also lampooned the way Helmholtz's adherence to it

[1] An early version appears in Müller's 1826 monograph on the comparative anatomy of vision in animals and humans (44–55). The common German name is "Gesetz der spezifischen Sinnesenergien"; in English, sometimes the term "law" is used rather than "doctrine" and/or "sense" rather than "nerve"—I follow the older English nomenclature here.

rendered his theory of "the a priori . . . a mere extension of a certain individual result of natural science" (1912, 96; c.f. Patton 2009, 284). Psychologist J. W. Bridges (1912) criticized the phenomenological support for the Doctrine and argued it contradicts our understanding of the evolution of sensory organs. J. J. Gibson (1966) had even harsher words for the Doctrine, implying even in his arrangement of epigraphs that he considered it false (xv). For Gibson, Müller illegitimately emphasizes an atypical case, of marginal importance in the study of perception:

> We may sometimes be "aware of the state of a nerve," as Müller put it, but we are more likely to be aware of patterns and transformations of input that specify the causes of arousal quite independently of the specific nerves that are firing. (Gibson 1966, p. 38)

As we shall see, Müller's own understanding of the Doctrine was far more congenial to Gibson's approach than Gibson himself realized.[2]

The aim of these papers is to explicate the conceptual origins of the Doctrine in Müller and Helmholtz and to argue for its continued significance today. Part I analyzes Müller's argument for the Doctrine as it appears in its most influential statement, as well as his own assessment of its philosophical significance. I argue that some tenets of the Doctrine merely summarize data while others constitute substantive theoretical conclusions. These conclusions follow from the data only on the assumption of certain methodological principles. It is these methodological principles then that constitute the implicit heart of the Doctrine. Part II demonstrates the perseverance and entrenchment of these principles in Helmholtz and beyond to the contemporary science of perception, and argues that the Doctrine has substantive implications for today's naturalistic philosophy of perception and the history of philosophy of science.

Fortunately, the Doctrine does not, as some critics have worried, necessarily imply idealism or skepticism.[3] Müller himself endorsed a form of indirect realism, best described as *structural realism*. Epistemic structural realism denies us direct epistemic access to the natures, or essences, of objects and properties in the world; nevertheless, we can still achieve knowledge of the structural relations that obtain between them. The Doctrine's claim that the direct objects of perception are just internal states of the sensory nerves does not motivate a thoroughgoing anti-realism unless paired with some further empiricist principle, for instance that sensation is the sole source of knowledge. Müller himself endorsed the view that knowledge derives from our innate capacity to abstract general principles from patterns in experience. Thus, although the qualities of our sensations do not reveal to us the essential natures of external objects, the principles we abstract from regularities in these sensations do constitute knowledge of the structural relationships and interactions between external objects and properties. Müller's position here is informed by his analysis of the nature of scientific knowledge. Just as Newton was able to derive quantitative laws about the behavior of gravity without "feigning hypotheses" about its nature, the sciences of electricity, light, and heat also in Müller's day developed scientific laws without definitive theories of the underlying nature of the "energies" they concerned. So also the position of the physiologist towards the nervous energy—he may derive rules about its behavior while remaining forever ignorant of its essential nature; so also our epistemic access to external bodies—we may gain knowledge about their behavior, even as their essential natures remain forever hidden from us.

I begin with a discussion of Müller's theory of knowledge. This is because, unlike Cassirer's Helmholtz, Müller's philosophy does not derive solely from his physiology, but rather his physiology is informed by his

[2] Other critics include Lotze (Woodward 1975), Weber (Boring 1950, p. 89), and Köhler (e.g. 1947, Ch. 3).

[3] An interpretation embraced even by some of its supporters, e.g. the neo-Kantian Liebmann (Edgar 2015).

philosophy.[4] I then examine Müller's statement of, and argument for, the Doctrine in detail, emphasizing the methodological presuppositions he employs to turn undirected experimentation into a focussed *science* of perception. I conclude by briefly foreshadowing Part II, and the open questions still to be addressed if the Doctrine is to have significance for science and philosophy today.

2 Müller's Epistemology

Müller begins Book VI of the *Handbuch*, "On the Mind," with a discussion of his general philosophical views on the nature of mind, life, and the cosmos, developing a theory of knowledge that, by his lights, treads a middle path between Hume and Kant. The crucial issue here is the origin of concepts ("Begriffe") and their relationship to ideas, or representations ("Vorstellungen"). With Hume, Müller endorses a picture on which sensations generate simple ideas, and these ideas become connected through associations, resting primitively on a relation of resemblance (2:519/1347, cf. 2:523/1351).[5] However, with Kant, Müller argues the abstract concepts we *de facto* posses indicate a richer innate capacity than Hume allows, as they could not possibly arise through mere association or habit (2:519/1348). After outlining Müller's positive theory, it will be helpful to contrast it with that of post-Kantian psychologist Johann Friedrich Herbart's *Lehrbuch zur Psychologie* (1816/1834, 2nd ed.). Müller explicitly cites the *Lehrbuch*'s account of concept formation, and there are illuminating similarities and differences between the two theories.

Although he recognizes the need for some innate source of concepts beyond mere association or habit, Müller rejects Kant's theory of a rich set of *a priori* concepts ("Verstandesbegriffe": concepts of the understanding) qualitatively distinguished from other ideas. Grouping Kant here with Aristotle, to whom he ascribes a notion of innate categories, Müller argues that only a single innate capacity is required to generate the elements on both their lists of supposed *a priori* concepts. He introduces this capacity through a discussion of the inadequacy of habit for forming an abstract notion of causality:

> [T]he human mind ... would never derive from the mere experience afforded by the senses, and from habit, the general abstract concept of causality, unless it had a certain power of abstraction [*Vermögen der Abstraction*],—a power namely, of forming a mental something out of the returning combinations of two things, of which one requires the succession of the other. (2:519/1347–8*)

While rejecting Hume's reliance on mere habit, Müller nevertheless considers all knowledge to have *some* root in experience. This is why the various categories of Kant and Aristotle are not truly innate.[6] Nevertheless, with the addition to experience of the human faculty of abstraction, these same fundamental categories can be derived.

> I do not [accept] that the mind is originally occupied by the concepts of the understanding of Kant, or the categories of Aristotle; these appear to be the fruit of experience and of the power of abstraction. But the original power by which the different categories are first acquired, from

[4] Müller 1826 insists on the "need" for a "philosophical perspective" in physiology, 1–36; c.f. Lenoir 1982, 105–111.

[5] All references to Müller's *Handbuch* give volume number, then page in the German edition followed by page in the 1842 English edition. Wherever possible, I give Baly's translation. When it has been necessary to change the translation (typically in order to maintain consistency in technical terms), the page number is marked with an asterix.

[6] Of course, Müller may be misinterpreting Kant and Aristotle in ascribing to them the view that their respective categories are innate.

> the observation of external nature, is the faculty of extracting the general property from many specialities or separate perceptions, in other words the power of forming a concept, λόγος. (2:519/1348*)

This power of abstraction distinguishes humans from animals, and is the fundamental source of all knowledge (2:523–5/1351–3).

The distinctive character of Kant's concepts of the understanding for Müller is not their innateness, but their *generality*. Concepts such as quality, change, infinity, finitude, causality, space, and time are abstracted from many distinct ideas, and thus capture that which is common across all of them. In virtue of this generality, they constrain ("binden") thought, guiding our reasoning about the world. Such binding concepts may *appear* to constitute innate constraints on thought (i.e. fundamental categories, or concepts of the understanding) in virtue of their broad applicability. Nevertheless, mere reflection on those concepts that appear extremely general will never produce more than an arbitrary list (hence the difference between the lists of Kant and Aristotle). By positing a single process by which all abstract concepts are generated, Müller avoids this problem.

However, Müller must also avoid another of his own criticisms of the innate concept strategy of Kant and Aristotle for grounding epistemology. He argues that the mere positing of innate structure does not provide a satisfying solution to the problem of knowledge of the external world. The reason is that this strategy appears to rest on the assumption of a "pre-established harmony between the world of phenomena ... and the mind" (2:517/1346). Only an assumption of such pre-established harmony could justify the conclusion that innate concepts indeed correspond to true categories in the world. Yet positing a single innate capacity for concept formation does not at first seem to avoid this problem. What guarantees that Müller's abstracted concepts constitute correct descriptions of the categorical structure of the world? Is not the correspondence between such abstracted concepts and the world just as mysterious for Müller as for Kant and Aristotle?

Müller avoids this worry because his power of abstraction does not add anything to the simple ideas derived from sensation and their relations. It is not a "special power" ("besonderes Vermögen") in the sense of a distinct, function-specific ability; it is rather a general capacity for allowing concepts to *emerge* from the structural interactions between ideas.

> The faculty of concept formation is not, however, a special power of the mind acting on the ideas; but it consists in the mutual reaction of related ideas amongst themselves. The human capacity for ideas has such a degree of development that many distinct perceptions or simple ideas may exist in it simultaneously, and react on each other. If many related ideas are present, which in one respect differ, while in another they agree, the points of difference amongst the mass of ideas become obscured [*verdunkelt*], while only that which the different ideas have in common remains distinct. ... The more general is the application of these concepts, the more binding they are for the intellect, once they are experienced. (2:520/1348*)

It is the uniquely human ability to entertain multiple ideas simultaneously that allows the process of abstraction to occur. But this process is not active, it does not add anything to these simple ideas, it merely allows those features on which they differ to fade away ("verdunkelt"). The remainder is just the more abstract concept that captures their points of similarity, and in so doing, constrains thought just as do Kant's concepts of the understanding. Since the features of this abstract concept were already present

in the simpler ideas derived from experience, however, its correspondence to the world is not the result of pre-established harmony. Rather, it constitutes knowledge of the world in that it was derived wholely from structural relations between sensations of the world.[7]

Müller's discussion here owes much to the chapter "On the Formation of Concepts" in Herbart's *Lehrbuch zur Psychologie*, which he cites. Herbart (1776–1841) developed an empirical approach to psychology in tandem with a realist interpretation of Kant, thereby providing an avenue for Kantian influence in German psychology that continued throughout the 19th century. In contrast to the post-Kantian idealists, Herbart accepted the reality of things in themselves, and argued that a correspondence between conception and reality could be achieved through a program of refining and reworking philosophical concepts (Hatfield 1990, pp. 118–9). In his psychology, Kant's forms of intuition and concepts of the understanding were transformed into objects of empirical investigation (Lenoir 2006).

While they both aim to provide an empirical corrective to Kant, there are fundamental differences between Müller's and Herbart's accounts of concept formation. Like Müller, Herbart criticizes Kant for the "delusion" that concepts constitute a distinguished class amongst ideas (§180).[8] For Herbart, concepts in the strict logical sense are not actually achievable in human cognition, but may only be approached as an "ideal" ("Ideal," §78; §180). Consequently, whereas in logic we take concepts to be more fundamental than judgments ("Urtheil"), in psychology, judgments should be taken as more fundamental:

> [H]uman thought very often ... assumes the form of judgments. The combination of a subject and predicate lies at the foundation of nearly all forms of speech in the languages of civilized peoples. It must not be forgotten, however, that the logical demand that the subject and predicate shall be clearly defined concepts, is not complied with in actual usage. (§80*)

It is by means of such judgements that concepts are approached in thought.

In fact, Herbart vehemently denies the existence of a faculty of abstraction ("Abstractionvermögen") capable of separating the similar from the dissimilar aspects of ideas, arguing such a faculty is not only a "fantasy" but an "impossibility" ("Unmöglichkeit"). The reason is that, for Herbart, simple qualities themselves are indivisible, and once simple qualities have been blended into an idea, they cannot then be separated (§180). Nevertheless, Herbart agrees with Müller that concepts are distinguished from simple ideas in virtue of their abstraction, that the ability to produce such abstractions is the dividing line between animalistic and intelligent thought (§64), and that those ideas which approach concepts are

[7] I believe the most consistent interpretation of Müller treats this process of extracting commonalities to generate general constraints on thought as applying also to his understanding of Kant's forms of intuition, i.e. space and time. This contrasts with the reading of Lenoir (1993, p. 114), who interprets Müller as completely endorsing Kant's theory of space as a form of intuition ("Anschauungsform"). Müller does indeed claim that newborn animals have intuitions of spatial juxtaposition ("Anschauungen vom räumlichen Nebeneinander," 2:558/1387), and refers to an innate ability to perceive spatial forms by fundamental intuition ("Grundanschauungen," 2:362/1176) in his discussion of the Molyneux / Locke problem: will a person blind from birth, familiar with triangles and circles as sensed via touch, be able to distinguish triangles and circles via vision if suddenly granted the ability to see? Müller answers in the affirmative since "the senses of touch and sight are both based on the same fundamental intuition by which we are rendered conscious of the extension of our own organs in space" (2:362/1176*). However, Müller also places space and time on his list of fundamental concepts derived through the power of abstraction (2:520/1349). On my reading, what is innate is the effect of the spatial arrangement of nerves in the retina and nerves on the surface of the skin—in both cases, these convey spatiality to sensation. However, our abstract *knowledge* of spatial relations in the world depends crucially on the application of the power of abstraction across these two sensory modalities, hence the disagreement with Kant and the notion of space and time as derived concepts (c.f. the discussion of Law VIII below and Hatfield 1990, 155–6).

[8] I cite Herbart's *Lehrbuch* by section number. Wherever possible I follow the translation of Smith; amended translations are marked with an asterix.

somehow derived from their particular instantiations in simpler ideas. The question then arises to what extent their disagreement is merely terminological.

Herbart and Müller both use the evocative term "verdunkeln" (occluding, darkening, or obscuring) to characterize the effect of the concept formation process on the differences between simpler mental entities. They differ, however, on the details of this obfuscating mechanism.

> [C]ertain total impressions [*Gesammteindrucke*] of similar objects are presupposed as raw material from which general concepts are gradually constructed. These total impressions are, however, nothing but complexes in which the similar characteristics of the partial ideas have a preponderance over the different characteristics. Such excess becomes gradually stronger and more decisive. At first the repeated apprehensions of similar objects form a time series [*Zeitreihe*] ... the frequently recurring becomes a persistent, the idea of which now remains in a condition of involution. The inhibition [*Hemmung*] amongst the differing determinations[9] has thereby transformed into a permanent obscuration [*dauerende Verdunkelung*] of them, although they are not completely separated from the similar ones. (§180*)

Herbart's mechanism of concept formation, like Müller's, involves the interaction of simpler entities, the obscuring of their differences, and the persistence of their similarities. The simpler entities involved here are not mere perceptions or ideas, however, but sequences of such ("Reihe," or series). These series are not bound into single ideas, and so their similarities and differences are free to interact. For Herbart, ideas are like forces, which vie for a place in consciousness (§10–§12). Ideas which differ inhibit or resist ("Hemmung") each other (§14). Only by the fading of their differences, then, can this inhibition be mitigated, and multiple ideas become entangled together into a more general one.

The two views exhibit four points of apparent contrast: (i) status of the faculty of abstraction; (ii) the fundamental entities involved in concept formation; (iii) their arrangement in the mind; and (iv) the end products of concept formation. The first two points can be reduced to mere terminological differences; the latter two, however, constitute substantive disagreements. First, Herbart's rejection of an *Abstractionvermögen* is a rejection of a special faculty, since he rejects the positing of faculties in general (§58, §120; c.f. Hatfield 1990, 122). Emphasizing that concepts are formed through judgments is not for him an endorsement of a faculty of judgment, but rather an emphasis on the generality of the process. This is essentially the same point Müller makes when he emphasizes that his *Vermögen* of abstraction is not a "besonderes Vermögen," i.e. not a special power or faculty of the mind.

Herbart's claim that it is not simple ideas but series of total impressions which serve as the starting point for concept formation seems largely consistent with Müller's view. At least in the particular case Müller discusses of the concept of causality, it is "the returning combinations of two things, of which one requires the succession of the other" (2:519/1348) that form the basis for abstraction. So causality is derived from a complex structure with parts arranged in sequence much like Herbart's series. In general, Müller must not intend the starting point of concept formation to be ideas so simple as to have no component parts (e.g. bare color patches), as only if the ideas are rich enough to have multiple characteristics can some of these be the same and some different across multiple ideas. Something like

[9] *Bestimmungen*—I follow here the suggested translation of Ferreirós (1999). "Bestimmung" is a technical term for Herbart, referring to particular, or determinate, instantiations of a more general manifold of possibilities, for instance an instantiation of a particular color. We can empirically investigate the structure of the manifold of color by following a series ("Reihe") of these determinations, such as that from red, through orange, to yellow (§75, §190; Isaac 2013).

Herbart's total impressions, or combinations of such, then seems charitable as an interpretation of Müller's ideas.

However, the arrangement of ideas in the mind which induces concept formation appears to be different in the two theories. For Herbart, simultaneously presented ideas that differ inhibit each other, thus resulting in a state of (near) equilibrium, with both ideas obscured, and neither rising to the threshold of consciousness ("Schwelle des Bewusstseins": §13–§16). Perhaps to ensure consistency with this aspect of his view, ideas which approach concepts are formed from the sequential presentation of complexes of ideas. This *diachronic* theory of concept formation contrasts sharply with Müller's *synchronic* story, in which the simultaneous presence of multiple ideas in the mind is precisely what initiates the process of obscuration of their differences.

The final, and most striking divergence is the status of the ideas which result from these processes. Herbart insists that they are mere ideas, which only approach concepts as ideals, while Müller seems to countenance them as full-fledged concepts. The difference is revealed in their differing criticisms of Kant: for Müller, it is merely the *innateness* of concepts which is in error, while for Herbart, the status of concepts as mental objects *at all* constitutes a confusion. A related point here is just what each means by "verdunkeln": Herbart emphasizes that, although the differences between complexes are obscured permanently, nevertheless they remain attached to the similarities that constitute the more general idea, implying that obscuration is never complete. Müller, in endorsing the view that the results of this process are true concepts, and furthermore that they have the power to constrain thought, seems to endorse a more thorough notion of obscuration. If features previously obscured during concept formation continued to play any functional role, it seems that should impede the application of concepts to new ideas that contrast with them, yet this would undermine the constraining power of concepts on thought.

Despite these differences, Müller and Herbart reach essentially the same epistemological conclusion: knowledge of the world is possible through concepts that, though distilled through distinctively human abilities (whether abstraction or judgment), nevertheless are determined structurally by the world and thus correspond to it. Müller's understanding of this process and his epistemological commitments will turn out to be essential for understanding his realist interpretation of the Doctrine of Specific Nerve Energies.

3 The Doctrine and its Defense

Müller's statement of the Doctrine of Specific Nerve Energies in the first section of Book V of the *Handbuch*, "On the Senses," is divided into ten "Grundsätze": fundamental principles or laws. These laws fall into three basic categories: (i) inductive generalizations (I–IV, VI, VII); (ii) theoretical conclusions (V, VIII); and (iii) conjectures (IX, X). Each law is defended with an argument. Inductive generalizations are supported by experimental results, while theoretical conclusions about the nature of perception are derived by combining these generalizations with substantive methodological presuppositions. The conjectures are effectively "just so" stories that bridge the gap between the counterintuitive conclusions of Laws I–VIII and familiar perceptual phenomena. Below, I examine the laws using this taxonomy. The goal is to uncover the presuppositions that motivate Müller's central conclusion: *we only perceive directly the activity of our nerves; nevertheless, we can have knowledge of the world.*

3.1 Inductive Generalizations

The six inductive generalizations are susceptible to two forms of criticism: the experiments themselves may be questioned, or the manner in which they are interpreted and summarized. I will focus on the latter problem.[10] While Müller does employ some contentious assumptions in his interpretation of the data, I argue that these do not substantively affect the conclusions of the Doctrine.

> I. [E]xternal agencies can give rise to no kind of sensation which cannot also be produced by internal causes, exciting changes in the condition of our nerves. (2:250/1059)

> II. The same internal cause excites in the different senses different sensations;—in each case the sensations peculiar to it. (2:251/1061)

By "internal" here, Müller means causes inside the boundary of the body. For instance, we may feel sensations of heat, pain, or cold within the belly, demonstrating that sensations of touch can be produced by internal causes. He counts flashes and sensations of color when the eyes are closed amongst such cases, as well as ringing in the ears and spontaneous sensations of smell.[11] In defense of Law II, Müller gives the example of "the accumulation of blood in the capillary vessels of the nerve," i.e. inflammation, which excites in the retina flashes of light, in the ear ringing and humming, and so on for the other senses, as well as the example of the introduction of narcotics into the blood, which, from a single cause, excites sparks before the eyes, ringing in the ears, etc.[12]

> III. The same external cause also gives rise to different sensations in each sense, according to the special endowments of its nerve. (2:251/1061)

> IV. The peculiar sensations of each nerve of sense can be excited by several distinct causes internal and external. (2:253/1064)

Together Laws III and IV describe a "double dissociation" between external cause and sensory effect, i.e. the same cause can produce different effects, while different causes can produce the same (type of) effect. Under III, Müller discusses three types of external cause: mechanical, electrical, and chemical. Mechanically, pressing on the eye produces sensations of color, while hitting the ear produces a ringing sensation. Electricity is an important example for Müller as it can stimulate all five of the senses differentially, and he discusses sensations induced by both Voltaic piles and electrostatic devices. Chemical agents (e.g. acids or alkalis) can induce tastes when applied to the tongue, smells when applied to the nose, and sensations of burning, pain, and heat in the body-wide organ of touch. Müller notes the effects of direct contact with the eyes and ears cannot safely be studied, but includes chemical substances introduced into the blood (e.g. narcotics) as a related case. Under Law IV, Müller relists experiments already mentioned, only this time reorganized by stimulated organ / type of sensation, rather than by cause.

[10] There is also room for criticisms of the former sort. Woodward (1975), for instance, argues that Müller was unduly precipitous in his rejection of Magendie's experimental data, e.g. on whether nerves of multiple sensory modalities can induce sensations of pain, attributing this rejection to Müller's pre-theoretical commitments. In my view, the experiments at issue constitute a small enough portion of Müller's overall evidence that they do not, as Woodward claims, "falsify and refute the Müller doctrine" (147).

[11] cf. Müller's discussion of phantom pains in missing limbs and sensations caused by brain stimulation in other parts of the *Handbuch*, including Law VII.

[12] Müller discusses the effects of narcotics on nerves more generally at 1:632–638/625–631, emphasizing in particular their different effects when introduced into the blood and when in direct contact with nerve fibers, 1:634–637/627–630.

The double dissociation between cause and sensation is the empirical heart of the Doctrine of Specific Nerve Energies. How plausible is it as an interpretation of the data Müller presents? The direction from same cause to multiple sensations is much more secure than the direction from multiple causes to same type of sensation. This is because the individuation and categorization of cause types is relatively uncontroversial. If wires from a Voltaic pile are applied to one's eye, then those same wires are applied to one's ear, and in the first case one sees a flash and in the second hears a ringing, there seems little doubt that the *same cause* produced those distinct sensations.

However, the question of how to individuate and categorize sensations is more contentious—at issue here is how to identify sensations of the same type, and whether there is indeed a determinate type peculiar to or characteristic of ("eigenthümlich") each sense organ. For example, the taste sensation induced by an electric current is quite unusual. Arguably, it is not very like taste sensations produced in the standard chemical way, e.g. the taste of chocolate cake. Perhaps all that unites them is that the tongue was stimulated—what legitimates the move from the claim that electrical current generates this particular taste to the claim that tastes in general may be caused by different types of stimuli? It appears at first as if Müller's reliance on the traditional classification of the senses into five is absolutely critical for this argument. So long as we countenance the battery taste and the chocolate cake taste as both *tastes*, the two together show that *in principle* tastes may be caused by heterogeneous stimuli. However, the fact that the tongue is stimulated in both cases is not enough to demonstrate that these sensations fall into the same category, as a strict correspondence between sensation type and sensory organ is part of what Müller needs to show. In fact, some of Müller's examples here seem extremely questionable; he claims, for instance, that the ability to stimulate a feeling of nausea with a finger in the back of the throat demonstrates that taste sensations may be induced by mechanical causes. Yet it is not obvious that nausea should be classified within a single sensory modality, nor if it were, that that modality should be taste.

This is one of the criticisms of Bridges (1912):

> It seems introspectively untrue that adequate and inadequate stimuli produce sensations that are essentially the same in character. There is always a quality or feeling associated with sensations produced by the latter, by which they can clearly be distinguished from sensations produced by the former. We are never deceived in this respect; and it certainly rests with the advocates of the doctrine to explain why this is so. (61)

"Adequate" stimuli are just those which typically stimulate a sense organ. Bridges' claim is that the taste of the battery is not qualitatively similar to tastes induced by foodstuffs; the colors seen when pressing on the eye are not qualitatively similar to typical visual sensations; the ringing in the ears resulting from a blow to the head is not qualitatively like typical sound experiences; etc. If we can always identify the sensations caused by "inadequate" (atypical) stimuli, then they do not seem to fall into natural categories with sensations induced by typical stimuli.

This line of objection is important, and I address it in depth in Part II. To foreshadow the discussion there, note three points. First, Bridges' insistence that we are "never deceived" by atypical stimuli is not obviously correct. In some cases, at least, we are arguably confused by atypical stimuli: a ringing in the ears may be mistaken for an external humming or a chemical burn on the skin may be mistaken for a burn due to heat. Second, significant support for grouping sensations due to inadequate stimuli

with typical ones is found in our ability to make comparisons between the two, employing a single vocabulary. I can note that a sensation induced by pressure on my eyeball is "purple" showing some standard of comparison with purple sensations due to light. This *principle of comparability* (if sensations can be compared, they fall in the same modality) was already present in Herbart, and is the foundational assumption of psychophysical measurement.

Finally, Müller elsewhere states as a methodological principle that each nerve should be assumed to project to a single point in the brain, and correspondingly should be associated with a single effect. If this *unitary correspondence principle* is assumed, then the fact that the very same nerve can be excited by both an electrical current and chocolate cake is enough to group whatever sensations result together. The motivation for and legitimacy of this principle is discussed in Part II. Here, simply note that the argument from this principle is not circular in the way an appeal to sensory organs would be. The claim is not that the taste of chocolate cake and that of a battery should be grouped together because the same organ is stimulated, but rather because the exact same nerve is excited.

> VI. The nerve of each sense seems to be capable of one determinate kind of sensation only, and not of those proper to the other organs of sense; hence one nerve of sense cannot take the place and perform the function of the nerve of another sense. (2:258/1069)

Müller notes that sensations due to a particular sense organ may vary in their degree of intensity, as well as in their degree of pleasantness or discomfort, without the qualitative nature of the sensation being altered, i.e. "even in the most excited condition of an organ of sense, the sensation preserves its specific character" (2:258/1069). A challenge here is the question of pain. Müller's strict adherence to five modalities forces him to classify pain as a sensation of touch, and he thus spends some time refuting claims that nerves of other modalities can induce sensations of pain (cf. Footnote 10); his strategy is to point out that nerves of touch are typically present either in, or in close proximity to, all sense organs. Much of this discussion involves specific vivisection experiments where animal sensory nerves were laid bare and stimulated in various ways.

While Müller's defense of Law VI again appears to rely heavily on his adherence to a strict classification of senses into the traditional five, subsequent developments demonstrate this assumption to be irrelevant to the Doctrine's fundamental conclusions. In particular, Müller's grouping of sensory qualities by modality was quickly replaced by an individuation of sensory qualities *within* a modality, and an antribution of these to distinct nerve types (a reform associated with Helmholtz, but first proposed as early as 1844 by Natanson, Boring 1950, pp. 91–4). On this view, color vision involves three distinct nerve types, with their own corresponding primitive sensations; audition more than four thousand types of nerve cell, each with a distinct sensory quality (Helmholtz 1954 [1862], p. 147); and touch distinct nerves for qualities of pressure, pain, heat, and cold. The perseverance of the central methodological and epistemological conclusions of the Doctrine across this reformation demonstrates again that the critical assumption is really the unitary correspondence principle.

> VII. It is not known whether the essential cause of the peculiar "energy" of each nerve of sense is seated in the nerve itself, or in the parts of the brain and spinal cord with which it is connected; but it is certain that the central portions of the nerves included in the encephalon are susceptible of their peculiar sensations, independently of the more peripheral portion of

> the nervous cords which form the means of communication with the external organs of sense. (2:261/1072)

Law VII is essentially a statement of ignorance: we don't know if it is the nerve itself or its locus of projection in the brain that determines sensory quality. It is particularly interesting from a historical standpoint, as those who have interpreted the Doctrine of Specific Nerve Energies solely on the basis of its name have thought it to be in conflict with our contemporary information-processing view of the nervous system. On current views, it is not any particular quality in nerves themselves, but their wiring that determines their effects. Yet it is precisely this possibility which Müller entertains here: that it is the points of projection in the brain which determine sensory quality, not the nerves themselves.

In fact, *all* the evidence given under VII supports the possibility that it is the locus of projection in the brain, not the peripheral nerve fiber, which determines sensory quality. Müller discusses instances where brain stimulation has produced sensory experience and an example of a patient who experienced phantom visions after his eye had been removed. He also references his earlier discussion of the general principles of the propagation of activity in sensory nerves (1:695/686*f*). A sequence of experimental results demonstrates that it is "a matter of indifference whether the stimulus be applied to . . . the nervous trunk; in the branches . . . ; or in the peripheral parts" (1:700/690). These considerations lead him inexorably to the conclusion that

> The primitive fibres of a nerve, whether long or short, would appear, therefore, to represent each but one point in the brain which makes us conscious of the same sensation at whatever part of its course the primitive fibre may have been irritated. The reason why the sensation appears to have its seat always in the skin, at whatever point of their length the nervous fibres are irritated, seems to be, that the sensations are ordinarily produced by an action on the skin, or on the cutaneous extremities of the fibres. (1:700/691)

So, stimulated location in the brain determines quality of sensation, and this quality is attributed to the periphery merely as a matter of habit. This observation is then followed by a number of supporting case studies, including especially those involving the phenomenon of "phantom pain" in amputated limbs (1:705–707/694–696).

If all the evidence supports the conclusion that it is loci in the brain, not peripheral fibers, that determine sensory quality, why does Müller continue to entertain the possibility that some property, or "energy," of the nerves themselves contributes to sensory quality? The key reason is purely historical, and demonstrates Müller's crucial position on the path toward functionalism. Müller was writing in the 1830's, shortly after the widespread rejection of phrenology by the broader scientific community. Phrenology is a theory of functional localization within the brain, and as it was discredited, so also was the more general theory. Müller himself explicitly rejects the phrenologist Gall's localization of sexual drive in the cerebellum (1:851–2/833–4), and more generally emphasizes the empirical inadequacy of phrenological theories localizing the appetites (2:539/1369) or different activities of the mind (2:516–7/1345) in distinct brain regions. Localization as a creditable hypothesis only began to reestablish itself a quarter century after publication of the *Handbuch*, when Broca presented evidence in the 1860's showing a correlation between localized damage in the left frontal hemisphere and specific language deficits, followed by the work of Fritsch and Hitzig on motor centers in the brain. So, Müller's defense here of the *possibility* of functional localization in the brain demonstrates both courage and foresight (see Boring 1950, pp. 88–9).

3.2 Theoretical Conclusions

Laws V and VIII articulate the substantive theoretical conclusions of the Doctrine. These conclusions combine the skeptical claim that we are only directly aware of the activity of our sensory nerves with the realist one that we can nevertheless know facts about the world. On the traditional interpretation (e.g. Boring 1950, pp. 87–8) our access to facts about the world rests upon the statistical prominence of the adequate stimuli for each sense—our eyes are more likely to be stimulated by light than by pressure or electricity. I argue, however, that Müller actually defends a stronger conclusion, namely our sensations provide us with definitive structural information about the world, and it is of these structural relations that we can have knowledge. This argument depends on reading Müller's defense of Law VIII in light of his general theory of epistemology.

> V. Sensation consists in the transmission to consciousness [*Bewustsein*], not of a quality or condition of an external body, but of a quality or condition of the sensory nerve, triggered by an external cause, and these qualities are different in different nerves in accordance with their particular energies. (2:254/1065*)

The most famous conclusion of the Doctrine is the claim that we are only directly aware (or conscious, "Bewustsein") of the conditions of our sensory nerves. Laws I–IV establish the double dissociation between cause and sensation and the equivalence of internal and external causes for inducing sensations. Law V goes beyond these causal claims to draw a skeptical conclusion about the information actually received by experience: we do not experience external bodies, but rather qualities of our nerves. The nature of these qualities is determined by the particular sense energy of the nerve involved. This follows from the fact that the same stimulus applied to different sensory organs does not induce the same sensory quality; since the vibration of a tuning fork induces a tickle, but no sound, when applied to the skin, "something besides the vibrations must consequently be necessary for the production of the sensation of sound, and that something is possessed by the auditory nerve alone" (2:256/1066).

Müller characterizes Law V as a rejection of the thesis that perception depends upon a "specific irritability" ("specifischen Reizbarkeit") of sensory nerves, i.e. the property of only being excited by a particular quality in the world. As the double dissociation between cause and sensation shows, the activation of a sensory nerve is not restricted to a unique, "adequate" stimulus. Nevertheless, Müller acknowledges that senses are *typically* excited by a particular type of stimulus, and that this is a fact relevant for understanding the physiology of sensation. Müller characterizes the relationship between sensory organs and their typical stimuli as one of *homogeneity* ("homogen," 2:255/1065*). The full import of this notion of "homogeneity" is only revealed in Müller's discussion of Law VIII. Before turning to that Law, and Müller's rejection of skepticism, we should examine the crucial methodological claim Müller makes in the defense of Law V, a claim about the appropriate evidential foundations for a theory of perception.

Criticisms of the Doctrine such as those of Bridges and Gibson can be understood as arguments about which data are fundamental for the psychology of perception. For Gibson (and the gestalt psychologists), organized patterns are to be taken as more fundamental than the individual sensory point-particulars studied by Helmholtz and the early psychophysicists. These patterns supposedly convey information about external objects, and have no corollaries in the artificially induced sensations studied by Müller and his disciples. Bridges offers a variety of evolutionary and functional considerations in favor of the

claim that only sensations induced by adequate stimuli constitute fundamental data for the study of perception. Neither Bridges nor Gibson denies the phenomena Mülller identifies in the first four Laws, nor that they demand some kind of explanation; they deny that these phenomena constitute the starting point from which to construct a theory of perception.

In his defense of Law V, Müller makes clear where he differs. In particular, he insists on the primacy of phenomena originally recognized as *merely* "subjective," and thus irrelevant to a theory of perception. These "subjective" phenomena are sensations generated by inadequate stimuli, or by adequate proximal stimuli which do not reflect invariants in the distal stimuli, and for Müller they form the fundamental data for both physiology and psychology of perception. In particular, the need for specific sense energies rather than specific irritability:

> ...has been rendered more and more evident in recent times by the investigation of the so-called "subjective" phenomena of the senses by Elliot, Darwin, Ritter, Goethe, Purkinje, and Hjort. Those phenomena of the senses, namely, are now styled "subjective," which are produced, not by the usual stimulus homogeneous with the particular nerve of sense, but by others which do not usually act upon it. These important phenomena were long spoken of as "illusions of the senses" [*Sinnestäuschungen*] and have been disregarded in an erroneous point of view; while they are really true actions of the senses [*Sinneswahrheiten*], and must be studied as fundamental phenomena [*Grundphänomene*] in the analysis of the senses. (2:255/1065*)

In Laws I–IV, Müller provides evidence for the double dissociation of sensation from cause in terms of the *outcomes* of experiments. Here, however, he emphasizes the figures whose astute observations of phenomena served as the *starting point* for experimentation and theoretical progress in the study of sensation. For example, R. W. Darwin (1786) begins from a careful description and classification of afterimages, that then motivates substantive theses about the physiology of the retina. This theoretical progress is only possible on the interpretation that "the retina is in an active not a passive state during the existence of these ocular spectra [afterimages]; and it is thence to be concluded, that all vision is owing to the activity of this organ" (314). The power of this explanatory assumption is demonstrated through the numerous analogies with well-known phenomena in other sensory modalities Darwin makes throughout his monograph; for instance the change in sensibility induced by staring at a fixed stimulus (e.g. a square of white paper on a black background) is compared to temperature adaptation, our inability to hear faint sounds immediately after exposure to loud ones, and even the tendency toward indigestion in those who have habituated their digestive organs to strong liquor (319–320). "Subjective" phenomena here provide the motivation and justification for substantive theoretical development.[13]

It is a matter of historical record that the "subjective" data Müller cites have been instrumental in the development of our understanding of the *physiology* of sensation. Gibson and Bridges might, however, grant this point while nevertheless insisting that they are not relevant for grounding the *psychology*

[13] J. W. Ritter reported his sensations upon stimulating all five sensory organs with electricity from a Voltaic pile in the early 19th century. Goethe's (1810) monograph on color, though theoretically misguided, collected an enormous number of careful phenomenological observations of color spreading, afterimages, and adaptation and contrast effects. Purkinje (1825) noted that colors in the blue-green range are relatively darker than those in the red-yellow range in bright daylight, but this relationship is reversed, and blue-green colors appear relatively brighter, at dusk. This careful observation was instrumental in driving research on dark-adaptation, scotopic vision, and the spectral sensitivity of rod cells; the "Purkinje Shift" continues to be cited in contemporary textbooks on both vision in particular and sensation in general.

or *epistemology* of sensation. I take it this issue turns on the question of whether the methods of psychology presuppose that "subjective" phenomena have the same evidential status as phenomena due to adequate stimuli. If they do, then Müller's assertion that they constitute fundamental data for the study of sensation in general would seem to be correct, and consequently any naturalistic epistemology of sensation would need to accept them as fundamental as well. Part II defends this position.

Müller concludes his defense of Law V with a reiteration of his skeptical conclusion that foreshadows the positive account of sensory knowledge in Law VIII:

> [T]he sensory nerves are not mere conductors of the properties of bodies to our sensorium, and . . . we are informed about objects outside of us only through the properties of our nerves and their susceptibility to be modified more or less strongly by outer objects. Even the tactile sensation of our hand does not in the first instance convey the surface state of the touched body to intuition [*Anschauung*], but merely those spots of our body which are excited by the touching. Representation [*Vorstellung*] and judgment [*Urtheil*] turn the simple sensation into something completely different.... Here we can also see why sensory knowledge [*sinnliche Erkenntniss*] can never unlock for us the nature and essence of the sensible world [*sinnlichen Welt*]. We constantly sense ourselves in interaction with the sensible outer world, thereby creating representations of the configuration [*Beschaffenheit*] of outer objects, which may have a relative correctness [*relative Richtigkeit*], but which never bring the nature of the bodies themselves to that immediate intuition [*umittelbare Anschauung*] by which the states of our body parts reach the sensorium. (2:258/1069*)

Müller articulates here a theory of indirect perception on which representations formed by judgments correspond to (configurations of) bodies in the world, but the essential natures of those bodies are forever opaque, corresponding in no way to the simple sensations from which these representations are derived. Nevertheless, these representations may have a "relative correctness" and, as we know from Section 2, juxtapositions of similarly structured representations generate knowledge about the external world, a conclusion elaborated in Law VIII.

> VIII. Although the sensory nerves feel in the first instance only their own states, or the sensorium feels the states of the sensory nerves, inasmuch as the sensory nerves are material bodies, and therefore participate in the properties of matter generally, occupying space, being susceptible of vibratory motion, and capable of being changed chemically as well as by the action of heat and electricity, they indicate [*zeigen*] to the sensorium, by virtue of the changes thus produced in them by external causes, not merely their own states, but also properties [*Eigenschaften*] and changes of condition [*Veränderungen*] of the external world, in each sense via the particular quality or energy particular to it. (2:262/1073*)

Law VIII is the philosophical core of the Doctrine. Although the first clause reiterates the skeptical conclusion of Law V, the remainder characterizes the perceptual origins of our knowledge of the external world. There are two steps in this account: the relationship between sensory organs and the physical world; and the process by which external "properties and changes of condition" are successfully "indicated" despite our indirect access to them. This first step elaborates on the claim of "homogeneity" between sense organ and adequate stimulus; the second step, when viewed through the lens of Müller's

epistemology, resolves the apparent tension in the claim that the senses cannot directly access external properties, yet nevertheless convey changes in these properties with "relative correctness."

Our sensory organs are connected to the physical world insofar as they are made of matter and share properties with other matter. Here is where we can make sense of the notion of homogeneity Müller invokes in Law V. The structure of a sensory organ facilitates interactions with certain types of external cause in virtue of the manner in which it interacts with them physically, as a body with other bodies. Why does light stimulate the eye, but sound stimulate the ear? The eye is structured to focus and respond to light; there is a chain of interactions from light source, through intervening medium, to surface, again through intervening medium, through lens of eye, through medium of the vitreous humor, to receptors at the retina. This chain of interactions is *causally homogeneous*: each stage involves the same type of causal process, the transmission of light. Likewise, the ear is structured to amplify and respond to vibrations in the air, and there is a chain of interactions from initial vibratory source, reflections off surfaces, through an intervening medium, until the vibrations impinge on the ear drum, and are transferred via the ossicles to receptors in the cochlea. This chain of interactions is also causally homogeneous, each interaction being of the same causal type, yet the causal type involved is not the same as that manifest in the chain of causal interactions which typically passes through the eye.

If this analysis of Müller's view is correct, it takes us halfway toward a form of perceptual realism. For the skeptical results of the first five Laws are a consequence of a feature of all nerves (motor as well as sensory): they may be excited in a variety of ways, but once they are excited they always produce the same result. However, our typical sensory experience is mediated by our sensory organs, and these organs, being causally homogeneous with aspects of the material world, are suited to convey to us veridical features of that world. Nevertheless, the type of sensory experience associated with a sensory modality cannot directly convey the type of external cause which induced it, so we cannot obtain knowledge about properties in the world by considering the qualitative character of our sensations. What aspect of sensation then is suited to convey knowledge about the world?

Here is where Müller's epistemology explains a puzzling feature of his defense of Law VIII. After listing those features of material bodies to which sensory organs are susceptible (occupying space, influence by vibratory motion, chemical change), Müller proceeds to show for each one of these material interactions how it may affect multiple sensory organs. Notice that on the traditional reading of Müller's realism, this makes no sense: if our knowledge of the world follows from the statistical prominence of the adequate stimuli in interacting with our sense organs, then Müller should present an argument that it really is, say, light which stimulates our eyes more frequently than pressure, electricity, etc. Instead, however, Müller takes care to demonstrate for each type of physical interaction he lists that *multiple* sensory modalities are affected by it, and takes this demonstration to constitute evidence that "extension, progressive and tremulous motion, and chemical change" are "properties which may be completely determined from the outside" (2:262/1073*).

This strategy makes perfect sense in light of Müller's epistemology, however. If knowledge resides in abstractions from similarities across multiple ideas, then showing there are similarities in patterns of sensation across multiple sensory modalities supports the conclusion that these similarities themselves constitute knowledge. In the case of extension, for instance,

> Although the senses of vision, touch, and taste are all capable of sensing the property of extension in space, yet the quality of the sensations which give the sensation of extension is

> different in each of these senses; the sensation in one is an image of which the essential quality is light; in another, a perception of extension with any of the modifications of the quality of touch, between pain, cold, heat, and pleasure; in the third, a perception of extension with the quality of taste. (2:263/1074*)

Extension, comprising spatial relations between qualities, is a structural property, which may be veridically detected through the activation of different sensory qualities across different organs of sense. As such, it does not matter for our knowledge of the world that our primitive sensory experiences only convey information about states of our nerves. For in interactions between these primitive sensory qualities, a structural whole emerges that is independent of the nature of those qualities themselves. Patterns of color and patterns of pressure may both convey that very same property of the world, extension.

Müller employs this same strategy to argue for our ability to veridically detect motion and chemical change. Vibratory motion is detected most obviously by audition and touch, though Müller also discusses the detection of vibrations through vision. Chemical changes are detected by taste, smell, and touch. Müller always leaves open the possibility that these properties may be detected by other senses. In fact, it is this very feature that ensures they are not mere artifacts of our perceptual system, but true properties of the world. For if extension, vibratory motion, and chemical change are actual properties of the world, then we *should* be able to detect them with multiple sensory organs: this is the positive content of the double dissociation between sensation and external cause—since our sensory organs can interact with heterogeneous causes in the world, they can detect invariant patterns in the world that are independent of the particular chain of causal influence leading to that organ.

The properties discussed by Müller here appear to roughly follow the traditional primary / secondary quality distinction. Color, taste, odor, etc. are typically identified as secondary qualities, our experience of which differs qualitatively from their instantiation in the world, whereas motion and extension are typical primary qualities, true qualities of the world veridically perceived by us as they are (and, on early modern accounts, themselves causally responsible somehow for our experience of secondary qualities). Yet Müller's motivation for this distinction is radically different from that of Descartes, Galileo, Boyle, or Locke. It is not the conceptual clarity of our understanding of the nature of extension, nor the legitimacy for or explanatory role of extension in science which gives it its privileged status. Rather, the distinctive feature of extension is just that it can be sensed in multiple sensory modalities. From this perspective, Müller's distinction is much closer to that between the special and common sensible qualities in Aristotle. For Aristotle, there is a distinctive set of special sensible qualities associated with each of the five sensory modalities (colors for vision; odors for olfaction; etc.). Properties such as movement, size, and number are distinguished from these in that they can be detected across any sensory modality.

These considerations shed light on Müller's handling of the Molyneux / Locke problem: would a person blind from birth, familiar with triangles and circles as sensed via touch, be able to distinguish triangles and circles via vision if suddenly granted the ability to see? Müller finds it "difficult to comprehend" how Molyneux and Locke might have answered this question in the negative (2:362/1176*). Yet this is not because he considers our concept of spatiality innate, as discussed in Footnote 7. Rather, spatiality is commonly sensed across different sensory modalities. The process of abstracting triangular and circular shape concepts from tactile experience is just the process of obscuring the particular qualities of individual pressures from which they are derived. Thus, when triangles and circles are seen for the first time, there is no problem of re-identifying them without their tactile component. Rather these new impressions are

just instances of *the very same concepts*, and having already been formed, these spatial concepts now *bind* the understanding and perception of their visual instances (cf. 2:271/1082).

Finally, this reading of Müller's realism, on which structural relations between external properties may be sensed, even as the natures of primitive physical properties are forever hidden from us, reveals a deep continuity with his arch-critic Gibson. Gibson's alternative to the focus on particular point sensations he saw in Müller and Helmholtz was to emphasize the informational role of dynamic patterns in the stimulus, such as the "optic flow" one experiences while moving through an environment (1986, 121–5). Yet Müller seems to presage this exact idea in suggestive passages such as this:

> [W]ith every movement of our body, with every step forwards, the forms of the images [on our retina] undergo a change, the remote become near, and the near objects present other surfaces to our view. This change in the images depicted on our retina during the locomotion of our body, must convey to the mind the idea of our moving in space between the different images,—of our advancing through the midst of them; for, during this locomotion, the image of our own body in the field of vision becomes constantly associated with new images of external objects, and the locomotion is the cause of this displacement of the images. (2:272/1084)

Like Gibson, Müller recognizes the importance of *change*, systematic relations between successive states of a sense organ, for conveying information about the world. Their true locus of disagreement, then, is only on the methodological question whether these patterns of change themselves *or* the primitive qualities they comprise constitute the foundational evidence for a science of perception. These points of agreement and debate are pursued further in Part II.

3.3 Conjectures

The last two laws of Müller's Doctrine address familiar features of perceptual experience at *prime facie* odds with the fundamental conclusions of Laws V and VIII. Unlike previous laws, however, the justification provided appeals neither to empirical results nor methodological principles; rather, Müller constructs "just so" stories to demonstrate how these familiar features might be recovered despite his previous conclusions.

> IX. That sensations are referred from their proper seat towards the exterior, is owing, not to anything in the nature of the nerves themselves, but to the accompanying idea derived from experience. (2:268/1080)

The most serious phenomenological challenge to the Doctrine is our attribution of sensed properties to an objective external world. Redness does not appear intuitively to be a property of my eyes, but rather of the surfaces of distant objects; how does this appearance arise if we only directly perceive states of our nerves? Müller focuses here on spatiality, and constructs a narrative on which the "percipient conscious subject" gradually comes to attribute properties it experiences to the "external world" with which it is "brought into collision." This process begins in the womb, as the child experiences resistance to its motions, and comes to categorize these forms of resistance as of two types: those originating with itself, as when one hand touches another; and those which originate outside itself, as when its hand touches the wall of the womb. These interactions inspire two notions of externality from the self, first the body external to the self, whose movements are nevertheless controllable, next the world external to the

body, distinguished by its being uncontrollable. Müller acknowledges at the outset, however, that it is "impossible" to have "a full recollection of the first impressions made upon [our senses] independently of the ideas obtained through their means." Thus, his theory of the process by which we come to externalize our sensations is not an empirical result, but a conceptual analysis of "the act of sensation" (2:268/1080).

It is difficult to interpret Law IX as anything other than mere conjecture, but one might worry that conjecture here is not enough, that our attribution of sensed properties to distal objects is of fundamental epistemic import, taking precedence over even the empirical arguments of the first eight laws (see Part II for further discussion of this line of reasoning). Müller, however, seems to regard our attribution of properties to external objects as so easily defeasible that it does not warrant privileged consideration:

> If we lay our hand upon a table, we become conscious, on a little reflection, that we do not feel the table, but merely that part of our skin which the table touches; but, without this reflection, we confound the sensation of the part of the skin which has received the impression with the idea of the resistance, and we maintain boldly that we feel the table itself, which is not the case. (2:269–70/1081)

Whether or not we agree with Müller that our tendency to externalize sensed properties can so easily be disregarded "on a little reflection," it is clear from Müller's discussion that the conclusions of Laws V and VIII are not meant to stand or fall with the plausibility of his account of this externalization. Rather, we should assess the arguments for the fundamental conclusions of the Doctrine on their own evidential and methodological merits.

> X. The mind not only perceives the sensations and interprets them according to ideas previously obtained, but it has a direct influence on them, imparting to them intensity. This influence of the mind, in the case of the senses which have the power of distinguishing the property of extension in objects, may be confined to definite parts of the sentient organ; in the sense gifted with the power of distinguishing with delicacy intervals of time, it may be confined to particular acts of sensation. It also has the power of giving to one sense a predominant activity. (2:272/1084)

Müller ends the Doctrine with a catalog of examples of the effect of attention on sensory experience. Sometimes, although our senses are functioning, sensory experience is not communicated to consciousness (not noticed or remembered) because our attention is turned inward to some other idea. When one sense is absent, greater amounts of attention can be distributed amongst those which remain, as in a blind man's heightened ability to discriminate surface properties through touch. By focusing our attention on particular sounds, we may distinguish one instrument amongst many in an orchestra performance. Müller also considers phenomena of binocular rivalry to demonstrate shifts in attention, as when looking at a white surface through differently colored, blue and yellow, spectacles produces alternating experiences of blue spots upon a yellow field and yellow spots upon a blue field (2:274/1086).

However, to say that they are instances of attention does not actually explain any of these examples. Nor are the examples themselves, with the exception of binocular rivalry, recondite discoveries of the lab, but merely sensitively described everyday phenomena. Unlike the inductive generalizations, this is not a systematization of experimental results, but a set of conjectures in need of empirical investigation. While thought-provoking, these conjectures do not themselves play any significant evidentiary role in establishing the substantive conclusions of the Doctrine.

4 Conclusion: Müller's Structural Realism

Müller's Doctrine of Specific Nerve Energies asserts that we perceive in the first instance the states of our nerves, that we cannot know the primitive properties of the world, but that we can veridically conceptualize relations that hold *between* properties in the world, namely higher-order features such as spatial extension, motion, and chemical change. In contemporary parlance, this is a form of *epistemic structural realism*: all we can know about the world is its structure.

Structural realism is not at present a common view in the epistemology of perception,[14] but it has wide-ranging support in philosophy of science. Müller himself is committed to structural realism as a general epistemological position, subsuming the knowledge claims of both perception and science, in part due to his Herbartian theory of concept formation through abstraction. However, his argument to the skeptical conclusion of the Doctrine, that we perceive in the first instance the activity of our nerves, rests only on a combination of empirical results and three methodological principles: the unitary correspondence principle, the principle of comparability, and the principle that subjective phenomena are foundational for the study of perception. If these methodological principles are endorsed by current perceptual science, then the arguments of the Doctrine remain valid, and any naturalistic philosophy of perception must accept its skeptical conclusion.

Part II pursues this line of thought and argues for the continued relevance of the Doctrine today. Müller's three methodological principles have indeed been validated and entrenched in the contemporary science of perception; consequently, naturalistic philosophers of perception must confront the Doctrine's skeptical challenge. I argue that the most promising response to this challenge is essentially Müller's own: epistemic structural realism. While contemporary philosophers and psychologists may not endorse Müller's theory of concept formation, they may still take inspiration from his vision of physiology, psychology, and philosophy as three intertwined endeavors, mutually advancing and supporting each other: a syncretic perspective that leads to structuralism. Müller's Doctrine also remains relevant for the history of philosophy of science, for his structuralism inspired that of Helmholtz, which in turn influenced the various structuralisms of Hertz, Cassirer, and Schlick, thereby shaping in part the project of the Vienna Circle. The question of the Doctrine's significance for contemporary philosophy of science is more murky, however, as it no longer recognizes the close analogy between the epistemological problems of science and perception that so moved Müller and his early followers.

Concluding Part I, I hope to have demonstrated that Müller's own understanding of the Doctrine of Specific Nerve Energies was considerably more subtle than that attributed to him by critics and supporters alike; that his arguments exemplify his commitment to a philosophical physiology, informing and informed by psychology; and that his epistemic structural realism is both intrinsically interesting, and of potential inspiration for contemporary philosophy.

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[14] Though it has been explicitly defended by Isaac (2014) and Patton (2014), and related views can be found in Hatfield (2007) and Akins and Hahn (2014), amongst others.

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