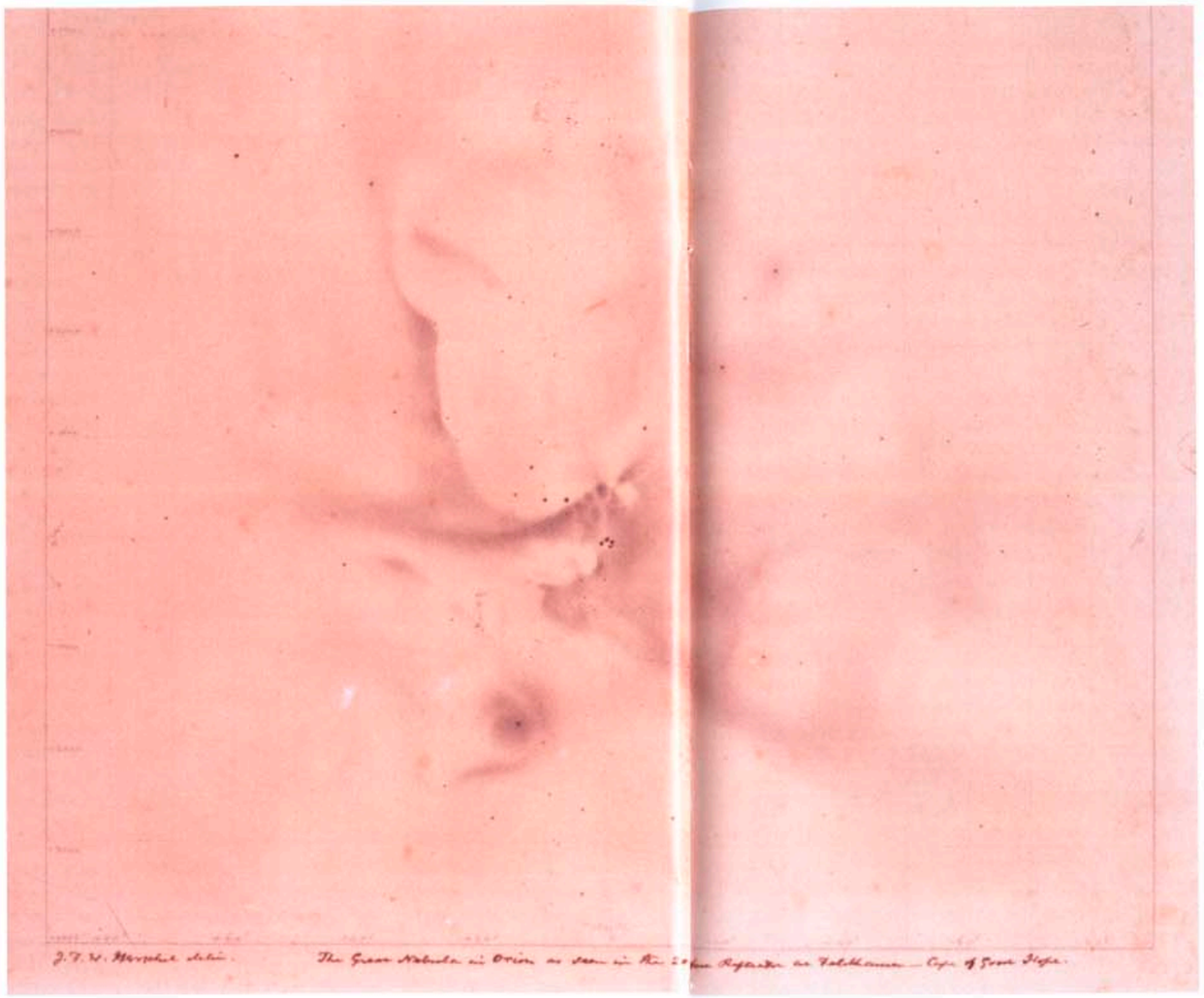
Science in Sketches

They look as if they've been haphazardly dashed off, are often hard to decipher and are obviously not intended for anyone else to understand. However, notebook entries and children's drawings are tools of knowledge creation – and that is precisely why **Christoph Hoffmann** *and* **Barbara Wittmann** *are interested in them. The researchers from the* **Max Planck Institute for the History of Science** *are studying how writing and drawing by hand can help us gain new understanding.*



The Great Nebula in Orion as drawn by British scientist Johann Frederick William Herschel, ca. 1835.

Photo: National Museum of Photography, Film & Television, Bradford

It's quite possible that Christoph Hoffmann could distinguish any number of archives in Germany by their very scent. For the life of him, he can't say how much of his time he's now spent in the study of archives. The inter-institutional research initiative "Knowledge in the Making. Drawing and Writing as Research Techniques" has been ongoing since the fall of 2006. The initiative was developed by Christoph Hoffmann and Barbara Wittmann in cooperation with Hans-Jörg Rheinberger, Director at the Max Planck Institute for the History of Science, and Gerhard Wolf, Director at the Kunsthistorisches Institut (Institute of Art History) in Florence (Max Planck Institute).

The project encompasses two groups of researchers at the two institutes studying the role that observational sketches, notes and drawings play in obtaining scientific insight, and in the aesthetic process. Each of them looks at it from a different perspective, with a different subject: Jutta Voorhoeve, an art historian at the Kunsthistorisches Institut, is studying the functions of drawing in contemporary art, and Omar W. Nasim, also from the institute in Florence, is investigating drawings of cosmic nebulae done by English astronomers and artists between 1830 and 1865. At the Berlin-based institute, Karin Krauthausen is working on the Cahiers (notebooks) of Paul Valéry, Christoph Hoffmann has devoted himself to Ernst Mach's notebooks, and Barbara Wittmann has taken on the task of examining the use of children's drawings in the field of psychology.

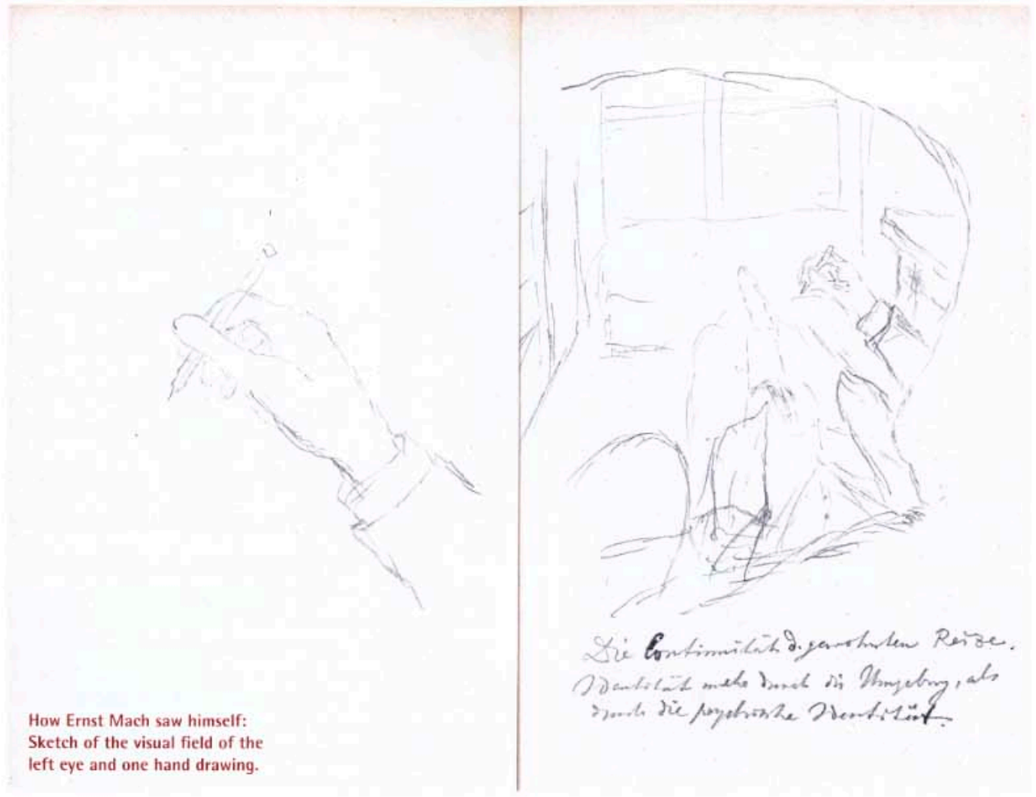
"We want to create an awareness of the fact that, even in today's highly technology-centered research context, apparently trivial actions like writing and drawing have something to contribute to scientific knowledge," says Hoffmann, explaining the goal of the research project. "Without the ability to write or the capacity to use a pen, science as we know it would not be possible." He goes on to say that, while pen and paper do not in themselves produce direct knowledge, they do influence people's cognizance and thinking.

"Thinking a thought and putting it down in writing and drawings are two completely different things," says Hoffmann. Apparently, we humans prefer to record things in black and white rather than merely keeping them in our heads. That is why things like lists are so popular – this is, incidentally, a form that Hoffmann comes across a great deal in his notebook studies. "A list is script-bound: you may have the content in your head, but you tend to write things down just in case – to help you not to forget, or to give you an overview of everything," says Hoffmann.

The value of the tool for knowledge acquisition becomes even more conspicuous when it comes to other mental tasks. "Some things need to be put down on paper before you can even conceive of them," explains Hoffmann. Functional graphs in mathematics are one example, as the scholar points out: "It's impossible to imagine diagrammatic operations in your head if you haven't seen them drawn somewhere first."

Painstakingly deciphering scribbles

Hoffmann, who studied modern history and German literature, is now very familiar with calculations, formulas and diagrams. After all, he chose the notebooks of physicist and philosopher of science Ernst Mach for his project work. There are 53 of these pocketbook-size volumes chronicling 40 years of research. The chronology shows that Mach began making his notes when he took over as head of the Physical Institute of the University of Prague. The first of the notebooks dates back to the early 1870s. In a bid to better understand the idiosyncrasies they contain, Hoffmann will compare them with the observation journals of biologist Karl von Frisch, written half a century later, as well as the notebooks of writers and



How Ernst Mach saw himself: Sketch of the visual field of the left eye and one hand drawing.

philosophers – he has Friedrich Nietzsche and Robert Musil in mind.

He's just returned from the archive of the Deutsches Museum in Munich. There he spent the entire day bent over Mach's notebooks, painstakingly examining them line by line and comparing each with other entries. How did the little books help Mach move his research forward? That is the question Hoffmann is hoping to answer with his archival archaeology.

The scribble pad as a memory aid

"I'm trying to attain a complete understanding of the different methods that appear in the books," he says. Lists, drawings, tables – there are functional differences between all of them. After all, there are many ways of recording the setup of an experiment. His aim is not only to shed light on Mach's particular method of note taking, but also to gain general insight into the notebook as a tool of science. "I want to make an inventory of all of the possible methods, and chose Ernst Mach because his notebooks are so extensive. They contain so many different things."

The notebook as a scientific tool – it's no easy task he has set himself. His chosen research object does not exactly make easy reading. The reason for this lies in the very nature of the object – after all, such notebooks aren't intended for further publication. They are testimonials of a purely personal nature, being – unlike a letter – not addressed to anyone. "Notebooks are normally seen as a kind of extended memory," says Hoffmann. That is why notebooks are not self-explanatory.

Mach's research springs back to life on the pages of his notebooks. The scribble pads accompanied him wherever he went. With space for data and observations, experiment setups and unsolved questions noted down side by side with drafts of letters or reminders of everyday things – like the entry: "Buy notebook." At the top of one page he notes a train connection; below it are details of an experiment setup, along with notes and comments. The rest of the page is taken up by a calculation.

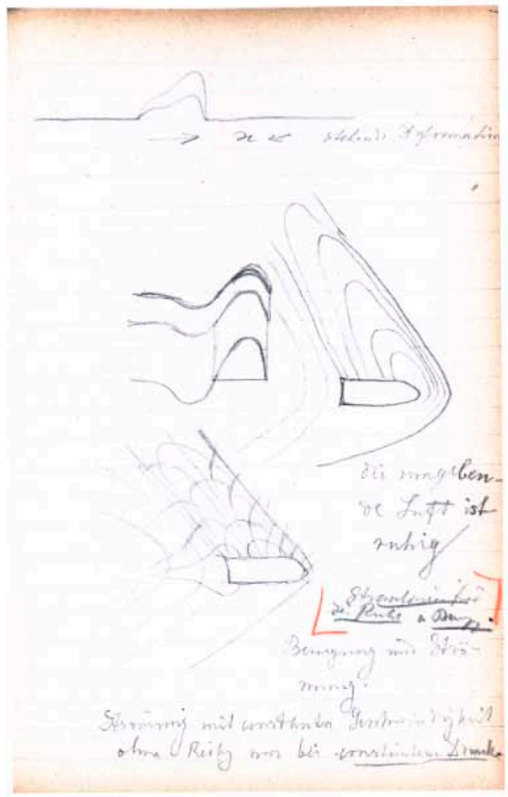
"Each of these notes illustrates different aspects of scientific activity: organization, experiment and data processing all strung together, seemingly at random and without context," says Hoffmann, describing the chaos spread out across the pages. The notebook researcher has noticed just one regularity about them: there is no law of sequence. Not even the chronological relationships are clear. It is impossible to say whether the entries on any given page were made in a single day or a single week; there is generally no indication of how much time passed between entries. For the Berlin-based science historian, they frequently bear witness to the concomitance of research projects. "The proximity of the entries points to the simultaneous events in Mach's working life," adds Hoffmann. A lack of chronological clues doesn't mean that the entries were made completely arbitrarily.

Hoffmann firmly believes that Mach's notes represent a scientific tool for the physicist – a means of guidance and support in the process of understanding, like differential calculus or photography. The notes in which Mach allows sketches and words to blend into one another also testify to this. Here, he is indicating that the things concerned are still only in the process of becoming conceivable in words. Now and then there are also little sequences of notes where a problem is outlined slightly differently each time, in sentences or drawings, as if the real task were to understand the problem in the first place. Or, in a technique typical of Mach: a formula is supported with a sketch that he uses to visualize the relationships between the items in the term in geometric form.

The range of methods is much more extensive than Hoffmann has discerned so far. But under no circumstances should you think that reading Mach's notebooks would be just like watching him at work. No, that would require too much reconstruction, and too much would remain a mystery anyway. "Each of the notes is quirky in its own way. You can see that there is method to it but, like a coded message, you can't always decipher just what it is."

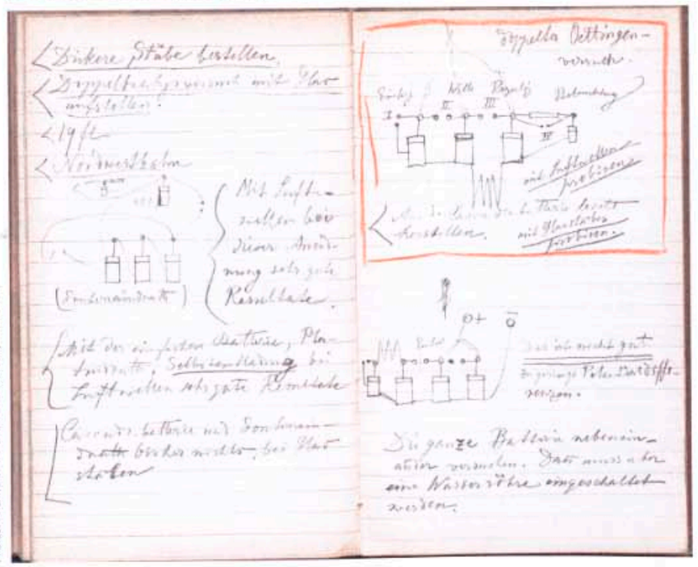
Barbara Wittmann, one of Hoffmann's colleagues at the Max Planck Institute in Berlin, also knows what it's like to have trouble deciphering things. She is working with two forms of drawing that differ greatly – at first glance, anyway. Part of her work is devoted to the use of scrawly stick figures, leaning houses and other imaginative children's drawings in the field of psychological diagnostics; her second case study concerns the role of freehand scientific drawing in modern biology. What both subjects have in common is the fact that drawing is seen as a tool in the true sense: as a technique for making visible something that had been forced to remain inaccessible with the help of other tools.

Like Hoffmann in his notebook research, Barbara Wittmann also steers clear of analyzing the content itself. The first of her two case studies focuses on the role of chil-



Depiction of the flows surrounding a supersonic projectile in 1887.

How the current flows: Mach's comments on various circuits for Leyden jars.



PHOTOS: ARCHIVE OF THE DEUTSCHES MUSEUM, MUNICH (3)

Drawing by a seven-year-old boy from an experiment by Jean Piaget, aimed at developing spatial thinking.

dren's drawings in psychology between 1880 and 1950. "Drawing was mostly seen as a medium for documenting perceptions, abilities and conflicts that the child was unable to articulate verbally," says Barbara Wittmann. More than games and make-believe or tall tales, drawings were supposed to provide insight into the sensomotoric development and spatial perception of children, their psychoanalytical dispositions and symptoms, as well as their intelligence and social integration.

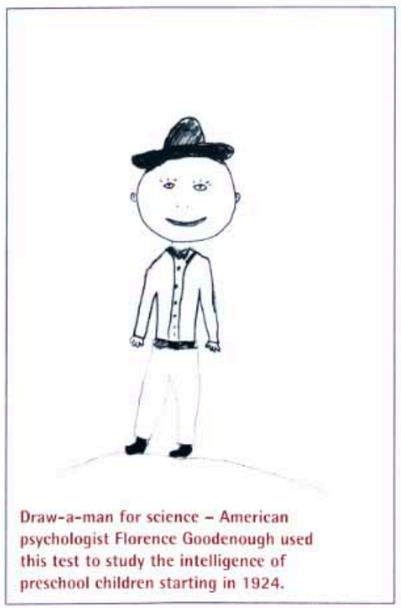
"This case study gives me the opportunity to study, based on examples, the conditions and methods that need to take effect in order for drawing to be a means of knowledge creation," she explains. What she is specifically interested in is demonstrating how it was possible to use children's drawings in the service of psychology. After all, practitioners were compelled to combine such doodles with other techniques, such as dialog, in order to ascertain anything approaching valid facts from them.

The timeless business of making notes

Her second case study also features close interaction between drawing and other techniques. This study is concerned with freehand scientific drawing in the life sciences. Until the invention of photography, but also afterward and even up to the present day, research done with microscopes was accompanied by freehand drawings. There was intense interplay between the techniques of preparation and representation, which helped bring about major advances in knowledge. Drawings, for example, played an important role in the development and dissemination of the realization that the nervous system consisted of neural units.

Freehand scientific drawing provides a particularly clear illustration of what it is that Hoffmann and Wittmann want to demonstrate: the inherent accomplishment of the tool or technique, which is more than a mere tool of execution. "The focuses of our respective research projects are actually not that far removed from each other," says Wittmann, referring to the notebook studies of fellow scientist Christoph Hoffmann: "Making notes, like drawing, involves very old-fashioned techniques that are still in use in today's high-tech era." They apparently do something that modern media cannot. The simple, old-fashioned practices survived not least because they can be made to 'communicate' with considerably more technologically complex methods and devices.

The Berlin-based scholars believe that the very fact that there are still people who fill notebooks and make scientific drawings proves their theory. As Barbara Wittmann puts it: "I am convinced that drawing makes it possible to see something that no other technique can reveal." Although electron microscopes, microphotography and CAD simulations now place a range of high-tech imaging tools at our disposal, traditional scientific drawing continues to hold its own in certain niches. These include supporting a scientist's work at the microscope in zoology and neurobiology; in drawings of type specimens made in the course of the first description of a new species; and finally, in research



Draw-a-man for science – American psychologist Florence Goodenough used this test to study the intelligence of preschool children starting in 1924.

Photo: Archives of Jean Piaget, University of Geneva (top)/File from: Dale B. Harris, Children's Drawings as a Measure of Intellectual Maturity: A Revision and Extension of the Goodenough Draw-a-Man Test, San Diego 1963 (bottom)

contexts that demand a substantial degree of reconstruction, such as paleontology and archeology.

Barbara Wittmann has found the zoological institutes and natural history museums of the capital to be particularly rich sources of scientific drawings. At the Institute for Biology at Humboldt University in Berlin, zoologist Gerhard Scholtz and his coworkers have been drawing for the past two decades using something called a camera lucida, a drawing device invented in the early 19th century to record the developmental biology of crabs.

She considers the zoologist's drawing practices to be "the very lucky case" of a method that has retained a great deal of continuity in terms of graphical conventions in the course of its almost 200-year history. Illustrators using the device restrict themselves to the outline and later add in dots to render the object in relief. Over the same period, there has been a major transformation in the facilities available in laboratories, the preparation of agents and the objects of knowledge.

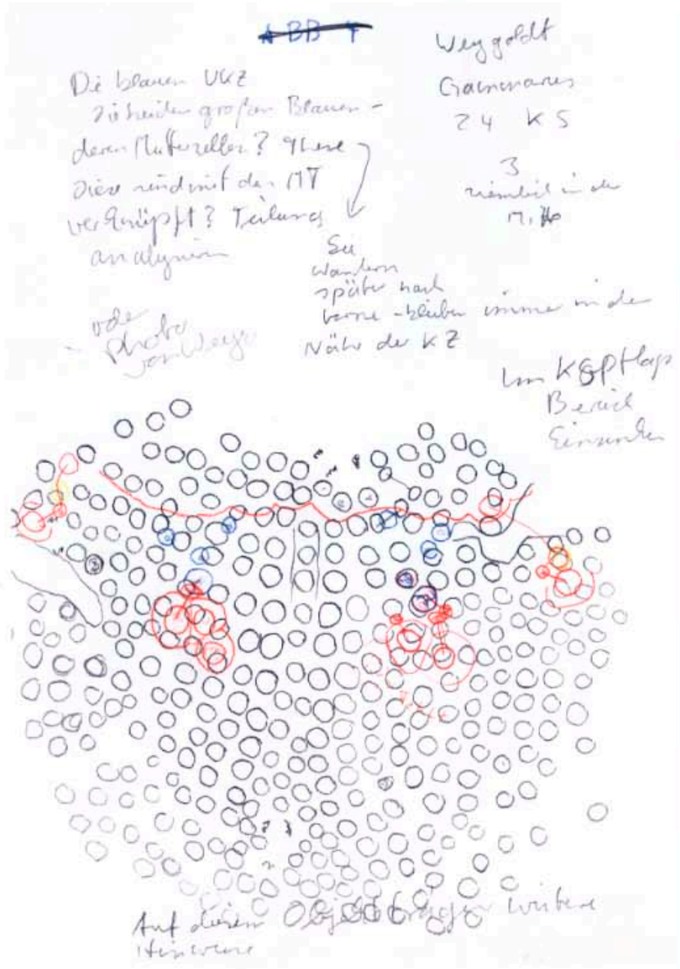
"Add to that the fact that all illustrators are compelled to think about an object's characteristics, to analyze it and interpret it as soon as they look at it," explains Barbara Wittmann. The pencil is therefore also a pedagogical tool. Before drawing the first line, illustrators need to decide, for example, what the edges and the boundaries of their object are, how the structure is composed and what does not belong there, having found its way into the picture by virtue of being nothing more than an artifact caused by the optical instruments or the preparation employed. By slowing down the observation – because drawing takes time – the pencil forces illustrators to take a careful look.

What's more, Barbara Wittmann says, if there's anyone who needs convincing that pens and notes really are important tools, they need only take a look around their own office: "Even today, many scholars in the arts and humanities can only sort out their thoughts if they occasionally turn off the computer and bring order to their many arguments and projects on paper."

Notepads are by no means disappearing from the everyday lives of academicians; they simply need to be incorporated in the scientific logic in a different way. Software developers are inventing note-writing programs, virtual index cards and electronic pens with this in mind. Most commonly, informal writings like scribbles, lists and diagrams are a means of managing what is known and what is not yet known, what has been done and what has not. As such, they document the evolution and processing of knowledge in a way that manuals, experiment setups and research reports are unable to do.

And this is where the science historians find the commonality between children's drawings and physicists' sketches, notebook entries and zoological drawings. All of these forms and techniques, so different on the surface, are part of the same toolkit of the mind – the resources of knowledge in the making that put us on the right path to understanding.

Birgit Fenzel



A drawing produced at the microscope with the help of a camera lucida on the development of an embryo of *Gammarus pulex* (incorrectly called 'freshwater shrimp').

Photo: Gerhard Scholtz, Humboldt University of Berlin, Institute for Biology – Comparative Zoology