

G. F. PARROT AND THE THEORY OF UNCONSCIOUS INFERENCES

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In 1839, Georg Friedrich Parrot (1767–1852) published a short note about a peculiar visual phenomenon—the diminishing of the size of external objects situated at a relatively small distance from the window of a fast-moving train. For the explanation of this illusion, Parrot proposed a concept of unconscious inferences, a very rapid syllogistic conclusion from two premises, which anticipated the revival of Alhazen's theory of unconscious inferences by Hermann von Helmholtz, Wilhelm Wundt, and John Stuart Mill. He also advanced the notion that the speed of mental processes is not infinitely high and that it can be measured by means of systematic experimentation. Although Parrot was only partly correct in the description of the movement-induced changes of the perceived size, his general intention to understand basic mechanisms of the human mind was in harmony with the founding ideas of experimental psychology: it is possible to study the phenomena of the mind in the same general way that the physical world is studied, either in terms of mechanical or mathematical laws. © 2005 Wiley Periodicals, Inc.

In September 1839, a celebrated member of the Imperial Academy of Science of St. Petersburg, Georg Friedrich Parrot (1767–1852), published a short note about a peculiar visual phenomenon he had observed in a fast-moving train commuting between Pavlovsk and St. Petersburg (Parrot, 1839). The seventy-two-year-old academician, who for a while had been in friendly relations with Emperor Alexander I of Russia, reported to his readers a spectacular visual illusion that manifested itself in the relative diminution of the size of external objects situated at a relatively small distance. According to Parrot's observations, this apparent reduction of objects depended on the speed of movement. When the speed of the train attained its ordinary maximum, guardhouses and men situated close to the train seemed to have only half of their regular size, and one might have an impression, as he put it figuratively, of being transported through a land of dwarfs. As the speed of the train decreased, the men and buildings grew in size, and when the speed was 10 or 15 ft per second, the objects appeared approximately in their ordinary size.

As far as we know, no one else had described the apparent reduction of the size of moving objects before Parrot. It would be logical to expect that many observers should have noticed this dramatic effect during 165 years that have passed since Parrot published his observations. However, nobody appears to have confirmed or independently rediscovered the phenomenon described in Parrot's paper, at least not exactly in the same form as he reported it. Perhaps for this reason, this publication has been forgotten, and Parrot and his peculiar visual phenomenon have not been mentioned in any comprehensive treatments of the history on movement perception (e.g., Anstis, 1986; Boring, 1942; Helmholtz, 1910; Wade, 1998). Was the described phenomenon only the creation of the vivid imagination of a respectable but aging academician?

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We shall preface a new English translation of Parrot's original paper with a brief biographical sketch.

WHO WAS GEORG FRIEDRICH PARROT?

Georg Friedrich (Georges-Frédéric) Parrot was born on 5 July 1767, in Montbéliard, France. His father, a surgeon by profession and the local duke's physician in ordinary, had a respectable position in the society, becoming the mayor of his hometown. As the family was Protestant, they sent Georg Friedrich to study physics and mathematics in Stuttgart (1782–1786) rather than somewhere in France. After graduation, Parrot came as a private tutor to Livonia, one of the Baltic provinces of the Russian Empire (cf. Drechsler & Kattel, 2000), in 1795. His reasons for leaving Germany were mainly economic: as he was recently married, he needed a more regular income than he could gain from giving occasional private classes in mathematics and attending to various contests of inventions. His talent was noticed, and he was appointed to be the first secretary of the Livonian Charitable and Economic Society (*Livländische gemeinnützige und ökonomische Sozietät*), founded in 1796 in Riga, the capital of Livonia, for the promotion of science and new ideas of management. At that time, there was no longer a university in the region. Although King Gustav II Adolphus had founded the University of Dorpat in 1632 as a Swedish university, it had ceased to exist in 1710 when Peter the Great had conquered the Baltic Sea provinces. Only in 1802 was the university refounded by the order of Emperor Alexander I as the only German-language and Lutheran university inside the Russian Empire (Siilivask, 1982, p. 4). Parrot was initially appointed to the Chair of Pure and Applied Mathematics but after defending his doctoral dissertation "On the Influence of Physics and Chemistry on Pharmacy" (*Über den Einfluss den Physic und Chemie auf die Arzneikunde*) in 1802, he was appointed to the Chair of Physics. Due to his extraordinary energy, he became the first rector of the Imperial University of Dorpat, being elected by the University Council consisting of all chaired professors. In this capacity, Parrot skillfully fought for the academic freedom and the self-government of the university, protecting it from the political pressure of Baltic German barons who had been given the right to autonomously govern in the Baltic provinces. The university was reopened on the initiative of the local aristocratic establishment, but they disliked Parrot for his unconcealed sympathy to the ideals of the Enlightenment. Parrot openly talked about equality of people, irrespective of their social status and heritage. In his inaugural speech at the opening ceremony of the university he said, addressing the students:

While you are using with a laudatory diligence all that science and art are able to provide for the benefit of your culture, the countryman is working for you on his field; he is devoting his toil for you, working in the hardest conditions all his days, even part of the nights, and because of that he is forced to fall behind you in his cultural development. . . . You understand that those who feed you are entitled to much more than merely a miserable existence, that they have every right to expect your gratitude, your respect, our gratitude, our respect. (Jäsche, 1803, p. 4)

According to the memoirs of Parrot's contemporaries, these words made an inextinguishable impression. However, Parrot's greatest hour of triumph arrived on 22 May 1802. Emperor Alexander I stopped in Dorpat on his way to Memel (Klaipeda) for the meeting with King Frederick William III of Prussia. Parrot was nominated to give a speech in his honor, with which he immediately won the sympathy of the young and ambitious emperor. Appealing to the ideal of enlightened monarchy, Parrot expressed his gratitude to the Emperor, who had ordered the reopening of the university, and repeated the promise to hon-

estly serve science and the whole of humanity. Alexander was so delighted with Parrot's eloquence that he asked him to prepare a written copy of his speech. This episode laid the foundations of a friendly relationship between the emperor and Parrot, which lasted for ten years and proved to be extremely beneficial for the university, to say nothing about Parrot himself (Bienemann, 1902; Krause, 1902).

In 1811, Parrot was elected to be a corresponding member of the Academy of Sciences of St. Petersburg, becoming a full member in 1826. In the same year, he retired from the University of Dorpat and continued his work as a head of the physics laboratory of the Academy of Sciences in St. Petersburg. He died on a trip to Helsingfors (Helsinki), in 1852.

Parrot as a Scientist

Although Parrot's administrative and rhetorical skills outweighed his achievements in physics, his contribution to science should not be neglected. He was one of the first to propose a chemical theory of osmosis (Parrot, 1840; Kaptsov, 1949) and to develop a chemical theory of galvanic electricity (Parrot, 1838; Spasskij, 1963, p. 264).

The paper under discussion here was certainly not the first in which Parrot discussed and tried to explain the mechanisms of human perception, although during his lifetime, the line between physics and psychology was very thin. In the second volume of his textbook of theoretical physics, *Grundriß der theoretischen Physic* (published in 1811), he described not just classical optical phenomena, but also problems that, without a doubt, belong to the category of human perception (Parrot, 1811). For example, one of his favorite subjects was a mechanism by which the distance of objects could be estimated. Parrot also discussed a method by which the duration of visual impression can be measured.

The method by itself, as Parrot noticed, was not new. If one rotated a rod glowing from one end with a sufficient speed, then the perceived trace of light seemed to form an uninterrupted circle. Because the glowing tip of the rod cannot be in all places simultaneously, it must mean that the duration of sensory impression lasts until the rod makes the full turn. Thus, Parrot concluded, it is possible to determine the duration of sensory impressions. Indeed, this fact was already known to Ibn al-Hayatam (Alhazen) and Leonardo da Vinci (Wade, 1998, p. 195). Parrot himself mentioned Johann Andrea von Segner (1704–1777), to whom he had attributed the idea of the experiment and the determination of the duration of sensory impression, which is close to one-half of a second (Parrot, 1811, p. 111). According to Parrot's own observations, the duration of sensory impression is about a quarter of a second in the dark and about one-sixth of a second in the light (Parrot, 1820). This last value is very close to a figure reported by the Chevalier Patrice d'Arcy (1725–1775), who did similar experiments in 1765 (Ramul, 1963; Wade, 1997, 1998, p. 196). Both values correspond closely to those obtained later with much more sophisticated experimental devices. What is particularly remarkable is that Parrot was reporting these values fully aware of the general logic by which the persistence of the visual system could be established (cf. Wade & Heller, 1997).

There was nothing unusual in Parrot's interests in perceptual phenomena. Almost every famous physicist of the nineteenth century, from Michael Faraday to Ernst Mach, left his trace in the history of vision by describing at least some new optical phenomena. Boring characterizes the general intellectual atmosphere at this time as the following: "The period under discussion—about 1825–1850—was, however, an era of popular scientific interest in the magic of illusions, the period of invention of the stroboscope, the stereoscope, the kaleidoscope and numerous other trick instruments for exciting wonder by deceiving the eye, instruments which scientists described and which then found their way into the parlours of the

Victorian intellectuals” (Boring, 1942, p. 588). The observations published by Parrot fit well into this picture. The steam engine, which gives to trains their required speed, joined other trick instruments that could deceive the eye and, through the distortion, reveal processes that are hidden from our usual experience. The steam engine, as Parrot noted in a moralistic manner, could be useful to mankind, but had also by the unrestrained fervor of an overdone industry become an infernal machine, “deleterious to the happiness and morality of people” (Parrot, 1839, p. 141).

We can conclude that Parrot, operating within a generally favorable intellectual atmosphere, was prepared to examine not only the mechanics of nature, but the mechanics of the human mind as well. Dorpat, where he spent the most productive years of his academic career, was particularly stimulating in this pursuit, thanks in large part to the existing academic spirit created by his own efforts and diplomatic skills.

For example, in 1811, Parrot organized a special stipend for a talented philology graduate, Friedrich Georg Wilhelm Struve (1793–1864), to continue his studies in a completely new direction—mathematics and astronomy. Just a few years later, in 1813, Struve became a director of the Dorpat observatory in exactly the same year a new observatory was erected in Königsberg under the supervision of Friedrich Wilhelm Bessel (1784–1846), who, in order to improve the precision of astronomical observations, proposed to calibrate observers by establishing their, as they came to be called, personal equations. Bessel was especially anxious to compare himself with Struve, who already had earned a reputation as being one of the best observers. Having no opportunity for a direct comparison, Bessel used data of three other assistants, Walbeck, Argelander, and Knorre, who visited Dorpat in 1821, 1823, and 1825, respectively, and compared their observation data with Struve. Through them, Bessel established indirectly the relation between the personal observation times of himself and Struve. Only in 1834 did Bessel and Struve find an opportunity to compare themselves directly and confirm the indirect predictions (Boring, 1957, p. 137). Although the personal equations did not solve any astronomical problems, these experiments clearly demonstrated that the speed of mental processes varies from one individual to another and that these individual differences are large enough for being subjected to an experimental analysis. It is very unlikely that Parrot was unaware of the problem or the studies in which his protégé and later fellow academician Struve was participating.

Among Parrot’s students was also his son, Johann Jakob Friedrich Wilhelm Parrot (1791–1841), who, after medical studies at the home university, became the first holder of the Chair of Physiology, Pathology, and Semiotics from 1821 to 1826, when he inherited his father’s Chair of Physics after the latter’s departure for St. Petersburg. Like his father, he also served as a rector (1831–1834) but is better remembered for his mountaineering accomplishments: he became the first mortal since Noah to reach the summit of Mount Ararat on 9 October 1829.

It is interesting to note that one of the next holders of the Chair of Physiology, Pathology, and Semiotics was Alfred Wilhelm Volkmann (1800–1877), listed by Boring as one of the “founding fathers” of experimental psychology (Boring, 1957, p. 384). One of his greatest scientific achievements was the first published scientific proof of inhibition in the nervous system in 1838, a type of action that was unknown until then (Käbin, 1986, pp. 78–82). After moving to Halle, Volkmann helped Fechner, his brother-in-law, with many experiments that formed the foundation of the epochal *Elemente der Psychophysik* (Boring, 1957, p. 281).

Therefore, it is perhaps not a mere coincidence that Emil Kraepelin, the beloved student of Wilhelm Wundt, who was elected to hold the Chair of Psychiatry at Dorpat in 1886, wrote

later in his memoirs, "The conditions for starting a school of psychology in Dorpat were favourable" (Kraepelin, 1987, p. 44).

TRANSLATION OF PARROT'S ARTICLE: "NOTICE ABOUT AN OPTICAL PHENOMENON OBSERVED ON RAILWAYS"¹

What can optics, one might ask, have in common with railways? This expression of a very natural doubt proves that there still exist some unknown relations between the parts of physical sciences that are most heterogeneous in appearance. Here is the phenomenon:

When one is in a car that is being carried at a high speed by a locomotive, external objects situated at small distances seem to diminish in size.

I have observed this phenomenon on every one of my railway trips from Pawlowsky to St. Petersburg. Guardhouses situated at a distance of a few yards seem to have hardly a half of their real size and, likewise, men standing in their proximity; one might indeed have an impression of being transported through a land of dwarfs. As the speed of the train lowers, the men and buildings grow in size. When the speed of the train attains its ordinary maximum, which is in this route approximately 40 feet per second, the diminution is also at its maximum, and when the speed is lowered up to 10 or 15 ft per second, the objects will appear to us approximately in their ordinary size.

It is thus the speed of movement on which this apparent diminution of objects depends. Now the problem consists of explaining how the diminution is produced by the movement of the observer.

Everyone knows that when an object is at a double, triple, quadruple, etc. distance of the eye, its visual angle diminishes proportionally. So an object placed successively at a distance of 2, 4, 6, 20 ft from the eye should seem to us as two, three, [four],² ten times smaller [larger]³ than at the first distance, because it covers at every one of these distances a surface of objects in inverse proportion of the distances. Nevertheless, it seems to us to be of the same size, except when the distance grows considerably; in that case it will seem to have diminished to the point that it eventually disappears entirely.

At the time when we have a perception of an object at smaller and smaller visual angles, we also have that [perception] of external objects situated between the object and the eye, and this last perception will allow us to form an idea of the distance of the observed object, and the approximate measure of that distance, as I believe to have proved in my Theoretical Physics.

From the idea and the measure of the distance, we infer the real size of the object. Thus, in addition to two perceptions, our soul performs two operations; it forms for itself an idea and draws a conclusion that does not miss any of the two premises of a complete syllogism. All this occurs with such rapidity that we consider the time necessary for these operations to be infinitely short; the speed is higher than any of the known movements. The speed of the thought has become a proverb. But is that true? Is the time necessary for these operations of our soul really infinitely short? The speeds observed on the railroads prove the opposite.

When the eye of the voyager, carried with a high speed by the locomotive, notes an external object at a small distance, it sees the object diminished because the soul does not have time to judge the distance with a certain accuracy and with the necessary promptitude; it

1. See Parrot (1839). This translation was done by Kenn Konstabel.

2. This is obviously a typographic or editorial error. The correct sequence, of course, should be "two, three, and ten."

3. Another indication that whoever edited or printed Parrot's text did not grasp the meaning of this sentence. The retinal projection becomes smaller with the increase of distance, not larger as it is in the text.

judges therefore the distance of the object and its size, partly on the basis of the former imperfect judgment and partly on the basis of the visual angle, which the soul does not have time to specify with accuracy. The first of these two imperfections comes from the fact that the soul does not distinguish, in the very short time that the locomotive allows it, all the external objects that [ordinarily] serve as a measure of the distance; because the more clearly one perceives these interposed [intercalés] objects, the larger the distance appears to us, and vice versa. If, for instance, one walks in an obscure forest, any distant and lightened object appears close to us, well more than it is really.⁴

This way, the judgment that our soul makes about the size of the objects is based on a preliminary false judgment. The minor premise of its syllogism is false.

When the observed object is at a large distance, we perceive many objects and long enough in order to estimate its distance, and the law of perspective enters in its rights; the object does not seem smaller than this law dictates. When, on the other hand, the object is close enough to the observer, then its visual angle is large enough to let the soul, while the observer looks at it, form its judgment. These two effects are confirmed by experience.

For the first case, I have the towers of Tsarskoye Selo as an object of observation, the towers that one notices soon after having left the park of Pawlowsky; one is then at approximately three-and-one-quarter versts from these towers,⁵ and when one has arrived at the station where one will stop, the distance is no more than one-and-a-half v. At approximately one-half v. from the station, the locomotive still moves at its maximum speed; at that distance, it starts continuously to lower its speed in order not to stop brusquely. At the beginning of the last verst, the distance of the observer from the towers of Tsarskoye Selo is 1.58 v., and at its end, as we have said, 1.50. The difference of one-nineteenth is too small to have a noticeable impact on the stationary voyager's observation. Thus, if the lowering of speed to 0 has any influence in this case, the apparent size of these towers should considerably increase, which does not take place.

As for the second case, we take the example of an observer passing a range of standing cars. This happens often when two trains meet on two railroads so close to each other that the inhabitants of the cars could easily shake hands with each other, and one might be afraid that the rails would approach to each other. However rapidly the observer moves in this case, the other cars and their inhabitants are perceived absolutely in their natural size.

Thus, for any given distance of an observed object, there is a speed of the observer that causes the maximum diminishment of size; and for a given speed, [141] there is the distance that produces this maximum. Out of the limits of those two maximal values, the diminution will be reduced until 0.

Physics has already succeeded in measuring the duration of visual sensations by an inverse method, by making objects move with variable speed in face of a stationary observer. The cited observations prove, already today, that the soul needs a certain time to form its ideas and to make its judgments about vision. New and exact observations, made on locomotives moving at given speeds and with objects placed on measured distances, could instruct us about the time that our soul uses to form its ideas and make judgments, the time that we until today have believed to be infinitely short [hors de toute mesure], and of which we were not even aware—an astonishing result that we owe to the steam engine, which could be so useful to mankind but which by the unrestrained avidity of an overdone industry has become an infernal machine, deleterious to the happiness and morality of peoples.

4. I could multiply the number of the examples, but only one is enough here. The reader will be able to remember similar ones that he or she has observed.

5. A verst is a unit of distance equal to approximately .66 miles or 1.06 kilometers.

HOW DID PARROT EXPLAIN THE PHENOMENON?

Parrot began his explanation with reference to the size constancy mechanism: although the size of the retinal image is known to decrease proportionally to the viewing distance, the perceived size remains unaltered. How can this be achieved? One obvious solution is to take the viewing distance into account and to compensate for the reduction of retinal projection in proportion to the viewing distance. There was nothing new in this proposal. The size constancy was described already by Ptolemy (Smith, 1996) and Alhazen (Sabra, 1989a), and after Descartes, Malebranche, and Berkeley, it became part of the common knowledge of educated people (Wade, 1998, pp. 349–353). According to Berkeley, for example, the size of objects is a property not immediately given and cannot be “seen” in the proper sense of the word. If we perceive the magnitude of objects at all, it is by taking distance into account (Berkeley, 1709, p. 195). However, association mediates the process of taking into account, not judgment or inference (Hatfield, 2002). Parrot obviously shared this by-then common doctrine: the real size of an object is suggested by the idea and the measure of distance. One of the mechanisms by which the distance can be measured is to count the objects between the object and the eye. The idea that the number of interposed objects can serve as a cue of distance was also not new; Jacques Rohault (1620–1675) formulated this potential cue for distance already in 1671 (Wade, 1998, p. 356). Parrot had previously discussed this distance-calibrating mechanism in his theoretical physics textbook, which was published 28 years earlier than his train illusion article (Parrot, 1811).

For Parrot, it was self-evident that the perceived size was a result of syllogistic reasoning: from the recorded retinal size and distance (minor premise) and the inverse proportion rule of retinal projection (major premise), an inference about the size can be made. This decision is made very rapidly, and, subjectively, we consider the time necessary for these operations to be infinitely short, so we are not even aware of their very existence. Using Parrot’s own words, this time is “the time that our soul uses to form its ideas and its judgments, the time that we until today have believed to be infinitely short, and of which we even were not aware” (Parrot, 1839, p. 141).

There is not much room left for skepticism that Parrot was formulating here the concept of unconscious inferences, although perhaps by accident or without being fully aware what he was implying. His narrative, although condensed, is entirely explicit, and there are no discrepancies between his own formulation and the much better-known definition of *unbewusster Schluss* by Hermann von Helmholtz—the psychic activities that lead us to infer that in front of us, at a certain place, there is a certain object of a certain character (Helmholtz, 1910). These activities, despite being generally unconscious, are equivalent to drawing a conclusion from premises. In their result, they are equivalent to conclusions, to the extent that the observed action on our senses enables us to form an idea of the possible cause of this action. The difference between perception and syllogistic reasoning lies in the fact that perceptual inferences occur almost instantly and that the major premise is not expressed in the form of a proposition, while the solution of a syllogism by rational thought may be difficult and time-consuming.

However, in the year of Parrot’s publication, Helmholtz was still 18 years old and would write his *Handbuch der Physiologischen Optik* only 20 years later. According to Boring, Helmholtz obviously adopted the idea of unconscious inferences while he was in Königsberg and exposed its essentials in a lecture published in 1855 (Boring, 1957, p. 315). The doctrine of unconscious inferences was implicit in this paper but was not so named. In this paper, Helmholtz was talking about the basic processes, which transform the sensation of light into

the perception of the external world. These processes, at least some of them, take place without our understanding and cannot be altered by our will (Helmholtz, 1896, p. 110).

The concept was soon elaborated by Wilhelm Wundt in his *Beiträge zur Theorie der Sinneswahrnehmung* (Wundt, 1858). It was in fact Wundt who used the term for the first time in his treatise (Boring, 1957, p. 315). Helmholtz gave the full exposition of the theory only in 1866, in the third volume of the handbook. He used the idea of unconscious inferences to explain the induced complementary hue, which obviously violated the principle of isolated conduction—each nervous fiber extends to the brain in isolation to conduct there the impression it receives—in which he faithfully believed (Ash, 1995, pp. 52–53; Pastore, 1971, p. 165). Since we are only immediately aware of the induced color, erroneously supposing that these colors are direct sensations, we are not aware of inducing colors, which remain unnoticed although they manage to deceive our judgment.

According to Reed's observation, around 1860 the importance of unconscious mental processes in the shaping of the human mind was finally realized as a necessary component for creation of a coherent associationist psychology (Reed, 1997, p. 255). John Stuart Mill elaborated the "principle of obliviscence" in his critical examination of William Hamilton's philosophy, which appeared first in 1865 (Mill, 1865/1979). According to this principle, not all the elements that generate an idea need to appear in consciousness; what does appear is only the end product of what might be a long chain of associated elements (cf. Demer, 1964, pp. 157–158). In the commentaries on his father's work, James Mill's new edition of *Analysis of the Phenomena of the Human Mind* (first published in 1829), John Stuart developed his hypothesis that some or all unconscious processes are similar to inferences (Reed, 1997, p. 255). Helmholtz, in turn, helped to close the gap by assuming that perceptual inferences are accomplished by the unconscious process of association of ideas in our memory (Hatfield, 1990, pp. 204ff.). Thus, only in the 1860s were the ideas of the unconscious and of the logical inference joined into a single and thematically emphasized concept of unconscious inferences.

Among many historians, the priority of Helmholtz in the discovery of the concept of unconscious inferences seems to be unquestionable. For example, in his fundamental study of the discovery of the unconscious, Ellenberger flatly states that Helmholtz discovered the phenomenon of unconscious inferences as a kind of instantaneous and unconscious reconstruction of what our past experience taught us about objects (Ellenberger, 1970, p. 313). The only predecessor mentioned by Ellenberger is Fechner, who around 1850, in order to check his metaphysical hypothesis about the relationship of mind and body, began a long series of experiments on the mathematical relationship of the intensity of stimulation and the intensity of perceptions. While computing the intensity of perceptions, he gave negative values to those below the threshold of perception (Boring, 1957, p. 293). But Fechner did not attribute any active, inferential role to these subliminal states of human mind.

Our observations convince us that Parrot deliberately used the concept of unconscious inferences for the explanation of the phenomena he observed through the window of a fast-moving train. However, he was obviously not the first one who implied the existence of the involuntary reasoning-like operations in order to reach a satisfactory explanation of certain phenomena in the human perception (cf. Hatfield, 2002).

Like Aristotle, Ptolemy believed that only light and color are the proper objects of vision, but, unlike Euclid, he recognized that the visual angle and the visual apprehension of size are not identical (Smith, 1996). He proposed that the visual angle is not perceived in its immediate form and an appropriate estimation of distance and obliqueness is required in order to reach the true size of the object. This estimation springs from judgment rather than a direct visual impression (p. 94). Though somewhat obscure, some authors have seen in this de-

scription similarity with unnoticed judgmental processes described by latter-day theorists (Hatfield & Epstein, 1979). Alhazen, however, was much more explicit about this visual judgmental process (Sabra, 1989a). Following Ptolemy, Alhazen was convinced that not everything perceived by the sense of sight is perceived by pure sensation; rather, many visible properties, like size of objects, are perceived by judgment and inference (II 22b). These perceptual judgments occur in an extremely short interval of time. Because the shape and size of a body are, in most cases, perceived extremely quickly, one is not aware of having perceived them by inference or judgment. The speed with which these properties are perceived by inference is due only to the manifestness of their premises and to the fact that the faculty of judgment has been much accustomed to discern those properties (II 25a–b). The faculty of perceptual judgment does not syllogize by ordering and composing words; that faculty perceived the conclusion without the need for words or for repeating and ordering premises (II 26b) (cf. Sabra, 1989b, pp. xcvi–xcvii).

Bauer was probably the first who pointed to a remarkable affinity between Alhazen's theory of "unconscious inferences" and Helmholtz's theory of *unbewusster Schluss* (Bauer, 1911). As Hatfield and Epstein (1979) have formulated, "The essentials of Alhazen's theory of vision are, in fundamental ways, parallel to those of the standard theory of the eighteenth and nineteenth centuries" (p. 369). In fact, there is no doubt that Alhazen has formulated, in a clear, precise, and orderly manner, the theory of unconscious syllogistic inferences 900 years before Parrot or Helmholtz. It had all the essential ingredients: some of the perceived qualities are not perceived directly but inferred from premises; the judgmental process is extremely rapid and one is not aware of these inferences; and although the process is syllogistic, it does not need words. There are no important differences between Alhazen's and the nineteenth-century theories of unconscious inferences.

Alhazen's works were translated into Latin in the late twelfth or early in the thirteenth century and dominated Western optical thought until early in the seventeenth century (Lindberg, 1967, p. 322; Sabra, 1989b, p. lxxiii). Lindberg wrote, "Alhazen's theory was comprehensive and systematic: it was superior in almost every respect to anything the West had known before" (1967, p. 331). Through the works of Roger Bacon, John Peckham, and Witello, Alhazen's optical theory, especially his doctrine of *perspectiva*, became a part of standard education (Lindberg, 1967, p. 334). Also, his realization that size and shape cannot be directly determined by visual angle and retinally projected shape was carried on by philosophers who started to realize its implications. In the tradition of Alhazen, Descartes believed that the size of objects cannot be perceived and must be estimated or judged. This judgment occurs so quickly that we fail to notice it. However, he denied the existence of thoughts of which we are not aware (Hatfield & Epstein, 1979, p. 377). Contrary to Descartes, both Ignace Pardies and Leibniz were convinced of the existence of "small perceptions" (*petites perceptions*) that can escape awareness, although they obviously influence our thoughts (Diamond, 1972). Berkeley, of course, placed the existence of the secondary objects of vision as the cornerstone of his new theory of vision. In *An Essay Towards a New Theory of Vision*, George Berkeley repeated Alhazen's claim that "distance, of itself and immediately, cannot be seen" (Berkeley, 1709, p. 171). Like that of his unnamed precursor, Berkeley's view was that distance was derived from cues present in visual experience but was not the proper object of visual faculty. According to him, we cannot separate and disentangle our judgments from the proper objects of sight—that is, light and color—and we are not aware of them as such (p. 235).

Although not associated with the inventor, all important elements of Alhazen's theory of unconscious inferences were circulating in the seventeenth and eighteenth century's scientific and philosophical discourses (cf. Hatfield, 2002). Therefore, it was not surprising that the prin-

ciple of unattended judgments was applied to explanation of various visual phenomena. For example, Harris used the same basic rationale to explain binocular fusion: “When both eyes look at the same object, the mind sees that object single. And it is very certain, that in at least an abundance of cases, the visive faculty is assisted by a kind of reasoning, drawn from former experience, tho’ perhaps unattended to at the time we use it” (Harris, 1775, p. 111). Later, Wheatstone also easily explained the processing of retinal disparity by invoking the notion of unconscious inferences. He wrote about the retinal disparity, “[T]he perception of these differences (though we seem to be unconscious of them) may assist in suggesting to the mind the distance of the object” (Wheatstone, 1838, p. 377).⁶ Thus, many researchers before or approximately at the same time as Parrot used the idea of the unconscious inferences, perhaps not even realizing that they were restating a theory that was originally formulated by Alhazen (Hatfield, 2002). In the second half of the nineteenth century, the unconscious started to dominate the research agenda, and the theory of perceptual inferences changed from an explanation of particular phenomena to a fundamental principle of how the human mind operates. Only then, thanks to the efforts of the associationists Helmholtz and John Stuart Mill, did the idea that at least some unconscious processes can be compared with syllogistic reasoning acquire a central position in the theoretical discussions. Nevertheless, Parrot, along with several other scholars, should be credited for one of the first unambiguous and clear formulations of the forgotten concept of unconscious inferences, which he used to explain a perplexing visual phenomenon he had observed from a window of a fast-moving train.

Returning now to the explanation of the described visual phenomenon, Parrot next questioned the proverbial truth that operations of the soul are infinitely short. He believed that the described railway illusion proves the opposite: the soul needs a certain time to form its ideas and to make its judgments about vision. In the given historical context, this was a relatively bold statement. The prevailing view of that time assumed that animal spirits flow very rapidly in the nervous tubes, perhaps with a speed that is comparable to that of light. By means of existing technical tools, the measurement of such high velocities was simply unthinkable. Johannes Müller, in the third edition of his *Handbuch der Physiologie des Menschen*, claimed that we shall probably never attain the power of measuring the velocity of nervous action (Boring, 1957, p. 41). Only a few years after this discouraging prophecy, in 1850, Müller’s own pupil Helmholtz measured this rate in a frog’s motor nerve and found it to be much slower even than sound (Boring, 1942, pp. 52–68). The implications of Helmholtz’s discovery were too surprising to be easily believed (Fancher, 1979, pp. 119–120). It is clear that Parrot’s idea that operations of the soul may be relatively slow was not the dominating opinion among physiologists, who were inclined to think that any operation of mind, and neurological events responsible for them, must be nearly instantaneous.

Why do rapidly moving objects appear diminished in their size? According to Parrot, the soul does not have the time to judge the distance and visual angle with the required accuracy. The soul does not distinguish all the external objects that are used for the measurement of distance in the very short time that is left to it by the rapid movement of a locomotive. Thus, the judgment that our soul makes about the size of the objects is in these extreme conditions based on a preliminary false judgment—the minor of two premises is false.

In the last paragraph, after making the assumption that for any given distance, there is a velocity that causes the maximum diminishment of size, and that for a given speed, that there is a distance that produces this maximum, Parrot proposed a plan of an experiment that was capable of determining the time that the soul uses to form its ideas and make judgments. The

6. We thank Nick Wade for drawing our attention to these sources.

idea is to make systematic observations about apparent size on locomotives moving at a given speed and placing objects at different measured distances. This experimental plan, irrespective of its actual accomplishment, clearly recognized the possibility of subjecting psychological processes to experimental study, contrary to Kant's influential opinion that this was impossible (cf. Hatfield, 1998). In this respect, Parrot should have been relatively well prepared for the emergence of the new field of experimental psychology, which was soon developed by Helmholtz, Fechner, Volkman, and Wundt.

SIZE DISTORTIONS OF MOVING OBJECTS

As previously mentioned, no one else seems to have observed exactly the same phenomenon as Parrot did in 1839. However, almost precisely a century after Parrot's original publication, Heinz Ansbacher (see Manaster, 1994) reported a phenomenon that was, in many respects, similar to the phenomenon described by Parrot. At a meeting of the American Psychological Association, Ansbacher talked about the apparent contraction of a moving object (Ansbacher, 1938). In fact, the apparent contraction of a rotating arc had already been observed by Harold C. Brown at Columbia University in 1937, but he had never published his observations (Ansbacher, 1944). The first comprehensive description of the phenomenon appeared six years later, leaving no doubt that the apparent shrinkage of an illuminated arc, rotating at less than fusion speed, is a robust and replicable phenomenon (Ansbacher, 1944). Since then, the apparent contraction of moving objects has been repeatedly demonstrated (Anstis, Sturzel, & Spillmann, 1999; Caelli, Hoffman, & Lindman, 1978; Day, 1973; Dzhafarov, 1992a, 1992b, 1992c; Dzhafarov, Allik, & Kapustin, 1984; Stanley, 1964, 1968). There is a crucial difference, however, between all these experimental findings and Parrot's phenomenal observation: the apparent length of a moving object shortens only along the motion's direction. Nobody else has observed the shrinkage of the whole moving object as Parrot described it in his note.

There are not many other illusory distortions to which the length-contraction phenomenon can be related. The only link that Ansbacher was able to find is the anortoscopic distortion first described by Zöllner in 1862. If simple figures are moved behind a narrow slit, then at a relatively high speed they appear narrower than they actually are—that is, as they look in an unrestricted viewing condition (Zöllner, 1862). Besides retinal painting as a likely cause of apparent compression, the process with the help of which successive part-views are synthesized into a unified form can also be considered as an additional candidate explanation. Although previously Cattell had stressed the principal similarity between the anortoscopic and the normal process of combining different samples of visual images over successive visual fixations (Cattell, 1900), this promising link was not explored by Ansbacher. Instead, he tried to explain the shrinkage by a hypothesis that the visual mechanism is active only for a certain period, which is followed by a period of inactivity. On the basis of his findings, he even calculated the duration of one pulsation of activity, which was in the range of 46 to 61 ms. However, this idea of periodic activity was completely discredited when Stanley demonstrated that the shrinkage became proportionally greater for the longer lengths of the arc (Stanley, 1968). Day continued the tradition of explanation in terms of local visual mechanisms and explained length contraction by the visual masking of a moving stimulus by its preceding and following positions (Day, 1973).

A radically different type of explanation was proposed by Caelli, Hoffman, and Lindman, who considered the length contraction as a manifestation of the spatio-temporal geometry of perceptual space in the way the Lorentz-Fitzgerald contraction manifests the fun-

damental geometry of the physical world (Caelli et al., 1978). However, aside from the uncritical application of Lorentzian kinematics, these authors were unable to separate purely geometric factors from the integration-interaction mechanisms, such as masking or luminance summation (cf. Dzhafarov, 1992c).

In order to separate these two groups of factors, Dzhafarov proposed an ingenious solution. Instead of presenting one moving object whose length is to be estimated, he presented two parallel but shifted replicas of each other, the observer's task being to estimate the spatial gap between these two objects. As any brightness effect should affect the two parallel moving objects equally, leaving the perceived shift unchanged, the seen contraction of the shift must be kinematic in its very nature. Indeed, besides deformations caused by visual integration-interaction mechanisms, there is a contraction of the perceived shift between two moving objects along the direction of motion that is attributable exclusively to the metric changes of visual space itself. The space contraction does not occur transversely, in the direction orthogonal to that of motion (Dzhafarov, 1992a). However, along the direction of motion, the apparent contraction increases monotonically, with the increase of speed reaching 90 percent of its value at rest as velocity approaches 90 percent. Carefully designed control experiments ruled out all explanations but the change of the frontoparallel metric of the visual space due to motion (Dzhafarov, 1992a).

In its spirit and general intention, the explanation of the phenomenon proposed by Parrot is certainly closer to the kinematic explanation by Dzhafarov than to local summation-interaction mechanisms proposed by Ansbacher and Day: the apparent diminution of the size reflects the basic mechanisms through which the parameters of the perceived space-time are established. Although Parrot, like all his contemporaries, had only a vague idea of what it means for the soul to need a certain time to form its ideas and to make judgments about the objects seen, he seemed to believe that the size and distance of the perceived objects are not immediately given but need some time to be established.

CONCLUDING COMMENTS

In this article, we have shown that Parrot formulated a concept of unconscious inferences, *unbewusster Schluss*, a very rapid syllogistic conclusion, from two premises of which we are not even aware. This concept was formulated and published many years before Helmholtz, John Stuart Mill, and Wundt articulated and coined the doctrine of unconscious inference, although it is they who are usually credited with the achievement and not Alhazen, who nine centuries before formulated a concept in every respect similar to it. Aside from the concept of unconscious inference itself, Parrot had the idea that the speed of mental processes is not infinitely high and that, in principle, it can be determined by systematic observations of phenomena like what he had observed in the moving train. Parrot was obviously mistaken in the description of the visual phenomenon—the size contraction of a moving object—which only partly corresponds to movement-induced changes of the metric of the visual space. However, his general intention to understand basic mechanisms by which the soul operates and reaches its decisions was surprisingly fresh and modern. In fact, his way of thinking was in harmony with Fechner, Helmholtz, and Wundt, who all, in one way or another, demonstrated that sensory judgments can be quantified, that a measurable amount of time is required for their execution, and that they are related to events in the physical environment in a meaningful way. Parrot shared the conviction of the founding fathers of psychology that it is possible to study the phenomena of mind in the same general way that the physical world is studied, either in terms of mechanical or mathematical laws.

For helpful comments concerning previous drafts of this article, we thank Wolfgang Drechsler, Anu Realo, Nick Wade, and two anonymous referees. This study was supported by the Estonian Science Foundation and Estonian Ministry of Science and Education. Correspondence should be addressed to Jüri Allik, Department of Psychology, University of Tartu, 78 Tiigi Street, Tartu 50410, Estonia. E-mail: juri.allik@ut.ee.

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