Hist. Phil. Life Sci., 35 (2013), 379-394

Induction of Visibility: Reflections on Histological Slides, Drawing Visual Hypotheses and Aesthetic-Epistemic Actions

Erna Fiorentini

Institut für Kunst- und Bildgeschichte der Humboldt-Universität zu Berlin
Georgenstraße 47, 10117 Berlin, Germany
erna.fiorentini@hu-berlin.de

ABSTRACT - This paper focuses on histological slides and on the strategies of visual transformation of Santiago Ramón y Cajal. His practices and concepts reveal that not only the slides as such and their images have cognitive and aesthetic values crucial to the epistemic gain about the original material, but also the processes that unveil and reassess these values during observation and imaging. Therefore, considering the nature of these processes contributes to – besides the inquiry about the slides themselves – disclosing their role as epistemic and cultural objects in the history of the life sciences. To be beneficial to this inquiry, however, a closer definition of these processes is needed. I propose to define these operations in terms of the notion of "induction of visibility," which specifies general concepts of "visualisation" or "making something visible" as an instrument generating and transporting visual knowledge. Processes of visibility induction, I argue, constitute a category of visual action in their own right, which derives from and generates aesthetic and epistemic operations likewise. For this category, I propose, therefore, the concept of "aesthetic-epistemic action."

KEYWORDS - Induction, visibility, visualisation, imaging, Santiago Ramón y Cajal, visual hypothesis, attention

Slides and processes

This paper addresses a special form of microscopic slide, namely thick sections of histological tissues. It focuses on the strategies that the neurologist Santiago Ramón y Cajal adopted in order to visualise the structures hidden in these tissues and to transfer by drawing not only their forms and relationships into images, but also the knowledge he gained about them during microscopic observation. In the case of histological preparations, the process of observation must begin with an "extortion of visibility" from the raw material, namely with staining procedures that uncover the structures that lay hidden in the object. The staining of a histological slide freezes a certain state of the material under certain

conditions and contains every possible meaning of this state. Cajal, as a microscopist and draughtsman, had to decipher these different hidden meanings in order to transfer them into images; thus, his knowledge about them first evolved from the action of visual processing.

Cajal's practices and concepts reveal that not only the slides and their images have cognitive and aesthetic values crucial to the epistemic gain about the original material, but also the processes unveiling and reassessing these values during observation and imaging. I contend, therefore, that thinking about the nature and the meaning of these processes contributes – like the slides themselves – to add to our knowledge of their role as epistemic and cultural objects in the history of the life sciences. To be beneficial to such an inquiry, a closer definition of these processes is needed: I shall argue that they are actions that bring about a new visibility and that do not merely imply visual reproduction, but consist in a simultaneity of aesthetic and epistemological critique that is essential to disclosing visually the content and the epistemic potential of microscope slides during observation. Consequently, I propose to define these operations in terms of "induction of visibility" as a notion that specifies too general concepts like "visualisation" or "making something visible." Processes of visibility induction, I shall argue, constitute a category of visual action in their own right: they produce and transport visual knowledge deriving from and generating aesthetic and epistemic operations likewise and can be therefore described by the notion of "aesthetic-epistemic action."

Induction of visibility

My reflections start from the observation that the significance of processuality for the understanding of visual transformation and imaging has not been discussed systematically in art history, the *Bildwissenschaft*, the history of science, and the image sciences in general, at least for operations involving an observer. Although "making visible what is not immediately evident for the eyes represents the fundamental gesture of modern science," the very process of making something visually available, the very act of producing visibility, and the process transforming this visibility into images as its palpable "traces," has "not at all [been] in the perspective of classic traditional epistemology" (Rheinberger 2009, 127-128).[1] Indeed, the history of science mainly focuses on object-related notions, which consider the efficacy of the "epistemic things" that

[1] All translations, if not otherwise stated, are my own.

are the subject of study (Rheinberger 1997), i.e., the object or the visual product itself, and to a lesser extent the processes leading to their form or appearance.

Also, unlike the critique of production in literary theory, such as the author-oriented methods that discuss the degree of involvement of a subject in the production and the shape of a certain literary phenomenon (Foucault 1979; Schmidt 1991), the processes of production and transformation of visibility are still not the focus of attention in aesthetic image theory and in its methods. Despite the fact that art history, in its comprehensive understanding as a science of the images, aspires to relate "form, history, perception and content" of images (Bredekamp and Werner 2003, 7), so far the interest for these relationships in terms of imaging processes has mostly faded behind the screen of the visual objects themselves, of their nature and their effects; the latter were mostly considered as the image's intrinsic power to influence and move the beholder (that is, to exert an independent *Bildakt* upon him or her; see Bredekamp 2010), or in terms of the image's deictic power, its capacity to show (Boehm 2010) or directly demonstrate something. It seems that the conviction persists that images are "detached from their coming-into-being" and that "in the presence of the art work, the procedure of its production is constitutively forgotten," and impossible to grasp (Egenhofer 2010, 7).

Currently, transdisciplinary attempts are beginning to germinate that are directed at surveying the conceptual and historical significance of visibility production, particularly in the image sciences. However, an attempt at complementing a static, classificatory, deterministic conception of imaging *practice* by means of a dynamic, possibly stochastic concept of imaging *process* is still pending. Yet a more critical conception of processuality is needed if we want to understand the practices that give rise to visibility in images; question their motivation, their theory and their history, eventually being able to learn more about the intentions of visual transformation that are peculiar for individual cultures of visualisation; and, moreover, understand what the images that are created in these contexts intend, and what happens when we look at them and why. Ultimately, in fact, not until "the act of representing is consulted for its meaning, [will] the looking at the image and thus the field of its external relations [be] reflected" (Krüger 1997, 82).

To date, operations and processes giving rise to visibility have been generally subsumed under a general concept of "visualisation" or "making visible." However, both terms are limiting, since they imply that what is becoming visible pre-exists in a certain form or happens in a certain way – even when it is visually hidden – and that this form or phenom-

enon is simply transferred by the observer, by means of whatever practice, into a material dimension accessible to perception. But such translations are often more complex: they are transformations involving a continuous interplay between the observed object, the observing subject and the image that s/he produces; they consist in visual intervention based upon selective perception, the rational and emotional analysis of what is perceived and the visual re-arrangement of this analysis. The general terms of "visualisation" or of "making visible" convey the idea of a procedure of translating invisible things into visible dimensions, and does not account for the complexity of these operations. I will propose in the following to think of such processes in terms of an "induction of visibility." This term conveys both the idea of making objects or phenomena visible and, very much in the sense of inductive logic, the idea of inferring a new general visual form from a number of particular visual actions. Induction of visibility allows one to describe more accurately the complex processes that are going on between the beholder and the object of visualisation under circumstances in which visual accessibility of the object is restricted and must be brought about in the first place; it can provide a tool to encompass the complex variants of visualisation in which the beholder, the object of visualization, and the resulting image mutually depend on each other.

But how can we map induction of visibility as a particular variety of visualisation? Can we detect characteristic features for these processes that specify this notion and allow us to define it as a category of visual processuality? The processes of visual transformation in microscopic slides, and in imaging processes during microscopic observation in general, offer an ideal experimental field to work out the features of procedures inducing visibility; in particular, the strategies of preparation, observation and imaging of histological slides. In the following, I will focus specifically on visualisation procedures adopted by the neurohistologist and 1906 Nobel laureate in Medicine, Santiago Ramón y Cajal, in order to discuss the nature of processes of visibility induction. Cajal's visual strategies, I will argue, involved complex interactions between object, observer and image; in other words, they embody processes of perception, cognition and reasoning, of analysis, judgement and synthesis, and in sum, all the processes of knowledge application and production that are performed by an observer during the passage from one form of visibility to another.

Histological slides

To understand that Cajal did not simply visualise something, but rather induced visibility by his imaging strategies, it is important to recall

that the objects of neurohistological inquiry, i.e. the tissues of the brain and the nervous system, are completely opaque, showing nothing of their complex structure if left in their natural state. In unprocessed histological samples of these tissues "structures of formidable complexity appear under the microscope with the colourlessness and the simplicity of architecture of a mass of jelly;" these structures are hence not "directly accessible to the senses." Thus, "histology and bacteriology are obliged to fulfil the preliminary and difficult task of making visible their special objects of study before they can commence the work of analysis" (Ramón y Cajal 1988, 526-527); they must purposely bring the structures hidden in the matter of the specimen into view, highlighting them in the jelly-like mass of the raw brain tissue. To accomplish this, histologists use selective staining, a method first developed by Camillo Golgi in 1873 (Golgi 1873), which blackens certain nerve cells by chromoargentic reactions, and only these cells, not the tissue mass surrounding them. The method of selective staining induces in the specimen the visibility of cell structures that are not visible otherwise; it can effect the visual release of structures that are possibly hidden in the natural material in order to make them perceptible. This process fits the general notion of "visualising" discussed in the previous section because it corresponds to processes that literally "visualise" something or "make something visible." But isolating structures that are not visible in an object in its natural state, by intervening in, and manipulating the object, is not only an "enhancement" of less visible structures (Rheinberger 2009, 132). It is rather an action that forces invisible structures to appear in the first place, since it is only the action of dyeing that brings about the visibility of these structures in the object. So it should be rather called an "enforcement" of visibility.

By means of this action, the histologist is eventually able to see more in the histological slide, namely neuronal cells emerging from the jelly mass as dark structures (Figure 1). However, although the staining action factually colours the structures in the specimen thoroughly, the whole structure of these cells is still not completely available to the observer's perception; quite on the contrary: the three-dimensional whole of the structures in the specimen cannot be seen at a glance under the microscope. In the thick sections used as histological specimens to contain the neuronal structures in their three-dimensional ramifications, in fact, the cells are disposed in several planes and oriented in diverse ways. This means that, depending on which orientation is chosen to cut the sample for the histological slides, one sees different aspects of the cell form. In histological preparations, as Cajal explained, "we sometimes also had the chance to find cells, from time to time, that were placed parallel to the section [i.e., the surface of the slide], so that the majority of its ramifica-

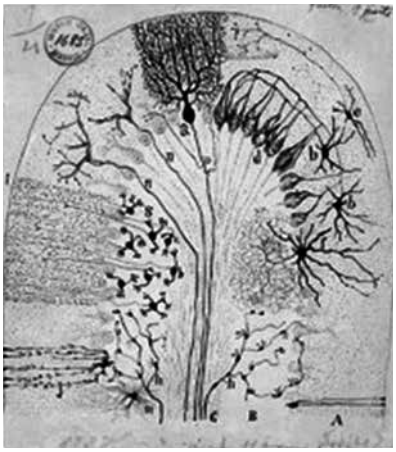

Fig. 1 - Photomicrograph from one of Ramón y Cajal's preparations of the postcentral gyrus of a newborn child, showing a layer V pyramidal cell impregnated by the Golgi method (Museo Cajal, Madrid). Reproduced from DeFelipe, Javier & Jones, Edward G., "Santiago Ramón y Cajal and methods in neurohistology," *Trends Neurosci.*, 15(7): 237-246 (July 1992), Fig. 2. © courtesy Elsevier.

tions are found in the same level of focus."[2] In this case, this means, one can approximately see how the whole structure develops in its length on the two-dimensional surface of the cut. But in other cases, the cells can be placed vertically to the surface of the preparation. Then, one only sees a cut through the cell from above, but the ramifications running in other directions remain concealed. Therefore, Cajal complained,

> it is certainly true that we can examine the nervous system […] and […] isolate its most characteristic elements, nerve cells. But consider their appearance! We usually observe […] fibres that seemingly whirl about in all directions; we identify various other components without being able to determine […] their form […]. What happened to the extensions of the cell? What is their actual length? What course do they take? What are their relationships, and where do they end? […] It is impossible under these conditions to recognize anything but a chaotic mass. (Ramón y Cajal 1995, 20-21)

This all means that even after selective colouring, the observer is still unable to see under the microscope the completeness of a neuronal structure, its extension and the features of the cells in the three-dimensional space of the thick section at a glance. Or in other words, the selective action of dyeing makes hidden structures in the neuronal tissue potentially,

[2] "Quelque fois nous aurons aussi la chance de trouver, de temps en temps, des cellules placées parallèment à la coupe et dont la plupart des expansions se trouveront dans le même plan focal" (Ramón y Cajal 1907, 25).

but not actually visible. Even after being visually separated from the mass by staining, these structures continue existing in a dimension that is not plainly accessible to our eyes. In this dimension, they therefore persist in a state of "visual latency" (Boehm 2008, 23).

Drawing visual hypotheses

The point raised in the previous section brings up the problem of how to release the whole three-dimensional complexity of the structure coloured in the specimen from its visual potentiality and to transfer it into the perceivable visibility of a two-dimensional image. According to Cajal, free-hand drawing offers the best chances to accomplish this since this imaging procedure "forces us to examine the entire phenomenon" (Ramón y Cajal 1999, 113). Although possessing a high command of many other techniques of imaging, among others the apparently more reliable techniques of visual recording like photography and film (Fiorentini 2011, 393; De Rjcke 2008, 296-299), Cajal thus intentionally gave priority to imaging strategies involving the judgement of the observer, discarding an approach in terms of "mechanical objectivity" (Daston and Galison 2007, ch. 3). Accordingly, while observing and drawing, Cajal applied as a first step the principle of selectivity, in the same way as he did in the objects with his staining technique. Thus, he purposely did not reproduce the whole field he saw under the microscope, but first recorded the specifics of single elements of the structure in separate drawings. He collected these specific views, extracting them from the specimen in different phases of observation. For instance, he drew individual structures as they appeared in different focal planes of one specimen, but he also made drawings of structures of the same kind from different parts of a specimen; moreover, he extracted individual forms of the same structure from different specimens; finally, he made these drawings at different points in time, in intervals of weeks, of months, and in some cases, of years (De Rijcke 2008, 294-295).

Selecting and extracting were the fundamental steps to lift the visual latency of the structures hidden in the matter of the histological slide and to transfer their visually inaccessible three-dimensionality into visible two dimensions. But these operations merely provided the basis for a more important imaging operation, namely the following process of drawing that should encompass "the entire phenomenon" and its meaning (Ramón y Cajal 1999, 113). This step consisted in creating a comprehensive image of the neuronal structure contained in the slide. Here, the problem not only concerned the way to resolve the visual latency of

three-dimensional structures; it also concerned the question of how to accomplish this passage from three- to two-dimensionality, from a higher into a lower dimension of space and perception.

Cajal's solution, which he called "combining the images" (Sotelo 2003, 76), was to reorganise into one main picture all the individual structures extracted by drawing selectively and consecutively from the slides (Figure 2). However, such reorganised images are not simply compounds of forms, which abstract or schematise what can be seen looking at the microscopic preparation. Cajal's combined image was not just the result of a simplifying addition of successive stages of perception, it was much more than an additive reduction of "highly complex, dynamic viewing experiences into flattened, static, comprehensive images of neurons" (Sotelo 2003, 76). It rather delineated an additional dimension, which does not exist at all in the form displayed in the drawing. In fact, the individual elements that appear on the two-dimensional surface of the combined image stand parallel, vertical or diagonal to the visible surface of the slide during observation. Their full form and spatial relationship cannot be gathered visually as a whole in the specimen, even if the observer was able to step into the three-dimensions of the preparation, and even if "a complete 'mental image' of the nervous tissue at hand" could be achieved during observation, as De Rijcke claims (De Rijcke 2008, 295).

Cajal's combined images are made up of structures that are not "nothing" since they are visible, even if only partially, and therefore do exist in some form; but these structures are also not "completely something;" in fact, they are only partially visible, and we cannot grasp their existence in full. Ontologically, therefore, the complete shape of the individual structures and their overall relationships remains a visual potentiality, since it is not fully accessible for the observer. Accordingly, the image resulting from combining successive observations and recordings cannot be but a visual hypothesis formulated by the drawing observer about the possible or probable nature and position of these structures. Such an image predicates more than the sum of its parts; it is neither the sum of forms reconstructing an extant structure, nor does it correspond to the factual observation of the whole structure: rather, it is an "ideogram […] a graphic depiction of certain ideas, of a certain sense, of a kind of understanding" (Fleck 1980, 183), that is, the knowledge achieved during observation and drawing. This is in compliance with Cajal's own conviction that "the first condition of the microscopist drawer [sic] is to know how to see and to interpret what he sees" (Ramón y Cajal 1889, 9).

The imaging process leading to this visual hypothesis neither fits the idea of visualisation in the sense of reproducing the forms that had been made visible in the specimen by means of dyeing, nor does it fit the pro-

Fig. 2 - Santiago Ramón y Cajal, The organization of a folium of the cerebellar cortex, drawing, 1894 (Instituto de Neurobiología "Ramón y Cajal", Madrid), reproduced from Sotelo 2003, figure 5, © courtesy Elsevier.

cesses of visual reduction and schematisation of individual observations. It is more complex than this: the imaging process consists in an action combining the visual analysis of individual structures, the evaluation of their relationship, and their visual rearrangement in a new dimension according to this evaluation and to the new knowledge deriving from it. It is an act of visual recombination that serves the purpose of histological inquiry, which is not to reproduce forms or subsume them under a scheme, but to show "their precise arrangement and their relation with other, extracellular structures" (Ramón y Cajal 1988, 520); in other words, the aim is to show not merely the forms observed, but what could be educed about their possible relationships during observation and during the assessment of the best strategy to display this knowledge in the images. Such imaging procedures do not reproduce a given visibility, in whatever form, be it pictorial or schematised; it rather brings about a new visibility in the images, which incorporates the forms observed as well as the new insights inferred from them during observation and the very process of drawing. In this, the action is far from being a non-mediated, objective and naturalistic representation of the observed structures, exactly like the actions and procedures of selection and mounting adopted for the film *The Unseen World* described by Oliver Gaycken in this issue.

Aesthetic-epistemic actions

As explained in the previous section, processes of inducing visibility may involve more than the idea of "abstraction" (De Rijcke 2008) of observations or even of their "synthesis in an expanded framework" (Fiorentini 2011, 393). They rather fit the Deleuzian concept of "assemblage" (Deleuze and Guattari 1987, 504-505). Applying Deleuze's notion, we can spot three characteristic phases responding to each other in processes of inducing visibility: first, the deciphering of available circumstances (as in the selective visual analysis of structures in the histological slide), then their new encoding (as in the formal extraction of important

features of one chosen structure), and finally, the merging (or assemblage) of these codes to produce a new form able to convey the new information and the new meanings obtained about the circumstances observed (as in the process of recombining images).

In these phases as a process of Deleuzian "assemblage," induction of visibility has a fundamentally epistemic quality, both in the sense of knowledge application and of knowledge production. Indeed, the visual operations in this process are in the first instance "inseparable from the known" (Zimmermann 2005, 11). They in fact apply extant knowledge, for instance, to induce visibility in the object (say, the knowledge about chemical reactions, which only display certain cell structures in raw compounds); but they also rely upon the standard of knowledge and interpretation available to the observer while selecting a strategy of graphical representation that should enable the image to convey the new insights and knowledge gained by observation.

But actions of visibility induction are also inseparable from the expectation of a "still-to-be-known," from the prospect of a growth in knowledge, of an epistemic gain – an expectation, which itself triggers operations generating knowledge during processes of observation and imaging. The specific case of histological slides exemplifies this very well. Actions inducing the visibility of hidden forms by selective dyeing create new objects of perception and inquiry in the matter. By colouring, these objects turn into entities with individual shapes that, rather than showing immediately the state and the nature of the whole structure in which they are embedded, freeze a specific form of the matter. Through dyeing, they become "images of themselves, or material metonymies" (Rheinberger 2003, 10) that represent nothing but give an individual, visual statement about their nature and relationships. The observer needs to interpret and evaluate these visual statements, not only applying, but also modifying and enhancing his or her knowledge about them while isolating them through operations of discernment and intuition. The selection of relevant visual features and the choice of the most significant formal elements in the slide are epistemic operations constitutive of the Deleuzian processes of deciphering the object of inquiry in both content and form.

To convey the results of this process of discernment and intuition via imaging, a new formal encoding of the structures under investigation is necessary. During observation, this encoding procedure requires judgement about what should be translated into the images. This translation, the act of drawing, is an extraction of the relevant forms and relationships at stake. Here, again, the process is driven by a continuous reflection about what the forms mean, about the new contents they disclose during the process of deciphering and about how to transmit these new

contents via the forms in the image. The shifts in knowledge during such judgement operations are constitutive of the fundamental step of the reorganisation, the "assemblage," in which the draughtsman rethinks the extracted forms in a new image; these epistemic shifts during drawing influence the decision about what it is exactly that should be made visible, and are actions of negotiation between the observer and the object, giving rise again to shifts in knowledge and insight in the passage between geometrical spaces of observation and imaging, between the slide and the image, via the drawing activity.

This negotiation via judgement not only makes the possible, but nearly invisible, forms accessible to the senses; rather, it displays the thoughts about them. In other words, it is an action of visual transformation inducing the visibility of the conclusions drawn from observation and from the assessment of forms and interrelations, that is, the knowledge produced during observing and drawing. In contrast to Wittgenstein's dictum that "what can be shown, cannot be told" (Wittgenstein 2003, 4.1212), the images resulting from this process are thus able to show and tell at the same time. They can show, for instance, the visual latency or "possible presence" (Boehm 2008, 23) of the neuronal structures, which cannot be told; and they can reveal what cannot be shown directly, such as the paths of cognition, reasoning and conclusion along which the process of drawing produces knowledge about these visually latent structures, their nature and mutual relationship.

That means that drawing, as an action that induces visibility, not only creates a new world in the image but also discusses possible versions of that world. Furthermore, the image shows this discussion and the gain in knowledge that occurred in the course of its creation; it is thus one of those "ways of worldmaking," which according to Nelson Goodman, are "modes of discovery," of "creation, and enlargement of knowledge" (Goodman 1995, 102). It is an epistemic action in the sense that it is an action of knowledge production and modification beyond the simple reproduction of forms. In this, induction of visibility differs in its quality from the idea of "epistemic action" that María J. Santesmases (2011) proposes, which she understands in terms of image manufacturing as an action of objectivation and stabilisation of "eyewitnessing" as described by Burke (2001).

The operations that belong to processes inducing visibility, to processes of Deleuzian assemblage, however, exceed purely rational activity during observation and imaging, since they fundamentally involve processes connecting the observer with the objects and the images via perception and visual assessment. These operations point to another quality of the induction of visibility that, even if related to perception, cannot

be defined in terms of simple *aisthesis* as a process of sensory perceiving and recording of visual information; this other component of the induction of visibility involves less passive perception, as it implicates active participation in the operations of judgement that influence visual decisions for the visual transfer of knowledge. Tentatively, we can apply the more complex attribute of "aesthetic" to this component in processes of inducing visibility, provisionally in terms of the original connotation of "aesthetics," in which perception is a sensory instrument of cognition (Baumgarten 1986 [1750]). But processes inducing visibility also involve amplification and sharpening of the perceiving capacities during observation. This not only improves the observer's ability to see, but also provides him or her with "a new sense for capturing the unknown" (Ramón y Cajal 1988, 526) that goes beyond passive cognition: this new sense is a more advanced sensibility that increases the observer's responsiveness for "unexpected details" (Ramón y Cajal 1988, 529) awakening visual curiosity. Such exceptions in the expected visibility can be many, but they can be generalised as anomalies of form, extension or distribution of structures. Anomalies catch the eye of the observer not only because they are unusual for a certain epistemic expectation, but also because they appeal to the attention as deviations from continuity in the shape of particular elements or in their mutual relationship (Menzel 2008, 15-16).

The aesthetic quality of visibility induction can therefore also be related to the response of the observer to the presence and degree of attributes like "elegance," "symmetry" and "harmony," which can represent deviations from what is expected. On the one hand, the attention to these categories fits the epistemic demands of what has been called the "aesthetic dimensions of science" (Krohn 2006, 3); on the other hand, it also matches the specific sensibility related to the sensory and emotional response to beauty, fitting the coordinates of aesthetics in its narrower, modern, philosophical sense. Not accidentally, the latter kind of aesthetic sensibility is programmatically incorporated in Cajal's strategies of observation and drawing as induction of visibility; it is part of Cajal's peculiar "aesthetic epistemology" (Fiorentini 2011) in which aesthetic sensibility is declared as the fundamental premise for grasping and selecting the essential features of what is observed and displaying this essence in images (Ramón y Cajal 1988, 414-415).

The aesthetic quality of the induction of visibility is thus multifaceted. It complements, but at the same time, contains the epistemic component, triggering its operations of discernment and judgement. In processes inducing visibility, epistemic and aesthetic components and operations thus do not exist separately, but are fundamentally interwoven and interdependent, possibly related to each other by imagining processes. The resulting

images become a vehicle to communicate or share the insights that derive from these actions merging epistemic and aesthetic moments. They "make visible those parts of reality that we would not experience without them" (Boehm 2007, 252). However, the visibility of insights induced in the images can make the beholder "see more […], open his eyes" (Boehm 2007, 39) on the knowledge transmitted, so that it can be possibly assessed anew, producing new insights. The visibility induced in the images, therefore, not only transports knowledge, but becomes an instrument of knowledge production itself (Goodman 1976, 32; see also Van Fraassen and Sigman 1993; Rheinberger 2003, 9). It becomes for the beholder "a tool, whose application facilitates novel actions" (Wiesing 2005,152), among them the revision or modification of the knowledge educed during observing and drawing. Therefore, even if the images display the knowledge gained during drawing, during the induction of visibility, they remain "scientific documents keeping their value indefinitely," so that their "revision is advantageous regardless of the interpretations for [sic] which they give rise" (Ramón y Cajal 1899-1904, Introduction, vol. I; English translation after De Felipe and Jones 1992, 243) The images themselves, in other words, give rise to a new epistemic gain, expanding the knowledge achieved during observation and drawing.

The oscillation between, and the merging of, epistemic and aesthetic components, which are mutually dependent and influence one another during observation and imaging, is the fundamental quality of processes of induction of visibility, and it also colours the epistemic and aesthetic efficacy of its visual products. As a particular category of visualisation, therefore, processes inducing visibility might be termed aesthetic-epistemic actions. The notion of induction of visibility as an aesthetic-epistemic action not only helps specify the general concept of visualisation, but also complements the revision of the passive concept of illustration (Bredekamp 2004, 46), at the same time offering the idea of a more complex action that displays the visible and thus produces "effects of objectivity" (Zimmermann 2009, 12) while admitting a place for judgemental subjectivity. Induction of visibility perceived in this way fits Frank Fehrenbach's notion of "affective rapture" accounting for an imaging process that transcends the perceived visibility and does not imitate, but creates reality (Fehrenbach 1997, 322-323, 330). What is more, this concept allows the methodical access to processes leading to specific visual coding rules and thus to differentiate "styles," which according to Ludwik Fleck, express "the disposition for directional perception, with corresponding reflecting and factual processing of the perceived" (Fleck 1980, 130).

Acknowledgements

I am grateful to Ilana Löwy (CERMES, Paris) and Staffan Müller-Wille (University of Exeter) for their precious suggestions, which helped finalise the shape of this article. The research for this paper has been performed in the context of my long term project "Induction of Visibility. An Attempt at the Notion of Aesthetic-Epistemic Action" funded by the German Research Foundation / *Deutsche Forschungsgemeinschaft – DFG.*

References

Baumgarten A.G., 1986, *Aesthetica* [1750], Hildesheim: Olms.

Boehm G., 2010, "Das Zeigen der Bilder," in: Boehm G., Egenhofer S. and Spies C. (Hg.), *Zeigen. Die Rhetorik des Sichtbaren*, München: Wilhelm Fink, 19-54.

Boehm G., 2008, "Augenmaß. Zur Genese der ikonischen Evidenz," in: Boehm G., Mersmann B. and Spies C. (Hg.), *Movens Bild. Zwischen Evidenz und Affekt*, München: Wilhelm Fink, 15-41.

Boehm G., 2007, *Wie Bilder Sinn erzeugen. Die Macht des Zeigens,* Berlin: Berlin University Press.

Bredekamp H., 2010, *Theorie des Bildakts,* Berlin: Suhrkamp.

Bredekamp H., 2004, "Bildakt als Zeugnis und Urteil," in: Flacke M. (Hg.), *Mythen der Nationen 1945. Arena der Erinnerung*, Berlin: Deutsches Historisches Museum, Bd. 1, 29-66.

Bredekamp H. and Werner G., 2003, "Editorial," *Bildwelten des Wissens,* 1(1): 7-8.

Burke P., 2001, *Eyewitnessing: The use of images as historical evidences*, London: Reaktion Books.

Daston L. and Galison P., 2007, *Objectivity*, New York, N.Y.: Zone Books.

Deleuze G. and Guattari F., 1987, *A Thousand Plateaus: Capitalism and Schizophrenia,* Minneapolis: University of Minnesota Press.

Egenhofer S., 2010, *Produktionsästhetik*, Zürich: Diaphanes.

De Felipe J. and Jones E.G., 1992, "Santiago Ramón y Cajal and methods in neurohistology," *Trends in Neurosciences,* 15(7): 237-246.

De Rijcke, S., 2008, "Drawing into abstraction. Practices of observation and visualisation in the work of Santiago Ramón y Cajal," *Interdisciplinary Science Reviews,* 33(4): 287-311.

Fehrenbach F., 1997, *Licht und Wasser. Zur Dynamik naturphilosophischer Leitbilder im Werk Leonardo da Vincis*, Tübingen: Wasmuth.

Fiorentini E., 2011, "Inducing Visibilities. An Attempt at Santiago Ramón y Cajal's Aesthetic Epistemology," in: *Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences* 42(4): 391-394.

Fiorentini E., 2009, "Placing Oneself at an Adequate Point of View. Santiago Ramón y Cajal's Drawings and the Histological Look," in: Brauckmann S., Brandt C., Thieffry D. and Müller G.B. (eds), *Graphing Genes, Cells, and Embryos. Cul-*

tures of Seeing 3D and Beyond, Berlin: Max Planck Institute for the History of Science, Preprint 380, 133-142.
Fleck L., 1980, *Entstehung und Entwicklung einer wissenschaftlichen Tatsache*, Frankfurt am Main: Suhrkamp.
Foucault M., 1979, *What is an Author?,* Oxford: Oxford University Press.
Golgi C., 1873, *Sulla struttura della sostanza grigia del cervello*, Milano: Rechiedei.
Goodman N., 1995, *Ways of Worldmaking,* Indianapolis: Hackett.
Goodman N., 1976, *Languages of Art,* Indianapolis: Hackett.
Krohn W. (Hg.), 2006, *Ästhetik in der Wissenschaft. Interdisziplinärer Diskurs über das Gestalten und Darstellen von Wissen*, Hamburg: Meiner.
Krüger K., 1997, "Geschichtlichkeit und Autonomie. Die Ästhetik des Bildes als Gegenstand historischer Forschung," in: Oexle O.G. (Hg.), *Der Blick auf die Bilder: Kunstgeschichte und Geschichte im Gespräch*, Göttingen: Wallstein, 53-86.
Menzel R., 2008, "Ästhetik als Mittel der Erkenntnis. Die Geschichte einer Entdeckung," *Bildwelten des Wissens*, 6(1): 9-18.
Ramón y Cajal S., 1999 [1854], *Advice for a Young Investigator,* Cambridge, Massachusetts / London: The MIT Press.
Ramón y Cajal S., 1995 [1899-1904], *Histology of the nervous system of man and vertebrates, Vol. 1,* (translated by Swanson N. and Swanson L.W.), New York / Oxford: Oxford University Press.
Ramón y Cajal S., 1988, *Recollections of my Life,* New York: Garland.
Ramón y Cajal S., 1907, "Notes microphotographiques," *Travaux du Laboratoire de Recherches Biologiques de l'Université de Madrid,* 5: 23-45.
Ramón y Cajal S., 1899-1904, *Textura del Sistema Nervioso del Hombre y de los Vertebrados*, 2 vols, Madrid: Moya.
Ramón y Cajal S., 1889, *Manual de Histologia Normal y de Tecnica Micrografica*, Valencia: Aguilar.
Rheinberger H.-J., 1997, *Toward a History of EpistemicThings: Synthesizing Proteins in the Test Tube,* Stanford, California: Stanford University Press.
Rheinberger H.-J., 2003, "Präparate – 'Bilder' ihrer selbst. Eine bildtheoretische Glosse," *Bildwelten des Wissens*, 1.2: 9-19.
Rheinberger H.-J., 2009, "Sichtbar Machen – Visualisierung in den Naturwissenschaften," in: Sachs-Hombach K. (Hg.), *Bildtheorien. Anthropologische und kulturelle Grundlagen des Visualistic Turn*, Frankfurt am Main: Suhrkamp, 127-145.
Santesmases M.J., 2011, "Samples, Cultures and Plates: Early Human Chromosomes," in: Löwy I. (ed.), *Microscope Slides – Reassessing a Neglected Historical Ressource*, Berlin: Max Planck Institute for the History of Science (Preprint 415), 25-34.
Schmidt S.J., 1991, *Grundriss der Empirischen Literaturwissenschaft*, Frankfurt am Main: Suhrkamp.
Sotelo C., 2003, "Viewing the brain through the master hand of Ramón y Cajal," *Nature Reviews Neuroscience*, 4(1): 71-77.
Van Fraassen B.C. and Sigman J., 1993, "Interpretation in Science and in the Arts," in: Levine G. (ed.), *Realism and Representation*, Madison: University of Wisconsin Press, 73-99.
Wiesing L., 2005, "Methoden der Bildwissenschaft," in: Sachs-Hombach K. (Hg.),

Bildwissenschaft zwischen Reflexion und Anwendung, Köln: von Halem, 144-154.
Wittgenstein L., 2003, *Tractatus logico-philosophicus,* Frankfurt am Main: Suhrkamp.
Zimmermann A., 2009, *Ästhetik der Objektivität. Genese und Funktion eines wissenschaftlichen und künstlerischen Stils im 19. Jahrhundert*, Bielefeld: Transcript.
Zimmermann A., 2005, *Sichtbarkeit und Medium: Austausch, Verknüpfung und Differenz naturwissenschaftlicher und ästhetischer Bildstrategien*, Hamburg: Hamburg University Press.