

On Photographs and Phonographs: New Techniques of Recording and their Influence on Mach's Conception of Knowledge

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My starting point in this paper will be the following quotation, which may almost be described as a prophecy:

The graphic arts, and especially photography and stereoscopy, today enable us to gain a wealth of intuitive pictures that would have cost immense effort fifty years ago. Distant lands, their peoples and architecture, scenes from tropical forest and polar ice all come equally alive. Colour photography and cinematography will further enhance the natural look, and the phonograph will do the same on the acoustic side¹.

This quotation is excerpted from a work named *Knowledge and Error* published in 1905 by the Austrian physicist Ernst Mach (1838-1916). In this work, Mach tries to account in evolutionist terms for the genesis of human knowledge, and this leads him to reflect upon what the future of such knowledge might be. According to these considerations, the answer to this question is clear: the future of human knowledge is essentially linked to the development of new techniques of picture and sound recording.

Ernst Mach had indeed at least three good reasons to be concerned with the development of such techniques. As a physicist, he had a special interest for the benefits of photographic techniques in the field of scientific investigations, and this led him to dedicate a memoir to the scientific applications of photography and stereoscopy². But Mach was also a physiologist and, as such, he was quite fascinated by the insights such devices would allow in the field of optics and

¹ Ernst Mach, *Erkenntnis und Irrtum*, tr. Th. J. McCormack and P. Foulkes: *Knowledge and Error*, Dordrecht, Reidel, 1976, "Sensation, Intuition, Phantasy", §9, p. 109.

² Ernst Mach: "Über wissenschaftliche Anwendungen der Photographie und Stereoskopie", *Sitzungsberichte der Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften*, Sitzung vom 21. Juni 1866, 1866 (1).

acoustics³. Lastly, a more indirect but maybe more interesting influence of these techniques can be detected in the reflections led by Mach in the realm of the theory of knowledge. Mach's epistemology is in fact wholly articulated around the notion of *picture* or *Bild*: science in general, in his opinion, can be regarded as an elaboration of pictures of reality. This is, for example, what he claims in the following quotation:

Our knowledge of a natural phenomenon (...) is as complete as possible when our thoughts so marshal before the eyes of the mind all the relevant sense-given facts of the case that they may be regarded as a substitute for the latter, and the facts appear to us as familiar figures, having no power to occasion surprise⁴.

My claim will be that such an approach of scientific thought science might have been if not inspired, at least supported by some developments in the realm of photography.

I will therefore examine some of these aspects of Mach's concern for photographs and phonographs. I will argue that there is an essential link between these two issues: not only because they both refer to technical innovations at the time; but because they both rest upon the idea of a very close relationship between pictures on the one hand, and knowledge or language on the other hand. I will start with the phonographs, and I will examine in particular Mach's reference to this device in his account of the development of written language. My point will be that Mach regards the phonograph as a device whose effect, just like in the case of Hieroglyphs, is both linguistic and pictorial. My second point will be to compare this reference to phonographs and hieroglyphs with some very similar insights in Wittgenstein's *Tractatus*. Lastly, I will address some aspects of Mach's interest in photographic techniques. I will focus on the significance of these new techniques in his theory of knowledge, and I will try to draw a parallel between Mach's conception of mental economical pictures and a photographic technique developed by Galton, namely the method of

³ His perfect acquaintance with phonographic devices was in fact correlated with his research in the field of acoustics, as appears in the following anecdote: "The first report of Edison's invention of the phonograph was told me as I was walking in the street, by a colleague who doubted the news. 'Why not believe it?' I replied. (...) Even before reaching home I was almost certain that the phonograph was a slight modification of König's phono-autograph which, instead of the writing motion in the cylindrical surface of the drum, uses a motion at right angles to the drum. Nor was it difficult to me to guess this, for I had been occupied with acoustics and especially with König's instrument, often demonstrating the speechlike sounds when a fingernail glides over a ribbed book binding". (*Knowledge and Error*, "Problems", p. 201, footnote).

⁴ Ernst Mach: *Die Analyse den Empfindungen*, trans. C.M. Williams: *The Analysis of Sensations*, Chicago, Open Court, 1897, "Physics", §5, p. 152.

composite portraiture. My claim will be that such generic pictures may be regarded as an illustration or as a metaphor of Mach's own characterization of theoretical, economical pictures.

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I. Mach on Phonographs: The Groove and the Hieroglyph

As I mentioned before, Mach was perfectly acquainted with the technique of the phonograph, to which he refers in many occasions⁵. I will focus on a definite passage Mach develops in his *Knowledge and Error*, where he compares the different systems of writing, referring to the phonograph as to one of them:

By using permanent visible signs instead of momentary audible ones, one obtains writing, whose advantage lies precisely in this permanence. The most obvious thing is to convey information or news about events by means of pictures, a method in fact used by North American Indians; witness a rock drawing near Lake Superior reporting about a naval campaign. (...) The further development of writing can proceed along two different paths: either the representations of things shrink through a quick simplifying script into conventional signs for concepts, as in Chinese; or the pictures, reminding one of the sounds of words in the manner of pictures puzzles, turn into phonetic signs, as in Egyptian Hieroglyphics. [Footnote: Since the invention of the phonograph, a spoken passage may be reproduced at will, just like a written one. The phonographic archives of the Vienna Academy are an example of this. The idea of the phonograph is due to the phantasy of Cyrano de Bergerac (*Histoire comique des états et empires de la lune, 1648*)]⁶.

My point is that, in this quotation, the phonograph is regarded by Mach essentially as a *linguistic* device. This is the meaning of the tribute Mach pays to the French author Cyrano de Bergerac in the footnote attached to this text, by reminding his reader that "The idea of the

⁵ Some of these references may be quite unexpected, and pertain even to the realm of Mach's (anti)metaphysical insights regarding subjectivity, as appears in the following quotation where the queer feeling one may have when hearing one's own voice on a phonograph is taken as an example of the self's exteriority to itself: "On good phonographs one recognizes the timbre of a friend's voice, but one's own sounds strange because the head resonance is missing". (*Knowledge and Error*, "Philosophical and Scientific Thought", p.12, footnote).

⁶ *Knowledge and Error*, "Development of Individuality in a Natural and Cultural Habitat", §17, pp. 59-63.

phonograph is due to the phantasy of Cyrano de Bergerac”⁷. In one of his novels, Cyrano had in fact fancied the following apparatus, which he described as a kind of “talking book”:

It was a book indeed; but a strange and wonderful book, that had neither leaves nor letters: in fine, it was a book made wholly for the ears, and not the eyes. So that when any body has in mind to read in it, he winds up that machine, with a great many little strings. Then he turns the hand to the chapter which he desires to hear, and, straight as from the mouth of a man, or a Musical instrument, proceed all the distinct and different sounds, which the *Lunar* grandees make use of, for expressing their thoughts, instead of language (...); so that you never want the company of all the great men, living and dead, who entertain you with living voices⁸.

From the very beginning, thus, the phonograph had been associated with the idea not primarily of recording *music*, but rather of recording *speech*. This identification of the phonograph with a kind of language can be confirmed by taking a look at the historical development of such techniques. The first of these devices was the phonograph introduced by Léon Scott in 1857, followed a few years later (1877) by Edison’s phonograph, by Chichester Bell’s and Thomas Tainter’s graphophone (1881), and “lastly” (1888) by Emile Berliner’s gramophone, whose major innovation was to use of a record rather than a cylinder. Now, if one pays attention to the very names that were given to all of these apparatus, one may see that they all appear as devices meant to transcript (*graphè, gramma*) the human voice (*phonè*). The most striking case indeed may be the case of the graphophone, whose function was to take note of the human speech before it should be typed, quite analogously to what the Dictaphone would do a few years later⁹.

Such a linguistic background of these new techniques is exactly what is emphasized by Mach in the quotation I am now considering. If one reads the rest of this footnote, one encounters in fact the following remark, where the inscription of sound on the cylinder of the phonograph is explicitly compared to other and more usual types of speech transcription:

⁷ *Knowledge and Error*, Dordrecht, Reidel, 1976, “Development of Individuality in a Natural and Cultural Habitat”, §17, footnote, p.63.

⁸ Cyrano de Bergerac, *Les Etats et Empires de la Lune* [1657], ed. M. Alcover, Paris, Champion classiques, 2004, pp. 136-137 ; trans. A. Lovell: *The Comical history of the States and Empires of the World of the Moon*, London, Rhodes, 1687, pp. 121-122. I am indebted to Mathilde Levesque for indicating this passage to me.

⁹ The main characteristic of this apparatus was in fact its re-inscriptible surface.

Since the invention of the phonograph, a spoken passage may be reproduced at will, just like a written one. The phonographic archives of the Vienna Academy are an example of this¹⁰.

This remark itself is inserted into a general and historical account of writing: of its birth and of its evolution. I will now sketch briefly this evolution in order to show how the phonograph fits into it. Mach's claim on that issue exhibits an evolutionist background combined with a pragmatic account of knowledge; the reason why writing in general had to arise is in fact that:

By using permanent visible signs instead of momentary audible ones, one obtains writing, whose advantage lies precisely in this permanence¹¹.

Up to this extent, Mach's account of writing is not extremely original. Yet, there is something peculiar in the view he defends: namely the fact that, instead of presenting writing as an opposite to picturing, he rather regards all of the different scriptural systems as various kinds of pictorial systems. Some of them will picture *things* themselves, some others will picture the *ideas* one has of things, and some will picture the *sounds* by means of which one refers to these ideas. The first of these strategies is, in Mach's view, the most basic of them:

The most obvious thing is to convey information or news about events by means of pictures, a method in fact used by North Americans Indians¹².

Yet, in order to be more simple and more practical, writing has to be developed into one of the two alternate strategies, either by symbolizing concepts (as it does in the case of ideograms), or by symbolizing the spoken propositions themselves (as in the case of phonetics systems):

The further development of writing can proceed along two different paths: either the representations of things shrink through a quick simplifying script into conventional signs for concepts, as in Chinese; or the pictures, reminding one of the sounds of words in the manner of pictures puzzles, turn into phonetic signs, as in Egyptian Hieroglyphics¹³.

¹⁰ *Knowledge and Error*, Dordrecht, Reidel, 1976, "Development of Individuality in a Natural and Cultural Habitat", §17, footnote, p.63.

¹¹ *Knowledge and Error*, Dordrecht, Reidel, 1976, "Development of Individuality in a Natural and Cultural Habitat", §17, p. 59.

¹² *Knowledge and Error*, Dordrecht, Reidel, 1976, "Development of Individuality in a Natural and Cultural Habitat", §17, p. 59.

¹³ *Knowledge and Error*, Dordrecht, Reidel, 1976, "Development of Individuality in a Natural and Cultural Habitat", §17, p. 59.

However, something, in this last example, sounds rather puzzling. When Mach introduces this idea of a transcription of spoken propositions, the most obvious example one may have expected is *not* the one of Hieroglyphs: it is doubtlessly the one of alphabetic systems¹⁴. The Hieroglyphic system is usually not regarded as a phonetic, but rather as an ideographic or ideogrammic one¹⁵: then why does Mach take it as a paramount for phonetic writing¹⁶?

In my opinion, such a peculiarity of Mach's text a) has an essential reason in his very conception of written language, and b) is closely related to his appeal to the example of the phonograph. In fact, the most prominent feature of Hieroglyphics is that they are obviously figurative. The point Mach is trying to make here is therefore that *any* written system is, in a way or another, a *pictorial* system, including the phonetic one: for although phonetic systems do not picture *things*, still they do picture *sounds*. And this is also the reason why Mach introduces the figure of the phonograph: because in this case, too, the groove written on the cylinder can be regarded as such a picture of sound. Mach lays stress on the fact that the phonograph *reproduces* the spoken discourse: on that account, it does provide, in a very strong sense, a picture of sounds: "*just like a written one*".

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II. Gramophones and Hieroglyphs in Wittgenstein's *Tractatus*

To summarize, I have shown that Mach's claim is that any kind of language, should it be written or spoken, ideogrammic or phonetic, is always a kind of pictorial system; and I have argued that his appeal to the case of the phonographic inscription of sound was an argument in favor of this claim. I will now try to show that this very argumentation was to be almost mirrored, a few years later, in Ludwig Wittgenstein's *Tractatus logico-philosophicus*. Such a comparison between Machian themes and Wittgenstein's insights in the *Tractatus* has been developed by Susan Sterrett in an article by the name of « Pictures of Sounds: Wittgenstein on Gramophone Records and the Logic of

¹⁴ Note: Mach does mention the case of alphabetic or literal transcription, but he regards it as a *derived* case of phonetic system. Cf. further: "[T]he need to write people's names and proper nouns in general leads to the [phonetic system], which has given rise to literal script".

¹⁵ The Hieroglyphic system does combine its ideograms with important phonetic elements; yet, such a phonetic aspect is usually regarded as derived with respect to the pictorial and ideogrammic origins of this system.

¹⁶ One may note that Hieroglyphs had been interpreted by Jean-François Champollion as early as the 1830's, and that Mach could therefore not ignore their ideographic nature.

Depiction »¹⁷. Pr. Sterrett sheds light upon the parallelisms to be detected between Wittgenstein's idea of a sound picturing on the one hand, and the pictures of shock waves Mach published in 1887 in collaboration with Peter Salcher¹⁸ on the other hand. I think that this idea of a continuity between Mach and Wittgenstein is clearly confirmed when one reads together the developments I mentioned in *Knowledge and Error* and the section 4.01 of Wittgenstein's *Tractatus logico-philosophicus*. One of the most famous features of this work is in fact the so-called "picture-theory" of propositions, claiming that any proposition is a picture of a state-of-affairs. No wonder, then, that Wittgenstein had to address the same question as Mach, namely: in what sense can a *written* proposition be said to be a picture at all? Wittgenstein thus formulates this challenge as follows:

At first sight, a proposition – one set out on the printed page, for example – does not seem to be a picture of the reality with which it is concerned. But no more does musical notation at first sight seem to be a picture of music, nor our phonetic notation (the alphabet) to be a picture of our speech.

And yet these sign-languages prove to be pictures, even in the ordinary sense, of what they represent¹⁹.

But what is striking is not only the fact that Wittgenstein confronts the same difficulty as Mach: it is that he appeals to the same strategy in order to escape it. In fact, just the same way as Mach would refer to the different systems of writing so as to show their common pictorial essence, Wittgenstein also compares all of these systems by showing how they share something which is "essential to depiction":

In order to understand the essential nature of a proposition, we should consider hieroglyphic script, which depicts the facts it describes. And alphabetic script developed out of it without losing what was essential to depiction²⁰.

¹⁷ Susan G. Sterrett: "Pictures of Sounds: Wittgenstein on Gramophone Records and the Logic of Depiction", in *Studies in History and Philosophy of Science*, 36 A, 2005, 351-362.

¹⁸ Cf. Ernst Mach and Peter Salcher: "Photographische Fixirung der durch Projectile in der Luft eingeleiteten Vorgänge", *Sitzungsberichte der Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften*, Sitzung vom 21. April 1887; reproduced and commented in Christoph Hoffmann and Peter Berz: *Über Schall, Ernst Machs und Peter Salchers Geschossfotografien*, Göttingen, Wallstein, 2001.

¹⁹ Ludwig Wittgenstein : *Tractatus logico-philosophicus* (TLP), trans. D.F. Pears and B.F. McGuinness, London, Routledge, 1961. 4, 011.

²⁰ TLP, 4.018. One may notice that Wittgenstein, quite unexpectedly, seems to be referring to a historical development of these writing systems, as witnessed by his use of the verb "develop out" ("werden"). This could count as an echo to Mach's evolutionism.

And as I said, Mach would appeal to the phonograph in order to convince his reader that a depiction of sounds such as performed by the phonograph does have the sense of a picture of something. Wittgenstein does the same, with only one main difference, namely that (maybe for the sake of modernity) he no longer refers to the phonograph, but rather to the gramophone²¹:

A gramophone record, the musical idea, the written notes, and the sound-waves, all stand to one another in the same internal relation of depicting that holds between language and the world²².

In both cases, thus, the mode of depiction used by the phonograph (or by the gramophone) is compared with the mode of depiction of a hieroglyph, and in both cases this confrontation is used as a crucial argument in order to maintain the pictorial essence of written language, even in the case of phonetic systems of notation.

This parallelism between those two developments is so close that the section of the *Tractatus* devoted to the status of written proposition might really be read as a direct echo to Mach's account²³. Such a parallelism can take the form of a systematic correspondence between the propositions of the *Tractatus* and the passage I have been commenting upon here:

	Mach	Wittgenstein
Example: the picture of sounds provided by the phonograph/gramophone	“Since the invention of the phonograph, a spoken passage may be reproduced at will, just like a written one.”	“A gramophone record, the musical idea, the written notes, and the sound-waves, all stand to one another in the same internal relation of depicting that holds between language and the world”. (TLP, 4.014)
Conclusion: All of the different systems of writing are but different means for providing pictures	“The further development of writing can proceed along two different paths: either the representations of things shrink through a quick simplifying script into conventional signs for concepts, as in Chinese; or the pictures, reminding one of the sounds of words in the manner of	“In order to understand the essential nature of a proposition, we should consider hieroglyphic script, which depicts the facts it describes. And alphabetic script developed out of it without losing what was essential to depiction”. (TLP, 4.018)

²¹ One may note that Wittgenstein was no less aware of the developments of such recording techniques than Mach.

²² TLP, 4.014.

²³ Wittgenstein is known to have expressed his disgust towards Mach's writings; but this demonstrates at least that he was aware of them! On the idea of a continuity between Mach and Wittgenstein, Cf. Henk Visser: “Wittgenstein's Debt to Mach's Popular Lectures”, in *Mind*, 91, 1982, pp. 102-105, “Wittgenstein's Machist Sources”, in *Ernst mach's Vienna*, ed. J. Blackmore, R. Itaguki, S. Tanaka, Dordrecht, Kluwer, 2001.

	pictures puzzles, turn into phonetic signs, as in Egyptian Hieroglyphics".	
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In *Tractatus* 4.014, Wittgenstein convokes an example, namely the example of the gramophone described as a way to picture and/or to write sounds down: isn't this an echo to Mach's remark on the phonograph as a written reproduction of speech? In *Tractatus* 4.018, Wittgenstein draws the conclusion that writing, whether it be hieroglyphic or alphabetic is in any case a kind of pictorial activity. Is the coincidence between this remark and Mach's own conclusion as to the relationship between Hieroglyphic and phonetic systems merely accidental²⁴?

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In a nutshell, my claim is that the function of Mach's appeal to the phonograph, in his epistemological writings, is to demonstrate that written speech is always a kind of picture, even if this picture had to be a mere picture of sound. I will now investigate further this idea by examining Mach's debt to photography.

III. Mach's mental symbols vs. Galton's composite portraits²⁵

As I just mentioned, a very characteristic feature of Mach's account of written language, besides its appeal to the case of the phonograph, is the reference it makes to Hieroglyphs. What strikes me is that he uses exactly the same metaphor when he tries to account not only for written speech, but for knowledge in general. He does so in his *Popular-Scientific Lectures*, in a passage

²⁴ I would make two additional remarks on this issue. The first one is that, although Wittgenstein's perspective on language is quite extraneous to any kind of historical account, yet one may be struck by his idea that the alphabet would have 'evolved' on the basis of hieroglyphs: there again this might be an echo to Mach's evolutionism; the second of these remarks is that Wittgenstein, here, seems to rank the Hieroglyphic system among ideographic rather than among phonetic systems: this might in turn be regarded as an implicit criticism towards Mach's account of hieroglyphs. In other, the section 4.01 of the *Tractatus* could be understood both as an allusion to Mach's account, and as a refinement or as a correction of it.

²⁵ In this section, I will focus on a comparison between Mach's theory of knowledge and a very specific photographic device. I will not develop Mach's general views regarding the scientific applications of photography, nor will I develop the experiments on sound-waves pictures he led with Peter Salcher. On these topics, see Christoph Hoffmann and Peter Berz: *Über Schall, Ernst Machs und Peter Salchers Geschossfotografien*, Göttingen, Wallstein, 2001, as well as Susan G. Sterrett: "Pictures of Sounds: Wittgenstein on Gramophone Records and the Logic of Depiction", in *Studies in History and Philosophy of Science*, 36 A, 2005, 351-362.

where he specifies the overall claim I mentioned in my introduction, namely that science has to provide economical pictures of facts:

On the old Egyptian monuments we see objects represented which do not reproduce a single visual impression, but are composed of various impressions. The heads and the legs of the figures appear in profile, the thread-dress and the breast are seen from the front, and so on. We have here, so to speak, a mean view of the objects, in forming which the sculptor has retained what he deemed essential, and neglected what he thought indifferent²⁶.

To be more precise, one may draw a distinction between two successive steps of knowledge in Mach's epistemology: namely the perceptive step on the one hand, and the theoretical step on the other hand. Yet, a characteristic these two steps have in common is their resting on a production of symbolic pictures of reality²⁷. And a characteristic feature both of these perceptive and of these theoretical pictures is that they ought to be essentially composite pictures. The challenge they have to confront is in fact to create a single and unified whole out of these disparate elements. Just to illustrate this point, Mach mentions an interesting example, namely the composite portraiture designed by Giuseppe Arcimboldo²⁸:

A beautiful example of this class is furnished by the famous iconographs of Giuseppe Arcimboldo in the basement of the Belvedere Gallery in Vienna. These are symbolic representations of water, fire, etc.; human heads composed of aquatic animals and of combustibles. At a short distance one sees only the details, at a greater distance only the whole figure. Yet a point can easily be found at which, by a simple voluntary movement of the attention, there is no difficulty in seeing now the whole figure and now the smaller forms of which it is composed²⁹.

My claim will be here that Mach's approach of scientific pictures can also be illustrated by another kind of composite portraiture: namely by the composite pictures provided by Galton.

²⁶ Ernst Mach: *Populär-wissenschaftliche Vorlesungen*, trans. Thomas J. McCormack: *Popular Scientific Lectures*, Chicago, Open Court, 1897, "On the economical nature of physical inquiry", p. 210.

²⁷ Mach describes the ideas gained by means of perception as "mental symbols" of reality, while he describes scientific theories as "symbolic representations of reality". Although these two steps are sharply distinguished, they rest upon the same idea of a symbolic representation of phenomena.

²⁸ This example is mentioned by Mach in the context of an explanation of harmony in the case of visual perception, but I think it can be broadened to a more general account of the nature of symbolic pictures, whether they be perceptive or theoretical pictures.

²⁹ Ernst Mach: *Populär-wissenschaftliche Vorlesungen*, trans. Thomas J. McCormack: *Popular Scientific Lectures*, Chicago, Open Court, 1897, "On the causes of harmony", p. 36.

Sir Francis Galton (1822-1911) was a British naturalist, who had in fact many skills, since he was at once a geographer, an anthropologist, a statistician, a psychologist, and many more. Being a supporter of Darwin's evolutionist theories³⁰, he was thus aiming at a classification of living beings, including human ones. His purpose was to identify a set of human physiological types, which would in turn allow him to identify certain psychological types, since his claim was that physiognomy is correlated with psychology. This project had both a descriptive scope and a normative one, mostly because Galton wanted to set forth a (physical and psychical) norm³¹, as well as a typology of the various discrepancies with respect to that norm. And in order to do so, he decided to take advantage of the innovative techniques of his time, namely of the photographic one.

Galton's idea was in fact that, in order to gain a synthetic and general picture, a simple mean would be to superimpose the respective portraits of different individuals supposed to belong to the same type and to blend them into one single picture. Concretely, the solution he designed rested upon the fact that the length of exposure required by photography at the time was quite extended (about 80 seconds). In those conditions, he just had to take a certain number of portraits (e.g. eight ones), and to expose each one of them to the photographic plate for a few seconds (e.g. ten seconds). None of these pictures would have been sufficiently exposed to have impressed the photographic plate correctly; as a result, the features that would be idiosyncratic to each one of them would appear in a very light and indefinite way. However, the features that would be common to many of them would appear in a darker and more marked way. The outcome of such a process would be, in Galton's opinion, the following:

The photographic process of which there I spoke will enable us to obtain with mechanical precision a generalized picture; one that represents no man in particular, but portrays an imaginary figure, possessing the average features of any group of men (...); it is the portrait of a type, and not of an individual³².

Just to take an example of such an outcome, one may take a look at the following picture, supposed to embody the type of inclination to larceny:

³⁰ This is something he had in common with Mach.

³¹ Galton is thus remembered for his contributions to anthropometry, and he is besides known to have invented the technique of identification by means of fingerprints.

³² Sir Francis R. Galton, "Composite Portraits", in *Nature*, May 31st, 1878, p. 97.



Now, what does Mach's theory of knowledge have to do with such experiments? It might be noted that, in general, Mach was indeed very interested in such techniques, since, in his 1866 memoir on the scientific applications of photography he had sketched himself the scientific benefits of "composite pictures" obtained by means of a stereoscope³³. But my claim is that such an interest has an echo at an even superior level, in the case of his very approach of mental theoretical pictures. In fact, when Mach characterizes the kind of pictures science is supposed to produce of reality, he argues that these theoretical pictures must be synthetic, selective and abstract:

In the reproduction of facts in thought, we never reproduce the facts in full, but only that side of them which is important to us, moved to this directly or indirectly practical interest. Our reproductions are always abstractions. Here again is an economical tendency³⁴.

In other words, science doesn't have to provide a faithful reproduction of phenomena: it ought rather to focus on what is essential and/or useful, and to eliminate what is inessential and/or irrelevant:

Our theories are abstractions, which, while placing in relief what is important in *certain determinate* cases, neglect almost necessarily, or even disguise, what is important in other cases³⁵.

³³ Ernst Mach: "Über wissenschaftliche Anwendungen der Photographie und Stereoskopie", *Sitzungsberichte der Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften*, Sitzung vom 21. Juni 1866, 1866 (1). On this issue, cf. Herta Wolf: "Die Divergenz von Aufzeichnen und Wahrnehmen, Ernst Machs erste fotografiegestützte Experimente", in Christoph Hoffmann and Peter Berz: *Über Schall, Ernst Machs und Peter Salchers Geschossfotografien*, Göttingen, Wallstein, 2001, 289-314, who emphasizes the parallel between Mach's attempts in obtaining stereoscopic pictures of human skulls and Galton's own composite pictures of skulls.

³⁴ Ernst Mach, *Die Mechanik in ihrer Entwicklung, historisch-kritisch dargestellt*; trans. Thomas J. McCormack: *The Science of Mechanics, a Critical and historical account of its development*, Chicago, Open Court, 1942, ch. IV, section 4, §2, p. 579. Such a passage was published in 1883, and is thus quite contemporaneous to Galton's main publications on composite portraiture.

³⁵ Ernst Mach: "Facts and Mental Symbols", first published in *The Monist*, 1892, reproduced as an Appendix to *The Analysis of Sensations*, trans. C.M. Williams, Chicago, Open Court, 1914, pp. 182-183.

Such insights of Mach's, as far as I can see, can be regarded as a metaphorical application to intellectual life of what Galton had introduced on a concrete and physical level.

There is more: maybe Mach was not the first one who drew such metaphorical applications of Galton's conceptions in the theory of knowledge. In fact, the analogies between Galton's devices and the classical theories of abstraction are obvious³⁶: so obvious indeed that they have been pointed by Galton himself. As a matter of fact, in a paper published in 1879, Galton stresses explicitly the parallel between his technique of blended pictures and some features of mental life, thus showing the continuity between these two kinds of production of generic pictures:

[T]he formation of blended pictures is an habitude of the mind, whence those general impressions have arisen by which the great majority of our daily actions are guided³⁷.

Such a quotation has many things in common with Mach's characterizations of intellectual life, including its reference to pragmatic considerations. Just like Mach, Galton even regards such an intellectual capacity to generate composite pictures as an ideal for the mind:

The criterion of a perfect mind would be the power of always creating vivid images of a truly generic kind, deduced from the whole range of its past experiences³⁸.

Galton's paper, as I mentioned, was published in 1879. Mach's *Mechanics* was published in 1883. I do not know for sure whether Mach was or was not acquainted with Galton's papers, although I think he was. In any case, if I had to find a motto in order to summarize Mach's requirements as to thought in general regarded as a production of pictures, I would say that the criterion he sets forth is exactly the one that is exhibited here by Galton in connection with his method of composite portraiture.

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If I had to conclude by displaying the unity of Mach's reflection on phonographs and Mach's reflection on photographs, maybe the best I could do would be to refer to the following passage, which entails almost all of the elements I have considered in this paper:

³⁶ Cf. James Conant: "Family Resemblance, Composite Photography, and Unity of Concept: Goethe, Galton, Wittgenstein" (Lecture in Bergen 15.9.2005) to be downloaded on : http://wab.aksis.uib.no/wab_contrib-audio-cj-photo05.page

³⁷ Sir Francis R. Galton : "Generic Images", in *Nineteenth Century* 6 (July), pp. 157-69 (p. 160).

³⁸ "Generic Images", p. 169.

The most wonderful economy of communication is found in language. Words are comparable to type, which spare the repetition of written signs and thus serve a multitude of purposes; or to the few sounds of which our numberless different words are composed. Language, with its helpmate, conceptual thought, by fixing the essential and rejecting the unessential, constructs its rigid pictures of the fluid world on the plan of a mosaic, at a sacrifice of exactness and fidelity but with a saving of tools and labor. Like a piano-player with previously prepared sounds, a speaker excites in his listener thoughts previously prepared, but fitting many cases, which respond to the speaker's summons with alacrity and little effort³⁹.

In other words: to think is to produce economical pictures; such pictures are linguistic pictures; these are in turn phonetic pictures. Rather than reproducing reality, they rather generate a typical or generic, composite picture of it, as it were a mosaic; and they do it with the same virtuosity as a piano-player, whose music might be recorded by means of a phonograph.

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³⁹ Ernst Mach: *Populär-wissenschaftliche Vorlesungen*, trans. Thomas J. McCormack: *Popular Scientific Lectures*, Chicago, Open Court, 1897, "On the economical nature of physical inquiry", p. 210.

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