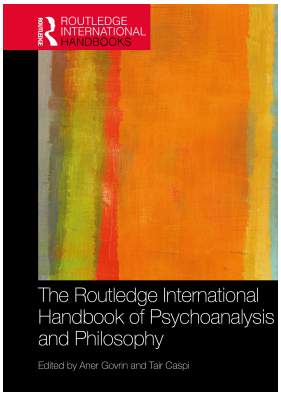

The Routledge International Handbook of Psychoanalysis and Philosophy

Aner Govrin, Tair Caspi

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Publication details
https://www.routledgehandbooks.com/doi/10.4324/9780429297076-9
Leonardo Niro
Published online on: 25 Nov 2022

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FREUD AND THE LEGACY OF SENSORY PHYSIOLOGY

Leonardo Niro

Introduction

In the literature on the philosophical background of psychoanalysis, Freud is often placed in a Kantian tradition via his engagement with authors such as Schopenhauer, Herbart, Lipps, Meynert, and, especially, the physiologists Hermann von Helmholtz, Emil du Bois-Reymond, and Freud's mentor during his medical studies, Ernst Theodor Brücke. Freud spent some of his most formative years, from 1876–1882, daily working at the Institute of Physiology of the University of Vienna. There, as he memorably described, 'in Ernst Brücke's physiological laboratory, I found rest and full satisfaction – and men, too, whom I could respect and take as my models: the great Brücke himself, and his assistants, Sigmund Exner and Ernst Fleischl von Marxow' (Freud, 1925a, p. 8). After leaving the institute, Freud continued to engage with the work of the group, in particular that of Fleischl and Exner,[1] well into the late 1890s. In fact, the *Project for a Scientific Psychology*, from 1895, can be read as Freud's attempt at reformulating Exner's *Entwurf zu einer Physiologischen Erklärung der Psychischen Erscheinungen* (Project for a Physiological Explanation of Psychical Phenomena), published the year prior (Exner, 1894).

Brücke, along with his friend and colleague Emil du Bois-Reymond, was a founding member and one of the leading figures behind the Berlin Society of Physics (*Physikalische Gesellschaft zu Berlin*), whose wide impact in nineteenth-century science led to its achieving a mythical status in the history of science (Schreier et al., 1995; Fiedler, 1998; Wise, 2018). While the goal of the society was that of the 'promotion of the study of Physics in a broader sense' (*Urkunde der Physikalischen Gesellschaft*, 1845), thus counting among its members with physicists, chemists, mathematicians, and engineers, as well as doctors, du Bois-Reymond and Brücke's initial aim in starting the society had been to create a space to share their physiological research (Finkelstein, 2013). The physiological work of the group came to form a coherent research programme – which later scholars titled *organic physics* – that became the most influential approach to physiology in late nineteenth-century Germany. Many of the founders of psychology – William James, Wilhelm Wundt, Ivan Pavlov, Ernst Mach, and Ewald Hering, among others – had their work directly influenced by organic physics. This was also the case of Freud.

The impact of their research programme in Freud's theories has not yet been thoroughly investigated; Freudian scholars have so far almost exclusively explored its influence in the metapsychological models, in particular the dynamic and economic models (Bernfeld, 1944, 1949;

DOI: 10.4324/9780429297076-9

Amacher, 1965; Pribram and Gill, 1976; Sulloway, 1979; Anzieu, 1986). Such analyses have led some authors to argue that due to the "scientistic" influence of organic physics – something that would be, along that reading, extraneous to the psychoanalytic project itself – it had come time to abandon metapsychology altogether, thus paving the way to a purely hermeneutic psychoanalysis (Ricoeur, 1970; Gill and Holtzman, 1976; Habermas, 1987). Such a reading presents, in my view, a gross oversimplification. The legacy of organic physics runs deep, constituting a central element of the psychoanalytic theory of the mind. Although the focus here will be on the impact of their work in sensory physiology in Freud's theory of perception, this is by no means their only influence – these are multiple and cannot be summarised in a single chapter.

In what follows, I will explore how Freud imported – and extended – Helmholtz's theory of perception in developing his new psychology. Further, I will also argue that the organic physicists' work on perception paved the way to an epistemology that would today be described as a type of epistemic structural realism, which, due to their influence, was also adopted (and again extended) by Freud. Following this assessment, I will present how the theories of perception proposed by Helmholtz and Freud are currently being recast in similar formats under predictive processing and embodied inference approaches in the neurosciences and philosophy of mind, as well as evaluating its epistemological implications. I will complete the chapter by schematically describing how the legacy of organic physics remained present (via Freud) in the work of the Kleinian school of psychoanalysis, and how this presents an isomorphism with predicted processing accounts of fantasy, dreaming, and primal forms of mental activity.

"Operationalised Kant": Helmholtz on Perception

In his *Handbook of Human Physiology* (1834–1840), the anatomist and physiologist Johannes Peter Müller (1801–1858), mentor to Helmholtz, du Bois-Reymond, and Brücke (cf. Otis, 2007), outlined his *Doctrine of Specific Nerve Energy*. At its core, the doctrine holds that the different sensory organs are connected to the external world via five different types ("energies") of sensory nerves in the human nervous system, representing each of the five senses. A consequence of the doctrine is that the direct object of sensation is the activity of the sensory organs themselves rather than properties of the external world (Müller, 1838, p. 253ff.). According to the doctrine, it was not the type of external stimulation that produced the quality of the sensation; this was a product, instead, of the type of nerve receiving the stimulus. The doctrine is based in two key observations: first, that one uniform cause – for instance, the rays from the sun – will appear to us as either light or warmth depending not on any inherent property of the cause itself but exclusively on the organ it excites (i.e., the eyes or the skin). Reversibly, widely different causes of excitation to the same organ generate similar qualities of sensation (ibid., p. 89ff.). Whether the retina is excited by a light source, or electricity, or simply by manual pressure to the eyeball, the different causes will all be experienced subjectively as light. Müller's doctrine, in short, holds a double dissociation between the causes of sensory input and its sensory effects (cf. Isaac, 2019).

If we only have access to the activity of our sensory organs – the 'egocentric predicament' described by Ayer (1940) – a potential epistemic consequence is global scepticism along the lines of a type of subjective idealism, the doctrine that only minds and mental contents exist. While Kant's defence against subjective idealism had been to propose the transcendental origins of intuition, Helmholtz in turn would deny any innateness in perception.[2] Although he depicted his theory of perception as an extension of Müller's doctrine into the specific energies of each sensory modality, and in agreement with Kant's doctrine of the *a priori* origins of perceptual experience, he also contended that 'the reasons which allow us to conclude that the intuitive form of space is transcendental are not necessarily sufficient to prove at the same time that the

axioms are also of transcendental origin' (Helmholtz, 1878/1968a, p. 218). As his experiments indicated, perception was thoroughly a learned psychological process[3] – in Helmholtz's "operationalised Kant" (Lenoir, 2006), the *a priori*s of intuition are empirically generated through the agent's active engagement with its sensory inputs. Although Helmholtz departed from Müller and more traditional Kantian perspectives in essential points,[4] rather than radically diverging from them, he portrayed his work as an update of their theories of perception in the light of recent findings in physiology, and his divergence can be seen as a form of overcoming the challenge of global scepticism (and thus, of restoring a form of realism) given the abandonment of transcendental philosophy.

Since his first writing on the subject of perception, his 1855 Kant memorial address *On Human Vision*, delivered shortly after arriving in Königsberg, Helmholtz presented his central question: 'How is it that we escape from the world of the sensations of our nervous system into the world of real things?' (Helmholtz, 1855/1903, p. 116). Throughout the following decades, he turned this epistemological question into a coherent research programme while formulating a distinct theory of perception – the empiricist theory – developed in several public lectures and, especially, in his deeply influential *On the Sensation of Tone* (1863) and the three-volume *Handbook of Physiological Optics* (1856–1867). In Helmholtz's mature version of the empiricist theory of perception, a perceptual image is nothing like a passive copy of external things; perceptions are, instead, purely symbolic representations, actively constructed by the mind for the practical purpose of gaining control of the external world.

Whereas Müller had argued for an interaction between innate physiological mechanisms together with psychological factors,[5] Helmholtz rejected that anything was given in the act of perception. For him, even the most simple and basic sensation (e.g., "red" or the note "C") required a great deal of learning and judgement. The position of Müller (and later, Ewald Hering) was a target of Helmholtz's criticism as he assumed nativism – the theory that concepts, mental capacities, and mental structures are innate rather than acquired – created an intractable barrier between objective and subjective realities, which remained independent but somehow causally related. Nativism, in Helmholtz's view, necessarily implied some form of pre-established harmony between external reality and the subjective reality of perception – a theory he considered incompatible with science. Moreover, his discovery of the speed of nerve transmission (Helmholtz, 1850), one of the greatest achievements of nineteenth-century physiology, had demonstrated that the velocity of transmission was much slower than previously assumed, so that perception could not be as immediate as Müller contended and the nativist theory implied.

In Helmholtz's constructivist theory, perception functioned through a slow process of learning by trial, error, and continuous repetition. Simple associations of physiological sensory stimuli (not yet the content of perception or having the quality of sensation) are progressively organised into a system of dispositions to act.[6] As these dispositions also become organised, they form unconscious inferences onto the causes of the sensorium. The act of perception is therefore the result of a complex psychological process of unconscious inference onto the causes of percepts, to which we never have direct access. Helmholtz repeatedly made use of the analogy of perception and the activity of the scientist, where the act of perception is understood as a continuous process of inductive inference – which, he argued, is equivalent to an 'unconscious conclusion' (Helmholtz, 1867/1962, p. 4).[7] Repeated experiences of a similar effect enable us to form inferences as to the possible causes of change. The inferences are signs (*Zeichen*), generated by our active engagement with the effects. Since the signs are generated by a sensory apparatus with specific qualities, as well as the history of our experience and engagement with reality, they are also imbued with the observer's inner qualities and education. This psychological inferential

process, Helmholtz would say, constitutes not only the foundation of perception but is the 'basis which underlies all that truly can be called thinking' (Helmholtz, 1878/1968a, p. 220).

If we do not have direct access to the causes of sensation, which are instead actively organised and constructed by the subject, Helmholtz argued that we *project* the inner activities of the nervous system externally (i.e., into space) as they would have to be present in order to cause these activities. Considering that perceptions are the result of inductive conclusions, of the same type as a 'scientific experiment,' in order to determine the distal cause of sensation an agent needs to perform experiments to test its inferences. This is firstly achieved by varying its perspectives upon them – that is, through *movement*:

> each voluntary movement by which we change the appearance of objects must be regarded as an experiment, by which we test whether we have correctly interpreted the lawful behaviour of the phenomenon in question, i.e. its postulated existence in a definite spatial arrangement.
>
> *(Helmholtz, 1878/1968a, p. 223)*

Space is therefore an *a priori* form of perception, learned through our active engagement with the world. In the Helmholtz scheme, action takes centre stage. Every movement, starting with eye movements, is understood as a perceptual experiment by which the agent (unconsciously, automatically) test its sensory signs, thus reaching an 'unconscious conclusion' – the perceptual image itself – in a process similar to hypothesis testing in the sciences. One special activity the agent needs to learn is to distinguish between themselves and the environment around. Such a distinction, he argued, is also learned through such a process of active experimentation. Percepts that can be changed (e.g., when I move my field of vision away from a light source), provide indications that they belong externally and are projected spatially; unchangeable states (e.g., memories, intentions, desires, moods) cannot be projected in space, and the mind learns to consider them 'the world of internal perception, the world of consciousness of one's self' (ibid., p. 214).

Helmholtz is emphatic in arguing there can be no possible relation of identity between the symbols of perception and the things they are meant to represent:

> In my opinion, therefore, can be no possible sense in speaking of any other truth of our ideas except of a practical truth. Our ideas of things cannot be anything but symbols (*Symbole*), natural signs (*Zeichen*) for things which we learn how to use in order to regulate our movements and actions. Having learned correctly how to read those symbols, we are enabled by their help to adjust our actions so as to bring about the desired result; that is, so that the expected new sensations will arise.
>
> *(Helmholtz, 1856/1968c, p. 80)*

As Lenoir aptly explained, 'the task of this symbolic language was to represent the relationship *between* objects affecting one another and our sense organs. The *structure* of the relationship was the crucial aspect to be grasped in a representation' (Lenoir, 1990, p. 144). This is important for two keys reasons: first, because the symbolic language allows the different sensory modalities to be linked together in an act of synthesis; and secondly, because a copy-theory of representation would not guarantee that the mind grasped the relations between objects and sensations. Since for Helmholtz the purpose of a representation is not that of providing a perfect copy of reality but of guiding action, a 'good representation is a symbol useful for organising the practical activities in terms of which we interact with the external world through our senses' (ibid.).

Perceptions are thus symbols that help us predict the structural relations between objects, as well as between our bodies and the world around.

Helmholtz's final position on the problem first expressed in 1855, articulated in his lecture *Facts on Perception*, was to claim that

> even if our sensory perceptions in their quality are only signs, whose special nature depends entirely on our organisation, they must not be discarded as empty appearances; rather, they are signs for something, either existing or happening – and, what is most important – they can represent the laws governing this event for us.
>
> *(Helmholtz, 1878/1968a, p. 213)*

His answer is therefore a pragmatic one. Although we do not have direct access to the properties of external reality, we have access to the structural relations *between* such properties. He would also defend a similar view in respect to the relation between our scientific concepts and theories, and the natural phenomena they are meant to represent (Helmholtz, 1856). Helmholtz's epistemology, articulated together with his research in sensory physiology, suggests a position that in contemporary epistemology would be called epistemic structural realism – the view that structural relations between simple perceptual properties convey knowledge of structural features of reality.

First introduced by John Worrall (1989) as a means of combining the claims of scientific realism and anti-realism in physics, structural realism defends that we commit ourselves only to the structural content of our theories. The debate has spawned an extensive literature in which numerous varieties of structural realism are advocated (cf. Ladyman, 2014). Realism, the view that 'we ought to believe in the unobservable entities posited by our most successful scientific theories' (ibid.), is countered by the history of radical theory change in science. Anti-realism, on the other hand, is countered by the "no miracles" argument, according to which the successes of science would be miraculous if not at least approximately true descriptions of the world. Structural realism would in that sense provide the "best of both worlds" (Worrall, 1989), since it accepts the historical contingencies of scientific theories but maintains that there is still retention of structure across theory change. Ladyman (1998) further raised the question as to whether Worrall's structural realism is intended as a metaphysical or epistemological modification of standard scientific realism, thus raising the distinction between ontic and epistemic forms of structural realism. Interpretations of Helmholtz's epistemology range from idealism (Heidelberger, 1995) to realism (McDonald, 2002), but most scholars contend his theory of perception implied a type of epistemic structural realism (Moulines, 1981; Hatfield, 1990, 2018; Lenoir, 1990, 2006; Isaac, 2020).

Inference, Translation, and Synthesis: Freud's Theory of Perception

'If I could give a complete account of the psychological characteristics of perception [. . .], I should have described a new psychology,' said Freud to Fliess in 1896 (Freud, 1985, p. 208). Throughout the following years, Freud would articulate a cogent 'new psychology' that retained the core elements of Helmholtz's theory of perception – namely, that we only have direct access to the activities of our sensory organs, a constructivist model of the formation of perceptual images, and the central role of action in perception. Further, Freud would extend Helmholtz's empiricist theory in three main ways: first, by giving greater consideration to the role of the endogenous sources of motivation (wishes, desires) in the construction of the perceptual image; secondly, by extending Helmholtz's analysis of the outer senses into the world of the inner

senses; and finally, by extending Helmholtz's structuralist epistemology of external reality to also encompass the internal perception of our mental and bodily states.

Even though Freud never studied under Helmholtz, it is clear that he must have been well acquainted with the physiologist's work on perception, not only through his reading of Helmholtz's 'Lectures'[8] but chiefly as a result of his time at the Institute of Physiology with Brücke and Exner – who had been a student of Helmholtz in Berlin in 1867–8 and who advocated a theory of perception along Helmholtzian lines in *Entwurf*. Brücke's work continued to be faithful to the organic physics programme while Freud was his student, as demonstrated by the content of his *Lectures on Physiology* (Brücke, 1876) and the theory of perception depicted there. Further, the work on perception by Helmholtz owed a great deal to Brücke's earlier studies on the structure of the eye and retina (Brücke, 1843, 1845b, 1845a, 1847b, 1847a), as well as to his treatise *On Subjective Colours* (Brücke, 1851; Kremer, 1994). In his recent and comprehensive account of the socio-cultural background of the development of the Berlin Society, Norton Wise made the case that their work was marked by the division of labour amongst its members (Wise, 2018, p. 234). Their research in sensory physiology provides one prominent example. We can therefore consider their views on perception as generally in agreement and forming a uniform project, where Brücke concentrated in describing the anatomy and physiology of the eyes, while Helmholtz provided both physiological experiments and the theoretical framework which was subsequently used by Brücke in his *Lectures*.

Despite his engagement with both philosophy and physiology, Freud was neither a philosopher nor a sensory physiologist. As such, he was never required to articulate a theory of perception with the same level of detail as did Helmholtz. However, the psychology developed in some of his key theoretical works allows us to outline some of his key assumptions, as well as their main influences. A mind that displays the capacity for phenomena – such as projection, transference, and defense mechanisms that greatly disturb perception – cannot be based on a sensualist theory of perception, according to which the qualities of sensations are derived from the external world; neither can it subscribe to a form of strict realism, whereby we would have access to faithful representations (copies) of reality. And considering the centrality Freud gave to the activity of reality-testing, subjective idealism as well as global scepticism are also not viable candidates. For Freud, perception is an active psychological process deeply shaped by our internal states, which, as will be argued, retains some form of indirect realism.

Although Helmholtz had partially discussed the role of the will in guiding perception (Helmholtz, 1894/1968b, p. 260), he never gave a systematic treatment to the role of internal motivation in his writings. Probably due to his reading of G. Fechner, he went as far as to argue that 'above all, it is pain that teaches us most impressively about the power of reality' (1878/1968a, p. 226), an assertion that greatly resembles how Freud would come to describe the activity of reality-testing. If perceptual images are, as we have seen, symbols imbued with the perceiver's inner qualities and education, whose purpose is of guiding action, one might assume that perceptual images would be at least partially determined by our endogenous needs since they provide the motivational factors for action itself. This constitutes Freud's fundamental extension of Helmholtz's theory of perception: a deeper consideration of the role of endogenous motivational factors in determining both the internal and external senses.[9] One could in fact read Freud's theorisation of the mind since the *Project for a Scientific Psychology* (Freud, 1895) as attempting to formulate a psychology that dealt with that central problem. Freud's core question there was of how the brain, shut inside the skull, is capable of learning both about external reality as about the internal demands of the body so that it can accomplish the task of meeting the bodily needs in the environment.

This question, I believe, remained structurally the same in his later works – how is an infant, prior to any experience, capable of learning about themselves and the world around so that it can satisfy its needs and desires? The answer he provided in the *Project* persisted largely unaltered.

In the *Project*, Freud described a 'primary brain' as the source of the primal form of mentality, the predecessor of the primary process type of thinking. He argued that because the primary brain is directly connected to the interior of the body and shut off from the external world, it should be understood as a 'sympathetic organ' – that is, as responsible for signalling the body's 'endogenous excitations' (ibid., p. 302).[10] Increases in excitation, Freud maintained, are subjectively experienced as painful or unpleasurable, while pleasurable sensations are the subjective side of a quantitative experience of its pacification. The pacification of the endogenous sources of excitations, in turn, can only be brought about by an 'alteration in the external world (supply of nourishment, proximity of the sexual object)', which requires a 'specific action', such as feeding or nurturing. At first, 'the human organism is incapable of bringing about the specific action. It takes place by extraneous help, when the attention of an experienced person is drawn to the child's state by discharge along the path of internal change' (ibid., p. 318). This constitutes the first 'experience of satisfaction' of the infant, who is now capable, via a 'basic law of association by simultaneity', of linking the endogenous excitation with the object that pacifies it. As the association is one of memory (i.e., the memory of the experience of satisfaction being contiguous with the experience of the specific action), when an increase in endogenous excitation occurs again, it triggers a wishful activation of memory traces, which in turn produces the 'same thing as a perception – namely a hallucination' (i.e., a fantasy of wish-fulfilment; ibid., p. 319).

From *The Interpretation of Dreams* (Freud, 1900) onwards, Freud would introduce one important change to his previous model, derived from his encounter with the work of philosopher T. Lipps (Freud, 1985, p. 325). Consciousness starts being treated as 'a sense organ' (*Sinnesorgan*) that receives stimuli from both the external world as from inside of the body itself (Freud, 1900, p. 574), which it translates into sensory qualities – in the *Project*, this function had been instead attributed to the neurons ω. Sensory perception henceforth becomes thus an exclusive attribute of consciousness, which in the topographical model is designated by a single rubric, the *Pcpt-Cs.* system. The qualities of sensation, along those lines, do not derive directly from the excitations themselves but are a characteristic of our physiological organisation and mental attributes, and our only means of access to the distal causes of perception (both internal and external) is through a process of *translation* of physiological excitations ("quantities") into psychological sensations ("qualities") – which are, by Freud's own definition, conscious. The activity of translation functions, much as in Helmholtz's theory of signs, through a psychological process of inference onto the causes of the sensory excitation:

> Every science is based on observations and experiences arrived at through the medium of our psychical apparatus. But since our science has as its subject that apparatus itself, the analogy ends here. We make our observations through the medium of the same perceptual apparatus, precisely with the help of the breaks in the sequence of 'psychical' events: we fill in what is omitted by making plausible *inferences* and *translating* it into conscious material. In this way *we construct, as it were, a sequence of conscious events complementary to the unconscious psychical processes*. The relative certainty of our psychical science is based on the *binding force of these inferences*. Anyone who enters deeply into our work will find that our technique holds its ground against any criticism.
>
> *(Freud, 1938, p. 159; emphasis added)*

If consciousness alone has access to the qualities of the senses, Freud would contend that both the external world and the internal states are in themselves unknowable:

> The unconscious is the true psychical reality; in its innermost nature it is as much unknown to us as the reality of the external world, and it is as incompletely presented by the data of consciousness as is the external world by the communications of our sense organs.
>
> *(Freud, 1900, p. 613)*

Freud, therefore, subscribed to the Kantian dissociation between noumena and phenomena, and in particular to Müller's and Helmholtz's "egocentric predicament" that we only have direct access to our sensory organs. On this, he famously stated:

> Just as Kant warned us not to overlook the fact that our perceptions are subjectively conditioned and must not be regarded as identical with what is perceived though unknowable, so psycho-analysis warns us not to equate perceptions by means of consciousness with the unconscious mental processes which are their object.
>
> *(Freud, 1915b, p. 171)*

Given its role of providing sensory qualities to both the outer and inner senses, Freud stated that the *Pcpt-Cs*. system must lie 'on the borderline between outside and inside', since the perceptual image it provides consists of a *synthesis* of 'perceptions of excitations coming from the external world and of feelings of pleasure and unpleasure which can only arise from within the mental apparatus' (Freud, 1920, p. 24). Consequently, consciousness functions as a mediator between the internal and external worlds, with the role of translating endogenous and exogenous stimuli into sensory qualities, thus forming a unified perceptual image that must be a synthesis of both if it is to meet its purpose of meeting internal demands externally.

Action in Perception, or How to Test Your Hallucination

Considering the picture above, we have a model whereby perception is understood as a thoroughly constructed capability. At first, consciousness translates endogenous excitations into sensations along the lines of the 'pleasure-unpleasure series'. As the infant gathers 'experiences of satisfaction', it progressively learns to synthesise the outer senses with the inner sense (Freud, 1911a, p. 220), which are not yet differentiated. Whenever endogenous excitation is again increased, the infant hallucinates the satisfaction of its needs as a means of temporarily meeting the demands; the experience of hallucinatory wish-fulfilment constitutes, Freud says, the 'first psychical activity of the infant' (Freud, 1900, p. 566). This model provides us with one main reason why Freud – who, as often noted by his biographers, was chiefly interested in formulating a general psychology, and only secondarily in understanding and treating psychopathology – gave such central importance to the phenomena of dreams and hallucinations: they are not only analogous to perception, or yet abnormal states of perception, but are rather its original template. A perceptual image is, along those lines, the result of a reality-tested hallucination, and dreams and hallucinations are, reversibly, perceptual images that didn't go through the process of reality-testing.

A question is therefore raised as to what the task of reality-testing (*Realitätsprüfung*) exactly consists of; Freud unfortunately never managed to present a sufficiently clear definition. Although the problem prefigured in his earlier works, the term itself was first introduced in *Formulations*

on the Two Principles of Mental Functioning (1911a). It wasn't, however, until *A Metapsychological Supplement to the Theory of Dreams* (1917) that he would treat it more systematically. There, reality-testing is described as the mechanism whereby the infant learns to discriminate 'between what is internal and what is external' (ibid., p. 233). In *Negation* (1925b) and *An Outline of Psychoanalysis* (1938), on the other hand, Freud defined it as the mechanism of discrimination between vividly experienced ("cathected") memories and perceptions. Such a distinction constitutes, along the lines of the model above, a false dichotomy since an experienced memory is by definition conscious and an object of perception, while a perception is a mnemonic experience since the inferential process that generates the perceptual image depends on associations of past experiences. All that would be required for the pragmatic purpose of meeting internal demands in the external world is that impingements belonging internally and externally are sufficiently discriminated.

In either case, the means by which the infant learns to discriminate, Freud argued, is *action*.[11] Regarding the first differentiation, he said:

> The still helpless organism [acquires the] capacity for making a first orientation in the world by means of its perceptions, distinguishing 'external' and 'internal' according to their relation to its muscular action. *A perception which is made to disappear by an action is recognized as external*, as reality; *where such an action makes no difference, the perception originates within the subject's own body* – it is not real.
>
> *(Freud, 1917, pp. 231–232; emphasis added)*

Nearly paraphrasing Helmholtz, Freud contended it is muscular action that allows the infant to determine whether a sensation pertains to the inner or the outer world, which explains his later assertion that 'the ego is first and foremost a bodily ego' (Freud, 1923, p. 26) – something that had been germinating in his writings since the *Project* (cf. 1895, p. 331). Freud followed Helmholtz in arguing that percepts that can be changed are projected spatially, and extends the projection theory to percepts that cannot be altered – these, he claimed, are projected onto the body. The subjectively experienced body is the result of 'the projection of a surface' (Freud, 1923, p. 26) and something that, just like perception of external reality, is psychologically constructed. In short, the process of discriminating between the inner and outer worlds is something entirely learned, mediated by a psychological process of inference and projection (as well as translation into sensory qualities), and reality-tested via muscular action.

Freud also found in action and active exploration the means for discriminating between memories and perceptions. In *Interpretation of Dreams*, after discussing his theory of 'perceptual identity' – that is, the indiscriminateness between memory and perception in early mental life – he argued that since hallucinatory wish-fulfilment is insufficient as it only allows the infant to momentarily meet its demands, the task of lowering the endogenous sources of excitation becomes diverted to 'a second system, which is in control of voluntary movement – which for the first time makes use of movement for purposes remembered in advance' (Freud, 1900, p. 565). Freud maintained there that this experience constitutes, on the one hand, the origin of thinking while, on the other, it provides the mechanism for discrimination between memories and perceptions. Though he did not make it quite clear there how this is achieved, he would hint at it later in *Formulations*: 'the motor discharge was now employed in the appropriate alteration of reality; it was converted into action' (1911a, p. 221). Freud was here employing a similar strategy as previously: the act of discrimination between memories and perceptions is accomplished by changing our inner sense (i.e., by meeting a need and thus lowering excitation) through active exploration of the environment (i.e., by finding the

object of pacification), something that cannot be achieved in a sustained manner through hallucinatory wish-fulfilment alone. Reality-testing is, in short, provided by action and active exploration, and they are, according to Freud, the mechanisms that allow the infant to overcome its "egocentric predicament".

Seeing Through Illusions: Distortions, Repression, and Motivated Misapprehension

Helmholtz devoted a substantial amount of his research and writing to describe the many ways human vision was less than perfect. Visual illusions, afterimages, spherical aberration of the eyeball, astigmatism, vitreous opacities, binocular rivalry, and the physiological blind spots generated by the head of the optic nerve in the retina were just some of the topics approached. In these phenomena, he saw examples of how perception's

> extraordinary value depends on the way in which we use it: its perfection is practical, not absolute, consisting not in avoidance of every error, but the fact that all its defects do not prevent its rendering the most important and varied services.
>
> *(Helmholtz, 1856/1968c, p. 80)*

Further, in visual illusions, he observed the mind's inferential process of perception at work, constructing visual images based on previous experiences, generating false conclusions to the causes of visual cues. For Freud, instead, by giving serious consideration to the role of endogenous motivation in the generation of perceptual images, distortions of perception were no longer simply the matter of the misinterpretation (or rather, mistranslation) of a "neutral" stimulus based on previous experience but indicated a *motivated* process of misapprehension. While for Helmholtz the formation of complete visual images despite the retinal blind spot revealed the operations, in psychoanalytic terminology, of the descriptive unconscious, Freud in turn believed that 'through the gap in the retina one could see deep into the unconscious' (Freud, 1930, p. 14) – that is, the dynamic and purposeful unconscious.

Since the *Project,* Freud had pointed out that 'the pathological mechanisms which are revealed in the most careful analysis in the psychoneuroses bear the greatest similarity to dream-processes' (Freud, 1895, p. 336). In his later works, he would describe a range of mental phenomena that do not go through reality-testing: dreams, psychotic hallucinations, neurotic symptoms, fantasising (the satisfaction of wishes in "day-dreaming" activities in waking life) and, most importantly, the unconscious contents of repression:

> The strangest characteristic of unconscious (repressed) processes, to which no investigator can become accustomed without the exercise of great self-discipline, is due to their entire disregard of reality-testing; they equate reality of thought with external actuality, and wishes with their fulfilment – with the event – just as happens automatically under the dominance of the ancient pleasure principle.
>
> *(Freud, 1911a, p. 225)*

Considering that in order for a sensory impingement to be perceived it must go through a process of translation into sensorial qualities, which are conscious by definition, Freud would argue that when an impingement is deemed intolerable to the individuals' morals and in sharp conflict with their expectations of themselves, the content is repressed (i.e., inhibited) and *projected* spatially as belonging externally. This process, first described as the psychological

mechanism underlying paranoia (Freud, 1892, 1911b), was later extended as general defense mechanism characteristic of normal mental life (Freud, 1901, p. 255ff.). Because repressed unconscious contents cannot be directly perceived, they remain at an indiscriminate state since they cannot be reality-tested through action. As the internal contents are indiscriminate and still merged with the outer senses, the mind *purposefully* misattributes the origins of the causes of sensations as a means of avoiding unpleasurable experiences. Strictly speaking, as discussed above, projection itself is a psychological process underlying all perception, internal and external, while projection *as defense mechanism* is the act of motivated misattribution of perceptual contents. Similarly, the idea of transference – the act of misattributing perceptual contents and feelings from past experiences to present ones – is dependent on such a view of perception, whereby the contents of perception are psychologically constructed based on our history of interaction with the senses.

An analogous process of misattribution takes place at the origin of somatic disorders, says Freud – contents banned from conscious experience can also be projected onto the surface of the body:

> When one carries out the psycho-analysis of a hysterical woman patient whose complaint is manifested in attacks, one soon becomes convinced that these attacks are nothing else but *phantasies translated into the motor sphere, projected on to motility and portrayed in pantomime*. It is true that the phantasies are unconscious; but apart from this they are of the same nature as the phantasies which can be observed directly in day-dreams or which can be elicited by interpretation from dreams at night. [. . .] As a rule, owing to the influence of the censorship, the pantomimic portrayal of the phantasy has undergone distortions which are *completely analogous to the hallucinatory distortions of a dream*, so that both of them have, in the first resort, become unintelligible to the subject's own consciousness as well as to the observer's comprehension.
>
> *(Freud, 1909, p. 229; emphasis added)*

Whereas Helmholtz used the phenomena of visual illusions to make sense of the normal act of perception, Freud relied in acts of "'misknowledge" – in symptoms, parapraxes, dreams, and ordinary projections – to make sense of the ways in which misapprehension is motivated. Such acts provided access to both the motivations themselves and to the psychological processes underlying the formation of the misapprehended perceptual image. Through such means, an observer – an "interpreter of translations" – is able to trace back the inferences, thus bringing to light both the underlying mechanisms of how we obtain knowledge of ourselves and the world around, as well as how these may fail.

If Helmholtz contented that we do not have direct access to the properties of external reality but do have access to the structural relations *between* such properties, Freud defended a similar epistemological approach in regards to the unconscious structures underlying conscious experience. Such an inferential process from conscious to unconscious content, as he said, provided the only possible method for a proper psychological science: 'we construct, as it were, a sequence of conscious events complementary to the unconscious psychical processes. The relative certainty of our psychical science is based on the binding force of these inferences' (Freud, 1938, p. 159). This implies treating the unconscious contents *as if* they were carriers of sensorial qualities, thereby having access not to the unconscious processes themselves but to the structural relations *between* them. Such a methodological approach situates Freud's views within a form of epistemic structural realism, as applied to our inner senses.

Bursting Your Bubble: Predictive Processing and Embodied Inference

The view presented thus far brings Helmholtz's and Freud's theories in line with emergent trends in philosophy of mind and neuroscience that define the activity of agents (and in particular their brains) as one engaged in the task of prediction (Friston, 2010; Hohwy, 2013; Clark, 2016). According to the predictive processing (PP) framework, brains are biological systems that generate complex, self-organising hierarchies with the task of predicting their incoming sensory signals, where each level of the hierarchy statistically models the inputs from the level below all the way down to the sensory organs. Mismatches between the top-down predictive (Bayesian) models and bottom-up inputs are understood as "prediction-errors"; the brain, along those lines, is in charge of reducing prediction-error by either changing its models of the distal causes of sensation (perceptual inference and learning) or by performing actions to bring about sensory states in line with predictions (active inference; changing the world to fit the model; Friston et al., 2010). As Andy Clark noted, this is not so much a matter of predicting the future as that of 'trying to guess the present' by self-generating the sensory streams arriving from the world (Clark, 2017, p. 727).

Proponents of PP often cite Helmholtz as a precursor.[12] In machine learning, algorithms that operate by creating generative models of distal causes (also called "hidden states") are called *Helmholtz machines* (Dayan et al., 1995; Hinton and Dayan, 1996). Such proponents, however, disagree on its epistemological implications. The recent debate between philosophers Jakob Hohwy and Andy Clark provides a pertinent example. Hohwy contends that PP's inferential character implies a 'veil of uncertainty' between perception and reality, so that we should embrace some form of scepticism (Hohwy, 2013). Considering that PP entails acceptance of the argument from Müller's *Doctrine* for the double-dissociation between the causes of sensory input and its sensory effects, it 'tells us how neurocentric we should be: the mind begins where sensory input is delivered through exteroceptive, proprioceptive and interoceptive receptors and ends where proprioceptive predictions are delivered, mainly in the spinal cord' (Hohwy, 2016, p. 18).

Andy Clark, on the other hand, contends that the "neurocentric" character of PP is minimised by a deeper appreciation of the role of embodiment and enactment, thus proposing a similar pragmatic epistemology to the one offered by Helmholtz as a means of breaking with our sense boundaries. For Clark,

> predictive processing results in the creation and deployment of 'pragmatic action-oriented representations': inner states tailored to the production of good online control rather than aiming for rich reconstructive mirroring of some action-independent world. Neural processing thus delivers a grip upon a world of possibilities for action and intervention. Perception delivers a world parsed for action, while action harvests the perceptual flows that secure both epistemic and practical success.
>
> *(Clark, 2017, p. 748)*

In much the same line of argumentation, computational neuroscientist Karl Friston also suggests that PP implies a form of *embodied inference*, the 'notion that our interactions with the world are akin to sensory experiments, by which we confirm our hypothesis about its causal structure in an optimal and efficient fashion' (Friston, 2012), thus counterbalancing the potential scepticism from PP and bringing it closer to realism. Following Helmholtz, Friston demonstrated how the act of sensory active experimentation starts with eye movements (Friston et al., 2012). The process of minimising prediction error in this embodied and enactive framework is known as *active inference* (Friston et al., 2010).

A fuller appreciation of embodiment entails not only a consideration for the role played by action, but also to the one played by our bodily states in both interoception (the sense of the internal state of the body) and proprioception (sense of bodily movement and position). Following embodied inference, as Friston notes,

> not only does the agent embody the environment but the environment embodies the agent. This is true in the sense that the physical states of the agent (its internal milieu) are part of the environment. In other words, the statistical model entailed by each agent includes a model of itself as part of that environment.
>
> *(Friston, 2011, p. 89)*

In interoceptive active inference, the body itself is deemed an object of inference and is seen as constructed from inferential hierarchical models, with higher levels 'integrating interoceptive, proprioceptive and exteroceptive cues in formulating descending predictions' (Seth, 2013, p. 567) – that is, forming a synthesis of the senses in the unified perceptual image. Such an extension of PP into the body and its internal states displays an isomorphism with Freud's extension of Helmholtz as described above.[13]

Freud had also proposed that inferences of internal states provided the initial prototypes for perception, which was progressively synthesised with the outer senses via experiences of satisfaction, with whom they subsequently formed a relation of co-dependence. Similarly, Anil Seth contends that a model of *interoceptive inference* starts with 'a desired or inferred physiological state' (ibid., p. 568) for creating generative models of both exteroception and interoception, so that 'the close interplay between interoceptive and exteroceptive inference implies that emotional responses are inevitably shaped by cognitive and exteroceptive context, and that perceptual scenes that evoke interoceptive predictions will always be affectively coloured' (ibid., p. 571). Such a co-dependence between inferred internal states (emotions) and inferred external percepts would imply that perceptions are not only 'affectively coloured' but affectively constructed. As affective researcher Lisa Barrett argued, 'the brain's ability to see in the present incorporates a representation of the affective impact of those visual sensations in the past,' where 'personal relevance and salience are not computed after an object is already identified, but may be part of object perception itself' (Barrett and Bar, 2009).

The Phantastic Organ and Unconscious Phantasy

The narrative above leads us to the picture of the brain as a 'phantastic organ' (Friston et al., 2014), that is, a biological structure capable of generating mental images (from Greek *phantastikos* = able to create mental images) that inferentially explain the causes of its sensory impingements. Similar claims have been made by various other proponents of PP, such as Chris Frith ('our perception of the world is a fantasy that coincides with reality'; Frith, 2007, p. 111) and Anil Seth ('we're all hallucinating all of the time, and when we agree about our hallucinations, that's what we call reality'; Seth, 2017). Though such assertions are by no means equivalent, they all convey the view that perception, hallucination, and fantasy are a lot more intertwined than formerly conceived in traditional cognitive science accounts, and that they serve the function of providing hypotheses about the causes of sensory impingements – which, as we have seen, have the nature of 'pragmatic action-oriented representations' (Clark, 2017, p. 748) rather than realistic copies of reality. This brings their views not only close to those of Freud, but also to later conceptual developments in psychoanalysis in the notion of unconscious phantasy by Klein.

Melanie Klein was notoriously not a very methodical theoretician. For instance, she never formally defined unconscious phantasy, and the concept became the most contentious topic of the *Controversial Discussions* (King and Steiner, 1991, p. 242ff.). The task fell instead to her followers and colleagues, such as Susan Isaacs and Hannah Segal. In *The Nature and Function of Phantasy* (1948), Isaacs provided its most coherent formalisation. Phantasy there was defined as the mental representative of the drives, which were henceforth understood as the purely physiological, non-mental, primarily somatic impingements. As such, phantasies were conceived as the primary content of all mental processes, and the basis 'of all unconscious and conscious thought processes' (Isaacs in King and Steiner, 1991, p. 277). Further, Isaacs argued that a hallucination is 'either identical with phantasy or the pre-condition for it' (ibid., p. 278). Unconscious phantasy, along those lines, is a primal picture – mostly visual, but not only – representing the internal bodily states of the infant, which grants it access to its own internal states and the world at large. Progressively, according to this account, external objects also become "introjected" (i.e., internalised, or modelled in the form of internal objects) and are reversibly used by the infant to represent internal processes, with whom they form a relation of co-dependence. This matches closely to what Klein described when she said:

> In the process of acquiring knowledge, every new piece of experience has to be fitted into the patterns provided by the psychic reality which prevails at the time; whilst the psychic reality of the child is gradually influenced by every step in his progressive knowledge of external reality.
>
> *(Klein, 1940, p. 129)*

Hannah Segal, in turn, would extend this analysis by likening unconscious phantasy to a type of *hypothesis* about the causes of sensory impingement: 'I think that it is implicit in desire that it gives rise to a phantasy of its fulfillment. A phantasy is like a wishful hypothesis which is constantly matched with reality' (Segal, 1994, p. 399). The infant is therefore likened – much as in Helmholtz – to a scientist conducting perceptual experiments, testing its hypothesis of reality: 'I see the infant experimenting in preverbal phantasy and testing in external reality as a budding scientist, and a successful one' (ibid., p. 400). By reality-testing its hypothesis, the infant is thus capable of using symbols, since only after achieving discrimination between internal and external realities in the depressive position does the symbol become 'a representation of the object rather than being equated with the object' (Segal, 1981, p. 90). In short, unconscious phantasy came to be understood in the Kleinian tradition as type of innate hypothesis, in the form of a perceptual image, about the origin of sensory impingements which allows them to be reality-tested, thereby learning to discriminate not only between inner and outer worlds but also between things and symbols.[14]

Such a view shares a close parallel to Friston and Hobson's notion that the brain is 'genetically endowed with an innate virtual reality generator' (Hobson and Friston, 2014). Allan Hobson, dream researcher and notorious anti-Freudian (Hobson, 2011), had previously proposed his *protoconscious theory*, the theory that a form of primal consciousness (both developmentally as evolutionarily) provides mammals and birds with an innate virtual reality model of the world, whose working is most clearly revealed in dreams. REM sleep – the sleep phase when most dreaming, and also the longest and most structured dreaming, occurs – developmentally reaches its peak in the third trimester of gestation, and it is progressively supplanted by what Hobson called *secondary waking consciousness*, 'the awareness of the external world, our bodies and our selves (including the awareness of our awareness) that humans experience when awake' (Hobson, 2009). Similar mechanisms of primal consciousness underlie not only dreams but also psychedelic states and psychosis (Carhart-Harris, 2007; Carhart-Harris et al., 2012, 2014, 2016). The

hyper-activation of the brainstem in REM sleep, combined with the 'active suppression of both external sensory input and motor output' (ibid.), indicates that its main purpose is one of homeostatic regulation, and that the form of mentality correlated with this state is highly affective in nature (cf. Solms, 2014) – much as in Freud's description of primary process thinking (or the role of the "primary brain" from the *Project*) and the function of dreaming, as well as in the Kleinian notion of unconscious phantasy.

By embedding this theory into a PP framework, the 'virtual reality generator' becomes conceptualised as an innate model of belief used to infer the causes of sensory impingement via active inference. Consciousness, along those lines, 'is an operation that produces beliefs and is therefore quintessentially inferential in nature' (Hobson and Friston, 2014, p. 17), whose origin is prior and independent of secondary waking consciousness, so that 'sleep is just a special instance of conscious processing that is untethered from the sensorium,' thus 'generating fictive sensations, using generative or virtual reality models' (ibid.). Following this view, *qualia* – the name contemporary philosophers gave to the "qualities" of consciousness that Freud discussed – are seen as 'probability distributions over the hidden causes of sensations' (ibid., p. 22) embedded in the hierarchical models of the brain and, like in Helmholtz, they are understood as "signs" constructed by the brain with the purpose of granting access to the structural relations between objects (including our own bodies) and our sense organs.

Conclusion

Much as in Plato's allegory of the cave, according to Helmholtz's theory of perception we are unable of directly perceiving reality, relying instead on "shadows" to infer the true nature of the external world. Unlike chained prisoners in a cave, however, we are capable of moving and actively experimenting with our sensations as a means of testing our inferences, thereby reaching a practical, action-oriented representation of reality. Freud accepts and extends this theory by arguing that similar processes of action-focused inference take place in the realm of the inner sense. It is through action that we "reality-test" our inferences, thus learning to discriminate what belongs internally to what belongs to the world outside. Further, since the inner and outer senses must go through a process of synthesis to form a unified perceptual image so as to satisfy its purpose of meeting the internal demands externally (and thus, staying alive), they mutually influence one another in a relation of co-dependence.

Contemporary PP approaches reach very similar conclusions. Our access to the world and ourselves takes place via 'pragmatic action-oriented representations' that infer the causes of the sensorium by actively generating models ("hypotheses") that predict its inputs, testing them against the actual sensory signals through action. If perceptions are thus seen as hypotheses tested in reality, a question is raised as to what the first (original) hypothesis consists of. Authors in the Kleinian tradition have called this primal hypothesis 'unconscious phantasy', while Hobson and Friston called it an innate 'virtual reality generator'. In both cases, the primal model of hidden states is said to be closely linked to REM sleep and dreaming. As Hopkins aptly summarised:

> On both accounts waking consciousness is underlain by an original imaginary (virtual reality/phantasy) process that later appears mainly in dreaming, and whose operation in waking is constrained by a model or system of representations of the causes of sensory impingement. On both, therefore, a central aspect of development consists in constructing the worldly model whose adherence to reality inhibits and overlays the imaginary process in waking.
>
> *(Hopkins, 2019, p. 383)*

Further, it was argued that the perspectives of Helmholtz and Freud implied a form of epistemic structural realism, the view that structural relations between simple perceptual properties convey knowledge of structural features of reality. In particular, it was contended that Freud extended Helmholtz's arguments for a structural epistemology of external perception towards the inner sense of our unconscious states. Such a perspective underlined not only their theories of perception but also their philosophies of science.

The legacy of sensory physiology, I have tried to show, runs deep and remains present in contemporary psychoanalysis, as exemplified in the Kleinian school. Understanding this intellectual influence is significant, as it allows us to place Freud's views within a certain philosophical tradition, originating in Kant and continued to this day. Such an approach also allows for an integration of different psychoanalytic theories to one another, as well as of psychoanalytic theory with theories derived from other sciences – including the neurosciences, the biological sciences, as well as phenomenology and psychiatric phenomenology, given the embodied and enactive implications of this theory of perception. This reading, most importantly, also avoids the difficulties implicit in views that attempt to exclude causal approaches in psychoanalysis, aiming to convert it exclusively into a hermeneutic discipline and thereby isolating psychoanalysis from its neighbouring sciences – ultimately, in my view, leading to its asphyxiation. Psychoanalysis was born as a *bridge* discipline, aiming to formulate a theory of mind that integrated the subjective and objective selves, the internal and external worlds, the mental and somatic, understanding and explanation, meanings and causes. Obliterating one of its margins not only renders the bridge irrelevant but destroys the foundation upon which the whole structure rests.

Acknowledgements

I would like to acknowledge Mark Solms, Matt ffytche, Bruno Rates, and Richard Simanke for the helpful comments to an earlier version of this chapter, as well as Jim Hopkins for the many conversations surrounding topics explored here.

Notes

1 Josef Breuer was also closely associated with the group, being an intimate friend and collaborator of both Fleischl and Exner. His training in physiology, however, took place under J. Oppolzer and E. Hering, who shared views on the nature and methodology of their science in many ways opposed to that of Brücke. Breuer's standing in relation to the organic physics programme, therefore, is a more complex one that was discussed in length by Hirschmüller (1989).

2 Though Kant never made the explicit statement that the *a priori* categories were innate, this was how it came to be interpreted by nineteenth-century German physiologists, who turned it into a research question on the origins of perception (cf. Hatfield, 1990; Turner, 1994).

3 The only exception, Helmholtz would argue, is the causal law; it is a requirement of the empiricist theory and something that could not be learned by experience (Helmholtz, 1878/1968a, p. 226). In Helmholtz's theory, the causal law functions as a "law of lawfulness", thus taking on the role that Kant ascribed to the transcendental.

Müller, in turn had already significantly diverged from Kant at points. These were analysed in greater detail by Lenoir (2018) and Isaac (2019).

4 Müller, in turn had already significantly diverged from Kant at points. These were analysed in greater detail by Lenoir (2018) and Isaac (2019).

5 Müller had, for instance, defended the theory that stereoscopic (binocular) vision was unified into a single perceptual image via anatomical tracts uniting each retinal point to the one in the opposite retina. Brücke's first publication, written shortly after starting work as his assistant, was a defence of Müller's theory of identity of retinal spots against Wheatstone's attack (Brücke, 1841). He would later follow Helmholtz in rejecting it (Brücke, 1876, p. 138ff.). For more on Brücke's work on physiological optics,

see Schickore (1999, 2007). For more on the nativism-empiricism debate, see Turner (1994) and Hatfield (1990).

6 One such example of a disposition: 'When those nervous mechanisms whose terminals lie on the right-hand portions of the retinas of the two eyes have been stimulated, our usual experience, repeated a million times through life, has been that a luminous object was over there in front of us on our left. We had to lift the hand toward the left to hide the light or to grasp the luminous object; or we had to move toward the left to get closer to it' (Helmholtz, 1855/1903, p. 26).

7 Helmholtz at points also states that the reverse is the case, that is, that the activity of the scientist is an extension of our natural capacity for perceptual learning: 'The same great importance which experiment has for the certainty of our scientific convictions, it has also for the unconscious inductions of the perceptions of our senses. It is only voluntarily by bringing our organs of sense in various relations to the objects that we learn to be sure as to our judgements of the causes of ours sensations. This kind of experimentation begins in the earliest youth and continues all through life without interruption' (Helmholtz, 1867/1962, pp. 30–31).

8 In his letters to his friend E. Silberstein, Freud remarks on his reading of Helmholtz's "Lectures" and his intention of spending the winter semester of 1875–76 in Berlin 'in order to attend the lectures of du Bois-Reymond, Helmholtz, and Virchow' (Freud, 1990) – which never occurred. He was probably referring here to Helmholtz's three-volume *Populäre Wissenschaftliche Vorträge*, published in 1871.

9 Which indicates the influence of yet another "philosopher-physiologist" highly influenced by Kant: Schopenhauer. His early work on the physiology of vision, the treatise *On Vision and Colours* (1816) shared many similarities with Helmholtz's; after reading *On Human Vision* (1855/1903), Schopenhauer in fact accused Helmholtz of plagiarism. The charge was dismissed by the latter, who attributed the similitude to their common Kantian influence (Cahan, 2018, p. 193ff.).

10 As I argued in a previous article (Niro, 2017), Freud's notion of a primary brain responsible for signalling endogenous excitations (i.e., the internal milieu) was derived from his anatomical studies of the spinal cord and medulla oblongata (Freud, 1882, 1884, 1886, 1888; Freud and Darkschewitsch, 1886; Freud and Ossipowit, 1886) conducted while an assistant at T. Meynert's psychiatric institute. The idea of a primal brain, both phylogenetically and ontogenetically, appears for the first time in his monograph *On Aphasias*, where he says: 'The whole organization of the brain seems to fall into two central apparatuses of which the cerebral cortex is the younger, while the older one is represented by the ganglia of the forebrain which have still maintained some of their phylogenetically old original functions' (Freud, 1891/1953, p. 49).

11 Freud had also previously articulated this argument in "Instincts and their Vicissitudes" (Freud, 1915a, p. 119).

12 Though this is true in some aspects, it is certainly not in others. Given its impact since the nineteenth century, a wide range of perception researchers, including more contemporary authors such as Richard Gregory (1974) and proponents of PP, have been highly influenced by Helmholtz's treatment of perception as an inferential process. Helmholtz, however, only rarely discussed the brain itself, and in his *Handbook* he squarely situated the study of perception as belonging to the domain of psychology (Helmholtz, 1867/1962, §26). In the physiology section of the book (volume II), his analysis did not go further than the retina and the optical nerves.

13 Although different in points, a more detailed consideration of the consilience between psychoanalytic and PP frameworks was provided by Hopkins (2012, 2016, 2018, 2019) and Solms (2014, 2019).

14 In a Helmholtzian terminology, what Segal calls a representation of a thing is already a symbol. What she calls a symbol, along those lines, would be a "symbol of a symbol".

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