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HELMHOLTZ'S PHYSIOLOGICAL PSYCHOLOGY[1]

Lydia Patton

Hermann von Helmholtz (1821–1894) contributed two major works to the theory of sensation and perception in the nineteenth century. The first edition of *The Doctrine of the Sensations of Tone* was published in 1863, and the first edition of the *Handbook of Physiological Optics* was published in toto in 1867. These works established results both controversial and enduring: Helmholtz's analysis of mixed colors and of combination tones, his arguments against nativism, and his commitment to analyzing sensation and perception using the techniques of natural science, especially physiology and physics.

This study will focus on the *Physiological Optics* (hereafter *PO*), and on Helmholtz's account of sensation, perception, and representation via "physiological psychology". Helmholtz emphasized that external stimuli of sensations are causes, and sensations are their effects, and he had a practical and naturalist orientation toward the analysis of phenomenal experience.

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Helmholtz's epistemological methodology and his sign theory were part of his response to nineteenth-century nativism and direct realism. On his view, sensation must be interpreted to yield representation, and representation is geared toward objective representation (the central thesis of contemporary intentionalism). The interpretation of sensation is based on "facts" revealed in experiment, but extends to the analysis of the quantitative, causal relationships between stimuli and responses. A key question for Helmholtz's theory is the extent to which mental operations are to be ascribed a role in interpreting sensation and in the occurrence and quality of phenomenal experience.

1. Naturalizing the mind

Gary Hatfield distinguishes between "normative" accounts of the mental, on which reasoning, judging, perceiving, and the like are "subject to appraisal as true or false, right or wrong," and "natural" accounts, according to which mental activity should be investigated using the techniques of natural science, without normative presuppositions (1990, 1). Kant's a priori justification of the categories as objectively valid concepts, and of space and time as formal principles of intuition, is characteristic of the normative approach. Helmholtz's approach

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"naturalizes" Kant by using the methods of natural science to investigate mental activity. Helmholtz considers perceiving and representing, and the conscious and unconscious inferences employed in these, to be psychological and physiological operations amenable to empirical treatment.

Helmholtz uses several terms for what we would call the "mind" in the *Physiological Optics*: *Psyche* (or *psychisch*), *Seele*, and *Geist*. These terms sometimes are translated "soul" or "spirit", and for many German-speaking philosophers responding to the Aristotelian tradition and to natural philosophy, they denoted functions associated with the body (sensing, feeling, desiring) as well as those associated with the mind (judgment, reasoning).[2] Some in these traditions used the terms, and their equivalents in other languages (*âme* in French, *psyche* in Greek), to represent the animating principle of the material human body.

In his *Handbook of Human Physiology*, Helmholtz's mentor Johannes Müller defends the vitalist position, that the body must have an organizing force beyond the mechanical forces at work in processes like metabolism. Müller draws his inspiration from Kant, but marshals evidence from Ernst Stahl's and Georges Cuvier's naturalist studies.[3] On Müller's reading of Stahl, the "Seele" is a "rational creative force," "the force of organization itself, expressing itself according to rational laws" (1844, 22). Müller distinguishes the *Seele* from the "unconsciously effective purposeful operation" of material forces and instinct (ibid., 23). The *Seele* is expressed in physical processes, but it is the source of the organization of physical processes toward a rational purpose.

Hermann Lotze's 1852 *Medical Psychology, or Physiology of the Mind*[4] locates the study of psychology in the examination of the *Seele*, which is the seat of psychological activity. However, Lotze argues that psychology has made the unscientific presupposition that there is a single, substantial "subject" that underlies all operations ascribed to the *Seele*, including observation, perception, feeling, and desire. But there is no introspective evidence for such a unified subject, Lotze urges, nor is there any scientific way as yet to prove its existence from empirical evidence.

Helmholtz calls the third part of his *Physiological Optics* the "psychological" part, but Helmholtz, in tune with Lotze and others, distinguished physiological psychology from pure or abstract psychology. Lotze's *Medical Psychology* is subtitled "physiology of the mind", and Wundt's *Outline of Physiological Psychology* (1874) connects the physiological to the psychological. Helmholtz engages in a "physiological psychology" in the "psychological" part of the *Physiological Optics*, and rules out more abstract psychological speculations:

> our purpose is only to investigate the matter of sensation, which occasions the formation of representations, in those connections which are important for the perceptions derived therefrom. This business can be carried out entirely according to the methods of natural science. In the process, we cannot avoid speaking of mental operations and their laws, insofar as they come into the consideration of sensible perception, but we will not

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> regard the investigation and description of these mental operations as a significant part of our work at hand, because in doing so we will hardly be able to remain on the ground of secure facts and a method grounded in general, recognized, and clear principles. So I believe it to be necessary, at least provisionally, to distinguish the domain of the psychological part of the physiology of sense from pure psychology, whose principal task is to establish the laws and nature of the operations of the mind.[5]

Helmholtz takes the study of psychological phenomena to be divided between the physiological study of the "mental operations" that act to bring about perception and the formation of representations and "pure psychology," the study of the "laws and nature" of the mind as it acts independently of perception and representation, sometimes resting on what Helmholtz sees as the scientifically immature analysis of introspective evidence.[6]

Helmholtz separates Lotze's question of whether there is a single, unified mind or *Seele*, along the lines of Kant's transcendental unity of apperception or Müller's rational organizing force, from the question of whether perception, representation, and intuition can be given an empirical treatment by investigating the "psychological part of the physiology of sense".[7]

2. Sensation, perception, and representation

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In the third, "psychological" part of the *Physiological Optics*, Helmholtz "attempted to provide explanations of a variety of the phenomena of spatial perception by bringing them under universal psychological laws; he also sought to extend his naturalistic account of the mind to the domain of 'higher' cognition" (Hatfield 1990, 167). Helmholtz "characterized the psychological processes underlying perception as unconscious inferences, and he emphasized the role of active experience in the formation and testing of such inferences" (ibid.) As de Kock puts it, "Helmholtz's empirical approach starts out with the basic assumption that the perceptual process is crucially mediated by psychological activity" (de Kock 2014, 106).

The naturalist approach Helmholtz takes raises the question: what, on his view, is the difference between perception, a mental operation, and sensation, a physical response? Helmholtz's approach begins with the observation that sensation presents us with indeterminate information. Bare or uninterpreted sensation consists of a set of electrical impulses sent along nerve fibers, which do not in themselves constitute determinate perceptions or representations. Sensation alone, as response to a stimulus, never adds up to perception or representation of an object. Sensation presents us with:

1 A stimulation of a nerve, which is like an "insulated telegraph wire."[8] Nerve fibers, for Helmholtz, carry signals independently of any other nerves, and carry those signals to the brain if they are associated with sensory nerves. Thus, importantly, each nerve or nerve fiber carries only information about

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the degree of stimulation of *that* nerve, and no information about other responses to stimuli in the nervous system.

2 A set of "accessory impressions". "For Lotze, and for Helmholtz, each sensory impression of color on the retina – red, for example – produces the same sensation [associated with] redness on all parts of the retina **a**, **b**, **c**, . . . But in addition to this impression at the parts **a**, **b**, **c**, . . . the light source also makes an accessory impression, . . . **α**, **β**, **γ**, independent of the color seen and dependent entirely on the place excited" (Lenoir 1993, 122).

Visual representations, perceptions, and intuitions are "derived from", "associated with", or "tied to" sensation. Helmholtz remarks,

> If we restrict the name of *representation* [*Vorstellung*] to the remembered image of visual objects that is not derived from any present sensations, that of *intuition* [*Anschauung*] to the perception$_W$ [*Wahrnehmung*] derived from the respective sensations, that of *perception$_P$* [*Perception*] to such an intuition in which nothing is contained that does not arise from the immediate present sensations, thus an intuition as it can be formed even without all memory of earlier experiences, then it is clear, first, that one and the same intuition can be derived in very different ways from the corresponding sensations, and that, therefore, representation and *perception$_P$* can be associated with intuition through quite diverse relationships. (*PO* 26:435)[9]

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An initial taxonomy, based on this passage:

Representation [*Vorstellung*]: "the remembered image of visual objects that is not derived from any present sensations".

Intuition [*Anschauung*]: "the perception$_W$ derived from the respective sensations".

Perception$_W$ [*Wahrnehmung*]: a kind of intuition and representation (see as follows) derived from sensation.

Perception$_p$ [*Perception*]: "an intuition in which nothing is contained that does not arise from the immediate present sensations".

Helmholtz uses the Latin term 'Perception' and the German term 'Wahrnehmung', both usually translated by "perception". I distinguish between them with subscripts. Intuitions are perceptions$_W$, while perceptions$_p$ are special cases of intuitions and of perceptions$_W$. Perception$_W$ is the most general type of mental activity Helmholtz describes. In turn, perception$_W$ is a form of representation, insofar as it is perception of an external object:

> We use the sensations that light stimulates in our apparatus of sensory nerves, to form for ourselves representations from [the sensations]

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> concerning the existence, the form, and the location of external objects. We call such representations *visual perceptions [Gesichtswahrnehmungen]*. [. . .] Since perceptions$_W$ of external objects thus belong to the representations, and representations always are acts of our mental operation,[10] perceptions$_W$ can come about only in virtue of mental operation, and thus the doctrine of perceptions$_W$ in fact already belongs to the domain of psychology.
>
> (*PO* 26:427)

All of the terms in the above taxonomy refer to mental activity. Perceptions$_W$ are already a form of representation, and this requires mental activity. In the remarks at the beginning of the "psychological" section 26, Helmholtz says:

> Thus, in the forthcoming section we have to investigate to which characteristics of retinal images, of muscular feelings, and so forth are tied the perception$_W$ of a specific position of the object seen with respect to direction and distance, on which particular features of the images depends the perception$_W$ of a corporeal form of an object extended in three directions, under which circumstances it [*the object*] appears single or double when seen with both eyes, and so forth. Thus, essentially, our purpose is only to investigate the matter of sensation,[11] which occasions the formation of representations, in those connections which are important for the perceptions$_W$ derived therefrom. This business can be carried out entirely according to the methods of natural science.
>
> (*PO* 26:427)

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Determining the distance of an object from the subject, the position of the object, and so on requires inference from the signs[12] on the retina, and that inference requires experience and memory. Even the initial perception$_p$ of external objects must incorporate inferences from experience if the objects are to be perceived in their proper spatial relationships to the subject.

3. The physiology of sensation

Helmholtz adapted his characteristic physiological stance on sensation from Johannes Müller. Müller objected to the "copy" theory of sensation, which has it that sensations are copies or direct impressions of their objects. In the work of Johann Georg Steinbuch and Caspar Theobald Tourtual, the copy theory was allied with an epistemological position, spatial realism, according to which sensations and perceptions of objects are immediate evidence for the properties of those objects.[13] Mid-nineteenth century debates over stereoscopic vision and binocular rivalry inform Müller's and Helmholtz's accounts on this score. Müller and Helmholtz cite results found using the novel stereoscopes created by Charles Wheatstone, David Brewster, and James Elliot[14] (Figures 5.1 and 5.2).

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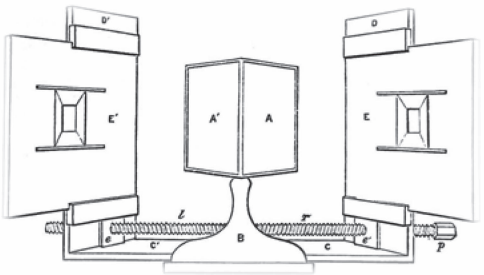

Figure 5. 1 Wheatstone's stereoscope.

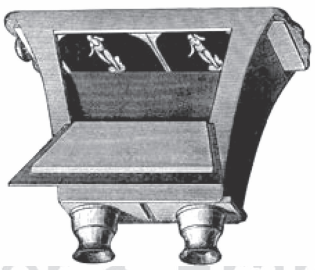

Figure 5.2 Brewster's stereoscope.

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A stereoscope separates the visual field of each eye, and presents each eye with a separate picture, which the brain then fuses into a single image only if the pictures are kept at the right distance and angle of sight. If not, the viewer comes to be aware that each eye is presented with a separate image. As Helmholtz observes,

> Very frequently, people who first are made aware of binocular double vision are amazed, usually because they would not have noticed otherwise even though at each moment, as their lives go on, they have seen singly only a small number of objects that lie more or less the same distance from the eye at about the same focal point, and [they have seen] the larger majority, namely the group of farther and nearer objects, double.
> (*PO* 26:432)

Wheatstone investigated cases in which the visual appearance of depth (of three-dimensional figures) was apparent when two separate pictures were synthesized by the brain into a single visual image. But when a viewer looking through the stereoscope shuts one eye, the visual appearance of depth vanishes. Moreover, as Helmholtz observes, the apparent position of objects in the picture can change depending on which eye one is viewing the picture with, and on the angle of the

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line of sight: this is known as stereoscopic parallax (*PO* 30:637–638). The stereoscope also made easier the investigation of the phenomenon of binocular rivalry, in which, when the two eyes are presented with distinct images, the two do not fuse into a single image, rather, they are perceived alternately.

The opthalmoscope allowed for the inspection of retinal images. It had been known at least since Descartes's dissection of a bull's eye in the *Optics* that images on the retina are upside down, even though we perceive them as upright. Helmholtz himself constructed opthalmoscopes in the 1850s, and could verify this for human eyes.

For Helmholtz, the facts demonstrated using these novel instruments are evidence against the projection or copy theory of perception.[15] Visual images are not copies of the stable properties of the external objects that are their stimuli. Rather, sensations, as reactions of sense organs to stimuli, are *effects*, and the stimuli should be regarded as *causes*.[16] Physiological sensations are not transparent to the properties of external objects; they must be interpreted to give evidence of objective properties.[17]

On Helmholtz's account of the physiology of sensation and perception, the physiological process of sensation alters or transforms the stimulus, so that we cannot make a direct inference from properties of the effect (the sensation) to properties of the cause (the external stimulus). For Lotze, a principal source of this argument, sensation is

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> a complicated chain of events consisting of several stages: external stimulus [. . .]; the effect of the stimulus on the nerves; the transmission of the nerve signals to the brain; the transmission of signals from the brain to the soul [*Seele*]; and finally the sensation as an object of self-awareness [. . .] the quality of the stimulus is transformed throughout this process, so that in the end there is no similarity between cause and effect. We therefore cannot conceive of sensations as a kind of copy or image of the objects that cause them.
>
> (Beiser 2013, 225)

Helmholtz concurs:

> Our intuitions and representations are effects, which the intuited and represented objects have brought about on our nervous system and on our consciousness. [. . .] To demand a representation that copied the nature of the represented, thus was true in an absolute sense, would be to demand an effect that was entirely independent of the nature of that object on which the effect was brought about, which would be a palpable contradiction. Thus all our human representations [. . .] are depictions[18] of objects whose kind essentially co-depends on the nature of the representing consciousness and is co-determined by its characteristics.
>
> (*PO* 26, 442–443)

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Intuitions and representations are brought about in a necessarily two-sided relationship between the causes (the intuited and represented objects) and the effects (the intuitions and representations). To understand intuition and representation requires investigating the "nature of that object on which the effect was brought about," that is, the nature and characteristics of the sensorium and the "representing consciousness."

Müller had argued that the possibility of giving a scientific account of physiological sensation required distinguishing the sensations specific to each type of sensory nerve: haptic, visual (optic), auditory, gustatory, and olfactory. He associated each kind of nerve with a distinctive type of response to stimuli, a principle called the "Law of specific nerve energies" (LoSNE) or "Müller's law".[19] In the *Physiological Optics*, Helmholtz restates Müller's law of specific nerve energies:

> Physiological experience has found, as far as testing is possible, that *through stimulation of each single sensory nerve fiber only those sensations can arise that belong to the quality sphere*[20] *of each single specific sense, and that each stimulus that is capable in general of stimulating these nerve fibers generates only sensations in these specific spheres*.
>
> (*PO* 17:193)

Helmholtz's reading of Müller's law leads to the following claim:

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> the quality of sensible experience depends primarily on the specific constitution of the nerve apparatus, only secondarily on the constitution of the perceived object. Which sense's quality sphere an occurrent sensation belongs to does not depend on external objects, but exclusively on the type of nerve struck. Which particular sensation from the encountered quality sphere will be generated, this, above all, depends on the nature of the external object that stimulates the sensation.
>
> (*PO* 17:194)

For Helmholtz, it is possible to identify which features of a sensation are objective by inquiring into the specific observed quality of the sensation.[21] The ability to identify a particular sensed quality as occupying a specific, limited position within the quality sphere of a nerve requires a causal inference. Such inferences take the following form:

1. The nerve at issue has a quality sphere, the range of which can be investigated.
2. Nerves are not stimulated for no reason; the properties of external objects or events are, *ceteris paribus*, the sources of our sensations.[22]
3. A specific observed quality of a sensation is thus a *limitation* of the quality sphere of possible sensations of a particular nerve.
4. Any such qualitative limitation must have a ground or cause.
5. The cause of the qualitative limitation is a particular external object or event.

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Thus, the specific qualities of our sensations can serve as evidence for the properties of the causes of those sensations, the external objects or events.
The particular qualities of sensations are the basis for a set of abductive inferences to the properties of external objects and events. While Helmholtz agrees with the Kantian distinction between the phenomenal and the real, he also argues that there are well-grounded inferences from sensations to their external sources.[23] Helmholtz has a long-standing commitment to the view that any perception of an external object requires representation, which at the least requires positing an object as the cause of the perception.[24]

For Helmholtz, the law of causality is an a priori, transcendental presupposition necessary to natural science in general and to the assertion that our sensations are
AuQ10 effects of objective causes in particular.[25] We cannot prove any correspondence between our sensations and their stimuli, with one exception: "The only respect in which an actual agreement[26] can obtain between our perceptions and actuality is the temporal sequence of events" (*PO* 26:445). Any causal connection in nature will be reflected by a regular sequence of sensations, as signs that indicate the regularities in the phenomena:

> Each law of nature states that on preconditions that are similar in certain respects consequences that are similar in certain other respects always occur. Since similars in our sensible world are indicated by similar signs, the nomological sequence of similar effects following similar causes corresponds to an equally regular sequence in the realm of our sensations.
>
> (Helmholtz 1878, 13)

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Sensations, as signs of their stimuli, may have no "agreement" with those stimuli other than the time sequences of their occurrence.[27] The regularities in what Helmholtz calls the "sign system" of perceptions of, and inferences from, those sensations are indications of causal regularities. Mental activity is necessary to transform sensations into objective representations of the regularities among the sensations.

4. Unconscious inference and objectivity

Helmholtz argues that inferences from sensation to objective representation, in many cases, are inductive "unconscious inferences".[28] Descartes treated the body as a mechanism operating separately from the mind. But Leibniz left room for "petites perceptions," minute perceptions of which the primary monad need not be aware. Acknowledging that sensation, and features of perception and representation, take place physically means acknowledging the possibility that elements of these occur outside consciousness.

In the first half of the nineteenth century, physiologists had begun to argue that even representations and ideas could be unconscious. Herbart argued that some rep-
AuQ11 resentations could be "suppressed" from consciousness by other representations.[29]

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In an early essay, Lotze argued that the "perceptions of the [Leibnizian primary] monad [. . .] constitute the 'essence' or 'meaning' of the body, because they realize its implicit, inchoate and subconscious forces" (Beiser 2013, 146). In *Medical Psychology*, Lotze argues that even conscious thoughts, including voluntary acts of will, incorporate the physical actions of a substance that take place outside the arena of consciousness (§109, 125–126). On Helmholtz's account,

> The mental operations through which we come to the judgment that a particular object in a particular state in a particular place outside us is present, are in general not conscious operations, but unconscious. In their results, they are similar to an *inference*, insofar as we achieve from the observed effect on our senses the representation of a cause of this effect, whereas, in fact, we can only perceive directly the nerve stimulations, that is, the effects, never the external objects.
>
> (*PO* 26:430)

Unconscious inferences are judgments that external objects bearing certain properties are present and are the causes of our sensations. I will elaborate on Helmholtz's own example of cast shadows. From the perspective of an observer on the Earth's surface, the shadows cast by tall buildings grow longer as the sun sets. The general relationships established by inductive inferences from observation are the major premises for an inference: an oblong, long shadow on the sidewalk at dusk probably is cast by a tall building, for instance. If I see an oblong, long shadow on the sidewalk at dusk (the minor premise), I infer that the object casting the shadow is a building (the conclusion).

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That "conclusion" is not a conscious inference, but a feature of the formation of my image that takes place in response to longtime habit. I interpret the glimpse of the shadow-casting object in my perception of a building, and my perceptual image of the building includes inferential information that may depend on my experience and on my practice interpreting sensations. I may perceive an outcropping on the shadow as a window, because I have interpreted, tacitly, the shadow's source as a building. When the outcropping moves, I may perceive this as the window opening, because of another unconscious inference.

All these interpretations could be false, and my reading of the sensory indications – which affects the formation of the image – depends on contextual clues. Maybe I am walking along a sidewalk at dusk in a new city, and I don't realize that on the other side of the sidewalk is a river with a line of ships at harbor, not a line of buildings. The "building" casting the shadow could be a ship, and the moving "window" a sail. If I look closely at the "building" and realize that it is a ship, the sensory material of my perception rearranges itself into a distinct "intuitive image." As Helmholtz puts it,

> the remembered images from earlier experiences work together with present sensations to bring forth an intuitive image, which intrudes upon

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> our power of perception with compelling force, without what is given through memory and what is given through present perception being separated in consciousness. The influence of understanding on sensations is even more striking in individual cases, in particular when with imperfect lighting a visual image is initially unintelligible, because we do not know how to give it the correct depth dimensions, when we, for instance, take some distant light as close, or a close one for distant. Suddenly it occurs to us what it is, and simultaneously under the influence of the correct understanding the correct intuitive image is developed as well in its full power, and we are not in a position to turn back from this one to the earlier incomplete intuition. This occurs quite often with complex stereoscopic drawings of crystal forms and others, which are intuited in complete sensible clarity as soon as one successfully achieves correct understanding.
>
> (*PO* 26:436–437)

Helmholtz observes that is difficult to distinguish which contents of our images are contributed by experience and practice, and which by sensations. This problem is just as pressing for perception as it is for representation. While it is true that perception allows access to the sensory material available from present stimuli, sensory material is never given passively, for Helmholtz. Observation is active, selective, and directed:

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> We do not merely abandon ourselves passively to the impressions impinging on us, rather we *observe*, which means we bring our organs into those conditions under which they can distinguish the impressions most exactly. For instance, in the observation of a complex object we direct our two eyes toward each other, accommodated as well as possible so that both continually are fixed on that point to which our awareness already has guided itself, that is on the position of clearest sight, and allow the eyes to wander together over all the points of the object worth noticing.
>
> (*PO* 26:438)

Helmholtz argues that our perception and observation are so geared toward perceiving distinct objects and their properties that practiced observers become unable to bring more purely subjective sensations, without objective import, to conscious awareness. For Helmholtz, this practical fact is a "general characteristic of our sensations":

> *we attend to our sensations easily and exactly only insofar as they can be used for knowledge of external objects, but* [. . .] *we are used to abstracting away from all those parts of sensations that have no significance for external objects*, so that most of the time special encouragement

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> and practice is necessary for the observation of these latter subjective sensations.
>
> (*PO* 26:431)

The blind spot is a classic example of a subjective sensation that is unnoticed in normal perception. Helmholtz also explains binocular rivalry, the phenomenon in which each eye is presented with distinct images but the brain does not fuse the two into a single image, by appeal to selective attention: the brain attends to one image, then the other, not both at once. Objective perception, for Helmholtz, is tied up with selective and guided attention.

On Helmholtz's view, our mental activity in experience is "directed" at representing objects. His theory could be seen as an early version of the "intentionality" thesis defended by Brentano – and later by Crane – according to which the mind's direction (*Richtung*) toward its own activity or toward objects is the distinguishing characteristic of mental activity, the "mark" of the mental.[30] Helmholtz's argument for intentionality extends to the claim that our selective awareness is directed unconsciously toward objective representation, and away from subjective sensations that are not employed in objective representation.

5. Phenomenal experience: plasticity and cognitive penetrability

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Helmholtz saw establishing the mathematical, lawlike relationships that describe the interaction between external stimulus and subjective perceiver as fundamental to his account of experience. Establishing these relationships required commitment to the plasticity of perceptual experience: the subject can engage in voluntary motions, for instance, that test the boundaries of the self against those of the object, and can bring novel sensations and perceptions into view.[31] These cannot be anticipated a priori. The "perceived sphere of presentabilia cannot be posited through a *conscious* act of our representation or will" (Helmholtz 1878, 38). We interact with "actual" *(wirkliche*) objects; they work (*wirken*) on us to produce sensory experience and perception.

Helmholtz's account, according to which sensations are effects of external causes, and perception and concepts of external objects involve "practical" knowledge of the possible effects objects may have on us and their modal physical properties generally, may appear to have much in common with recent "sensorimotor" or embodied approaches to consciousness and to phenomenal experience (O'Regan and Noë 2001a, 2001b). On the sensorimotor view,

> seeing is a way of acting. It is a particular way of exploring the environment. Activity in internal representations does not generate the experience of seeing. The outside world serves as its own, external, representation. The experience of seeing occurs when the organism masters what we call the governing laws of sensorimotor contingency. The advantage of this

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> approach is that it provides a natural and principled way of accounting for visual consciousness, and for the differences in the perceived quality of sensory experience in the different sensory modalities.
>
> (O'Regan and Noë 2001b, 939)

Prinz (2008) criticizes the sensorimotor approach for its "radicalism," arguing that, on this view, visual experience and consciousness depend on the location of the subject in a particular environment, the subject's "situatedness". On a strong reading of the sensorimotor view, consciousness isn't in the head.[32]

Helmholtz captures one of the attractive elements of the sensorimotor view, that our experience depends on causal relationships, interactions between features of the environment and the subject. But Helmholtz falls into another camp, one in which, as Prinz observes, Dretske, Tye, and Lycan fall as well: the combination of externalism with representationalism, including intentionalism about representation. On this view, the character of consciousness, including visual experience, can depend on causal interactions. But these interactions are described in nomological terms, as lawlike relationships necessary to determine objective representations, not as particular instances of situated consciousness being caused by particular external features of the environment.

There is a simpler, illuminating difference between Helmholtz's approach and sensorimotor theory. Helmholtz's theory of representation is *epistemological*. His main question of interest, as he puts it in "The Facts in Perception," is "What is truth in our representations?"[33] His analysis of phenomenal experience is aimed at finding the truth, not "accounting for visual consciousness". Accounting for visual consciousness is important to him, but the goal of doing so is to find the causal relationships and facts revealed in experience. These can be found only by reading sensory "signs" or indications, and interpreting the signs requires mental representation. By the time a sensation makes it to the subject, it is no longer really "external", because the process of sensing and perceiving fundamentally alters properties of the stimulus. To O'Regan and Noë, "The outside world serves as its own, external, representation". This would be anathema to Helmholtz: for him, any representation requires inference and interpretation.

The "truth" in our perception and experience is a practical truth, on Helmholtz's account (*PO* 26:443). Concepts of external objects are constructed using our knowledge of their effects on us as perceiving subjects. Knowledge of their properties is limited to the relational properties revealed by these interactions. We learn to read the signs revealed in these interactions, and we test our understanding by engaging in experiments that vary the conditions under which the interactions take place. Although the truth in perception is practical, it is not for that reason infinitely mutable. Stable regularities are revealed in these experiments, which cannot be overridden in experience. For instance, if I try to hear the note produced by a tuning fork tuned to C as an F, in normal conditions, I cannot. If I wish to see sunlight as a spectrum of color, I can cast the light through a prism, but I cannot vary the colors I see at will.[34]

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On the basis of his account of the stable, nomological properties of interactions between subject and object, Helmholtz defends what now is called an "adverbial" theory of the qualities of perception.[35]

> To ask whether vermilion is actually red, as we see it, or whether this is a sensory illusion, is therefore senseless. The sensation of red is the normal reaction of normally formed eyes to the light reflected by vermilion. A colorblind person would see vermilion as black or dark grey-yellow; this too is the correct reaction for a different eye. [. . .] In itself the one sensation is not more correct or more false than the other.
>
> (*PO* 26:445)

On the ground level of Helmholtz's multi-level account of sensation and perception, there are law-governed regularities between the external object, as cause, and the subject's nervous system, as effect. Vermilion has a certain wavelength; light reflected from it is taken up by the cells in the retina and sensed as red. This is the usual effect of that cause. Someone with a sensory mechanism configured in a certain way *must* see vermilion as red, and so it is "senseless" to ask whether vermilion is "seen as" red by that person.

On another level, the perceived *shade* of a vermilion object varies with its distance from the subject. The farther away it becomes, the hazier or lighter its color will appear (*PO* 26:433). Many perceived qualities that depend on spatial conditions, including distance and depth, can be "overridden" in experience by changing the conditions or interpretation of that experience. They are not ground-level sensory facts, they are stable, but malleable perceptual regularities.

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Helmholtz's experimental techniques in physiological acoustics and optics make concrete Müller's notion of specific nerve energies, explaining the characteristics of each type of sense nerve stimulation. Helmholtz isolated a number of simple sensory responses, and showed how some complex perceptions arise from the composition of such simple sensations. He defends a general principle for differentiating pure sensation from what is constituted by mental activity:

> *nothing in our sense perceptions can be recognized as sensation that, through moments demonstrably given in experience, can be overridden in the intuitive image and transformed into its opposite*. Thus, we must regard whatever can be overridden through moments of experience as itself a product of experience and practice. It will be shown that if we follow this rule, only the qualities of sensation are to be regarded as actually pure sensation, but most spatial intuitions by far as a product of experience and practice.
>
> (*PO* 26:438)

On the basis of facts[36] revealed in experiment, Helmholtz crafts a multilevel account of perceptual experience. On one level, there are sensory responses

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to stimuli, the effects of objective causes. These are stimulations of nerves in response to present stimuli. On another level, there are "representations" or "intuitions", which are constructed by the mind, and can be "overridden" in experience. Helmholtz argues that any non-sensory element of experience can be changed by training the observer. If you put the observer back in the initial situation after that training, the observer will no longer see things in the same way.

Helmholtz's view might be seen as an early version of Susanna Siegel's thesis of cognitive penetrability, according to which:

> If visual experience is cognitively penetrable, then it is nomologically possible for two subjects (or for one subject in different counterfactual circumstances, or at different times) to have visual experiences with different contents while seeing *and attending to* the same distal stimuli under the same external conditions, as a result of differences in other cognitive (including affective) states.[37]

Helmholtz's remark that a visual representation takes on a certain determinate form only once the observer has "understood" what is being represented supports such a reading, as does his position that features of complex sensations are the result of mental activity. His statement that "one and the same intuition can be derived in very different ways from the corresponding sensations, and that, therefore, representation and perception can be associated with intuition through quite diverse relationships", allows for the possibility of cognitive penetrability as Siegel describes it.[38] Finally, Helmholtz points out that subjects can be trained to "see" the same scene in a different way, or to "hear" the same chord differently, to the point that the subject can no longer perceive the scene or the chord as before.

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Helmholtz's account allows for at least two ways phenomenal experience can be changed. One is through training, by manipulating the causal relationships between sensing subject and external object, so that "normal" perceptual relationships are disrupted and novel perceptual regularities emerge. It might be objected that this is not cognitive penetrability, because the same subject is being placed in different contexts, not seeing the same scene differently. But Helmholtz's point is that, after such training, subjects placed back in their original context may have a distinct perception of the same external stimuli. The relevant question is whether this penetration is cognitive, since it results from training, which may involve learning but also may involve behavioral conditioning.

Phenomenal experience also can be changed in cases in which, when the subject reaches the correct understanding, a scene snaps into focus and can be interpreted correctly. This is also cognitive penetrability, because interpretation is required for perception. A difference in cognitive states allows for distinct interpretations, and distinct perceptions, of the same scene.

Helmholtz argues that there are limits to the extent to which our understanding or interpretation can influence the content of perceptual experience. These limits

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are given by the stable regularities, grounded by causal relationships, revealed in the subject's experience: regularities describing the stable relationships between cause (stimulus) and effect (sensation).

Still, Helmholtz argues that phenomenal experience has remarkable plasticity. The nomological regularities of the stimulus-response curve, or of the relationship between the wavelength of light and the stimulation of retinal cells, do not exhaust the content of sensory representation and experience. In support of his hypothesis of the plasticity of experience, Helmholtz argues against the nativist view held by Ewald Hering and Peter Ludwig Panum, according to which spatial perception is underwritten by innate mechanisms or perceptions:[39]

> it can be quite difficult to judge what, in our intuitions achieved through the visual sense, is determined immediately through sensation, and what on the contrary is determined through experience and practice. The primary, fundamental dispute that exists between different researchers in this area is connected to this difficulty. Some tend to allow the influence of experience the widest latitude possible, and in particular to derive all spatial intuition from it; we can describe this view as the *empirist theories*. Others indeed must allow the influence of experience for a certain class of perceptions, but believe they must presuppose for certain elementary intuitions that occur uniformly for all observers a system of innate intuitions not grounded on experience, namely spatial relationships. We may describe this latter view in contrast to the first as the *nativist theory* of sense perceptions.
>
> (*PO* 26:435)

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For Hering, our awareness and perception of spatial relationships is not inferred by the mind, but rather is a product of our binocular or "cyclopean" sensory mechanism.[40] Nativists employ innate mechanisms to explain the same phenomena Helmholtz explains through unconscious inference. Helmholtz remarks that

> the combination of sensations is maintained with the representation of their objects to seem so fixed and compulsive, to many physiologists and psychologists, that they are so little inclined to recognize that this combination rests on acquired experience and thus on mental operation, at least in large part, that they seek on the contrary a mechanical way that it takes place through pre-formed organic structures.
>
> (*PO* 26:431)

For Hering, there are innate relationships between cells on the retina, and between the retinas and nerves of the two eyes, that determine how spatial relationships are perceived. Elements of spatial relationships may be learned, as are particular spatial judgments, but our perception of spatial relationships is based on the innate constitution and mechanisms of our sensory apparatus.

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In objecting to Hering's view, Helmholtz cites experimental facts according to which perceived spatial relationships can be changed in experience and through practice. But the most significant argument is against the notion that the retina and the visual apparatus limit the determination of spatial relationships in sensation: "for the empirist theory [Helmholtz's theory] it is entirely unimportant how the retina is configured" (*PO* 33:801). Helmholtz does investigate, and in detail, the properties of the retina. His point is that, for him, the retina is a sensory instrument to be employed by the mind in constructing complex representations, not an organ that independently fuses sensations into complex images or representations. The empirist, unlike the nativist, need not assume any configuration or innate function of the retina itself, only a set of lawlike relationships between retinal points and their projections into space.

To Helmholtz, Hering and Panum do not allow for the plasticity of spatial construction in experience in response to sensory cues, which hampers their ability to investigate thoroughly the law-governed relationships between subjects and objects as revealed in experience. For him, nativists are required to assume a pre-established harmony between mind and nature, in which spatial representations that arise through an innate mechanism are supposed to correspond to actual phenomena (*PO* 26: 442).

Helmholtz's arguments for the plasticity of experience accompany a nomothetic methodology. Nativism, on Helmholtz's view, is a bar to investigating the full range of possible spatial relationships that can be revealed in experience. This hinders the thorough investigation of the lawlike relationships between, for instance, the voluntary movements of a perceiving subject and the spatial properties of external objects that can be revealed through those movements. On Helmholtz's view, sensations are effects on the subject caused by external objects. All spatial, quantitative features of our sensations are determinable in a two-sided causal relationship, governed by physical and physiological laws.

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Helmholtz pioneered an approach to perceptual experience according to which experience is geared toward representing external objects and the environment, representation is interpretive and intentional, and sensory signs must be interpreted to achieve representation. The occurrence and variance of a particular sign or class of signs can be shown to be governed by physical laws that describe the interaction between subjective sensation (effect) and external stimulus (cause). The account of these laws and these relationships is anchored by perceptual facts, revealed through practical investigation and experiment.

Helmholtz's approach is an early version of the influential blend of externalism and representationalism advocated by Dretske, Tye, and Lycan. His defense of an epistemological theory of perceptual experience gives support to a response to sensorimotor theories proposed by O'Regan and Noë. On Helmholtz's epistemological account, for visual experience to represent external objects requires inference and interpretation, which appears to rule out the sensorimotor theory. Helmholtz argues for an early, though limited, thesis of cognitive penetrability, defended recently by Siegel, and for an adverbial theory of color and of sensory

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qualities, related to a recent account by Chirimuuta. Helmholtz's view is a synthesis of naturalism and of nomothetic apriorism in the philosophy of mind, the former informed by his early engagement with the physiological tradition, and the latter influenced by Kant and Fichte.

Helmholtz's scientific results in his texts on sound and color have influenced present scientific and philosophical approaches to sensation and to sensory qualities. Helmholtz's view was intended, not solely as a philosophical position, but as a scientific approach to perceptual experience and its epistemological significance, and both aspects of his theory have had a deep influence.

Notes

1 Above all, I would like to thank Sandra Lapointe for her insight into the configuration and promise of this project, for conceiving of this volume, and for astute and perceptive responses to earlier versions, which shaped the project as it stands now. Clinton Tolley read the penultimate version of the paper and contributed invaluable suggestions, including preventing me from making a most consequential error of translation, for which I am grateful. Erik Banks's encouragement and suggestions made a real difference. Gary Hatfield published *The Natural and the Normative* twenty-five years ago, which introduced me to Helmholtz, to the significance of his work, and to the possibilities it contains.

2 For a discussion of "*Seele*" and "*Geist*" in the context of "faculty psychology," see Beiser (2014, 136–138 and 156–157).

3 1844, *Prolegomena* §2.

4 *Medicinische Psychologie oder Physiologie der Seele*.

5 "Seelenthätigkeiten". Helmholtz 1867, hereafter *PO,* 26:427. Citations of *PO* give the section, then page, number.

6 One might associate the German word "Geist" with "pure psychology" or with idealism, and "psychisch" and "Seele" with the physiological, naturalist approach. But Helmholtz, Wundt, and others seem to use the word "geistig" as a synonym for "psychisch," which undermines the basis for a principled distinction. Helmholtz does employ "Geist" more often when discussing idealist philosophers (*PO*, "Geist" and variants: Plato (17:207), Kant, Fichte and Schelling (26:456)), and "psychisch" and "Seele" more often when discussing physiological theories (*PO*, "psychisch" and variants: 32:772–774, §33, throughout; "Seele": §26, throughout; 29:620; §33, throughout). See Wundt (1874), "Psychologische Vorbegriffe: Die Begriffe Seele und Geist. Die Lehre von den Seelenvermögen," pp. 8–20. For more on the "Seele" in German idealism, see the concluding sections of Clinton Tolley's essay in this volume.

7 Helmholtz's theory of perception and sensation is born from his acquaintance with Müller, Lotze, Johann Friedrich Herbart, Gustav Fechner, and Ernst Weber, and from his early work with the Berlin Physical Society, with Emil du Bois-Reymond, Sigmund Freud, and others. For the former, see Hatfield 1990, Ch. 5; for the latter, see Sulloway 1992, 13ff. and 65ff.

8 Hatfield 1990, 172; see *PO* 17, 191–192.

9 I would like to thank Clinton Tolley on bended knee for saving me (and the reader) from a mis-translation of this passage, and from a terminological and interpretive confusion.

10 "psychischen Thätigkeit". On *PO* 17:207, Helmholtz uses "Thätigkeit" for Empedocles's "energeia".

11 *Empfindungsmaterial*.

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12 See the section following for a discussion of "signs" in Helmholtz.
13 See Hatfield (1990, Chapter 4: "Spatial Realism and Idealism") for a detailed account.
14 Brewster 1856 provides a one-sided but entertaining history.
15 See Lenoir 2006, 143–144.
16 *PO* 26:456. In the case of illusion, there may be no external stimulus, or we may form a mistaken judgment about the nature of the stimulus, but there was still *some* cause for the sensation, on this account.
17 For more on the sign theory, see Patton (2009 and 2014), including the citations to further work.
18 "Bilder".
19 The shorthand LoSNE appears to be due to Liesbet de Kock. She discusses Müller's law in De Kock (2014 and 2015).
20 "Qualitätenkreise". The term comes from Fichte (Helmholtz 1878, 9).
21 Hyder (2009) analyzes Helmholtz's related notion of determinacy.
22 Helmholtz does allow for illusory sensations, but he observes that even they have some source, though it may be internal to the subject.
23 See, for instance, *PO* 26, 427.
24 *PO* 26, 427, see Hatfield (2011, §5). As Hatfield notes, in 1855 Helmholtz argues that representation of objects in space requires "our positing objects as the causes of our sensations, and we make such posits in accordance with the proposition, 'no effect without a cause'" (Helmholtz 1855; Hatfield 2011, §5, 329).
25 "Every alteration in nature *must* have a sufficient cause" (Helmholtz 1847, 4). "The causal law is actually a given a priori, transcendental law. A proof of it from experience is not possible" (Helmholtz 1878, 41).
26 "Uebereinstimmung".
27 My hearing a thunderclap will take place at approximately the same time as the thunderclap itself. Though, as Helmholtz observes, we see the light from the stars many years after it is emitted, we can determine the temporal relationship between the star shining and my seeing the light.
28 "unbewusste Schlüsse". De Kock (2014, §3, 725–728) analyzes Mill's influence on Helmholtz's view of inductive inference.
29 Herbart (1816, 106–107): "one of the older representations can be suppressed entirely from consciousness for a while by a new one that is much weaker. However, its striving is not to be regarded as ineffective [. . .] rather, it works with its whole might against the representations found in consciousness".
30 See Robin Rollinger's and Peter Simons's contributions to this volume for discussion of nineteenth-century theories of intentionality, including Brentano's. Brentano objected to Helmholtz's theory of unconscious inference. Crane (2003) is a contemporary explanation and defense of intentionality.
31 Fichte's "nicht-Ich", in the "Facts in Perception" lecture (Helmholtz 1878, 35–38).
32 Prinz cites empirical evidence against these claims, but my focus here is on the philosophical account.
33 Helmholtz (1878, 42).
34 Studies of Helmholtz on compound colors and tones include Hatfield (2011), Heller (2012), Hui (2013), Hyder (2009), Kremer (1993), Sherman (1981), and Turner (1996). Helmholtz's papers on color mixing are collected in Helmholtz (1882).
35 Chirimuuta (2015) is a recent defense of the adverbial theory.
36 "Fact" ("Thatsache") is a technical term for Helmholtz, referring to a regularity demonstrated in experience, ideally in experiment. For instance, Helmholtz (1878) is entitled "The Facts in Perception."
37 Siegel (2012, §1); thanks to Preston Lennon for mentioning this work.
38 *PO* 26, 435.

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39 *PO* 26: 431, 456, and passim; §33, throughout. See §I.4 of Erik Banks's article in this volume for a discussion of the nativism controversy.
40 Hering (1861, 330ff.); see Banks, this volume, §I.4.

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