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Internal Rotation(s): Sociomaterial Practices and Embodiments in Hugo Sellheim's Experiments on Birth Mechanics

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SUMMARY: At the turn of the twentieth century, in the midst of a shift in obstetrical research toward physiology, German obstetrician Hugo Sellheim (1871–1936) embarked upon a research project on the laws of birth mechanics. In a comprehensive experimental program, centering on the internal rotation of fetuses during birth, he tried to find out what kind of mechanical and expulsive forces were at work in the birthing process. From these experiments emerged a wealth of objects such as anatomical models, mechanical dolls, measuring devices, new physical instruments, and also birthing machines. By paying close attention to these objects and the sociomaterial practices associated with them, this article identifies, tracks, and characterizes the shift to physiology in obstetrics. By adopting a historical-praxiographic method, the article reveals the entanglement between the social and the material and renders visible a new and wider set of actors and relationships that, in turn, adds a novel dimension to the historiography of obstetrics.

KEYWORDS: history of obstetrics, birthing body, birth mechanics, praxiography, historical ontology, sociomaterial practices, 3D models, embodiments, experiments, clinical research

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It might have been a very cold day in the fall of 1901 when August Mayer (1876–1968), a recently graduated doctor and the newest member of the medical staff of the University Women's Clinic (Universitäts-Frauenklinik) in Freiburg, confronted his first research task. At the behest of his supervisor Hugo Sellheim (1871–1936), he was expected to crawl through a newly designed birthing machine. Naked and covered with soft soap, Mayer squeezed himself into an enormous glass tube the size of a human adult and slowly crawled through it until he reached the curve of the machine (for a similar but downscaled version, see Figure 6). The construction of the tube and the design of this angle were the result of extensive research conducted by Sellheim. If everything was correctly calculated, then Mayer should bow his head as much as possible before reaching the curve and then rotate his head and body ninety degrees just as a fetus would on its way through the birth canal. Unfortunately, though, nothing like this happened. Instead of performing this complex movement, which obstetricians call internal rotation, Mayer got stuck. While some of his colleagues rushed to help, his superior, Sellheim, was not at all sympathetic. He called Mayer a "simple-minded birth object," wondering how he would ever become an obstetrician if he could not even reproduce the movements that most fetuses could perform so easily, elegantly, and effortlessly.[1]

[1] Mayer's account of his experience of being stuck in Sellheim's machine, which he characterized as "larger than life" (*überlebensgroß*), is found in his collection of papers in Tübingen University Archives. See August Mayer, "Klinik Hegar," University Archives, Tübingen University, NL Mayer, 150/1. Unless otherwise indicated, all translations are my own. This article is partly based on source material that I also used for my dissertation on experimental systems and clinical research in obstetrics around 1900 in Germany, see Martina Schlünder: Reproduktionen. Experimentalisierungen der Geburtshilfe zwischen 1900 und 1930. Eine *Dichte Beschreibung* [Reproductions. Experimentalizations of Obstetrics between 1900 and 1930: *A Thick Description*] (PhD diss., Charité-Universitätsmedizin Berlin, 2007).

The background of this failed experiment was Sellheim's research on birth mechanics. Since the eighteenth century at the latest, it seemed reasonable to Western obstetricians, in the wake of classical mechanics, to analyze the birth process as mechanical. Bolstered by the more frequent use of forceps (a mechanical instrument), mechanical concepts of the birthing body also took hold.[2] The attention of obstetricians of the time was focused, on the one hand, on the mechanical description of fetal movements during birth and, on the other hand, on the calculation of the relationship between the pelvic diameter and the fetal cranial circumference. They concentrated their research on the bony parts of the pelvis and skull, and related them with the help of lever points, lever arms, and pelvic planes. In short, they defined the birth mechanism with the help of mechanical laws of solid bodies and two-dimensional geometric calculations such as parallelograms.[3]

By the end of the nineteenth century, medicine and obstetrics had changed. In Germany, physiology had gained increasing influence as a discipline and contributed significantly to the establishment of scientific medicine and laboratory medicine.[4] From static

[2] Andrea Henderson, "Doll-Machines and Butcher-Shop Meat: Models of Childbirth in the Early Stages of Industrial Capitalism," *Genders* 12 (Winter 1991): 100–119; Ludmilla Jordanova, "Interrogating the Concept of Reproduction in the 18th Century," in *Conceiving the New World Order*, ed. Faye Ginsburg and Rayna Rapp (Berkeley: University of California Press, 1995), 369–86.
[3] For an overview of the literature on the conception of the mechanics of birth as a process of solid bodies, including a historical survey, see Hermann Franz Naegele, *Die Lehre vom Mechanismus der Geburt nebst Beiträgen zur Geschichte derselben* (Mainz: Victor von Zabern, 1838).
[4] Anja Hiddinga, "Obstetrical Research in the Netherlands in the Nineteenth Century," *Med. Hist.* 31 (1987): 281–305. Hiddinga examines whether and how physiology and the emergence of scientific medicine in Germany influenced the modernization of obstetrics in the Netherlands. For the role of physiology in medicine more generally, see Andrew Cunningham and Perry Williams, *The Laboratory Revolution in Medicine* (Cambridge: Cambridge University Press, 1998); John Harley Warner, "Physiology," in *The Education of American Physicians: Historical Essays*, ed. Ronald L. Numbers (Berkeley: University of California Press, 1980), 48–71; Erwin Ackerknecht, *A Short History of Medicine*, rev. ed. (1955; New York: Ronald Press, 1968), 170–74; Karl Rothschuh, *Physiologie: Der Wandel ihrer Konzepte, Probleme und Methoden vom 16. bis 20. Jahrhundert* (Freiburg: Karl Alber, 1968).

and morphological descriptions of the body and organ structures, research turned to processes and body functions. However, this not only was the case in physiology as a discipline but also occurred in the clinical subjects themselves, in a process called physiologization. This process involved the search for natural laws by experimentation. It also shifted the interest of clinical research from the pathological to the normal.[5] In the case of obstetrics, this meant that the case-based research of clinical cases or of pathological objects (such as the famous pelvic collections) was no longer the sole focus of obstetric research in general; instead, experimental methods (borrowed, for example, from physics) were used to study processes such as birth mechanics in more detail (see p. X). Yet physiologization did not happen as a Kuhnian revolution in which "suddenly" one paradigm replaced another. Rather, it resembled an evolutionary process that was closer to Ludwik Fleck's concept of slow changes of "thinking styles."[6] Physiological research complemented the anatomical, pathological, and topographical methods of obstetrics and gynecology; elements and practices from different traditions mixed, forming heterogeneities. This article shows that Sellheim's research on birth mechanics provides a rich case study with which to shed light on these issues. Obstetricians

[5] Georges Canguilhem, *The Normal and the Pathological*, trans. Carolyn R. Fawcett and Robert S. Cohen (1943/1966; New York: Zone Books, 1991).

[6] Thomas S. Kuhn, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press, 1962); Ludwik Fleck, *Genesis and Development of a Scientific Fact* (1935; Chicago: University of Chicago Press, 1979), 92–94, 100, 109–10. The English version translates Fleck's German term *Denkstil* as "thought style." But *denken* in German is a verb, in contrast to the noun "thought" (in German, *Gedanke*). Thus, it is more accurate to use "style of thinking" or "thinking styles," which also highlights Fleck's intention to examine thinking as a practice, an activity, and a collective process. See Martina Schlünder, "Pastorale: Sheep Traffic in Modern Trauma Surgery," in *Humans, Animals and Biopolitics: The More-Than-Human Condition*, ed. Kristin Asdal, Tone Druglitrø, and Steve Hinchliffe (London: Routledge, 2017), 85–100, esp. 87–88.

later referred to this process as the introduction of functional obstetrics and viewed this development as a *Gestalt* change.[7]

This article argues that the process of physiologization materialized a new birthing body and a new experimental version of birth. By examining Sellheim's research on the internal rotation of fetuses, it historicizes a specific form of the birthing body enacted through intensive experimentation at the turn of the twentieth century. As part of the new style of thinking, the experiments attempted to materialize the birth process as a hydraulic procedure no longer focusing on the bony parts of birth, on the measurement of the pelvis and the diameter of the skull, but on the soft tissues, the development and expansion of the pelvic muscles. Sellheim's main experimental strategy was to examine the birthing body through embodiment and performance rather than through the mathematical calculation of planes or parallelograms. As a result, his experiments enacted an almost disembodied birthing body, asexual, more abstract than carnal, that was constituted by the interplay of the purely mechanical forces of mother and fetus. Indeed, the female pelvis became a birth canal with a sharp bend: the so-called knee (Figure 2), which the fetus, stylized as a mechanical birth object and experimentalized as an unevenly flexible cylinder (*ungleichmäßig biegsamer Zylinder*) (Figures 4 and 5) could pass through only by means of rotation.

Sellheim's experimental system was the source of a multitude of objects through which the new experimental birthing body emerged. While Sellheim considered the objects and machines that materialized in these experiments as representations of a nature that was not directly accessible to us, this article follows the nonrepresentational life of these objects.

[7] August Mayer, *Alfred Hegar und der Gestaltwandel der Gynäkologie seit Hegar* (Freiburg: Hans Ferdinand Schulz, 1961); Hermann Goecke, *Gestaltwandel in der Gynäkologie und Geburtshilfe in den letzten 35 Jahren* (Münster: Westfälische Wilhelms-Universität zu Münster, 1962).

Instead of asking epistemic questions about the representability of nature, the text emphasizes ontological questions, such as how objects enact realities. To this end, it draws on historical-praxiographic and historical-ontological methods.[8] In this approach, unlike in traditional Western epistemology, the social and the material, rather than being assigned to different categories that interact with each other, are constitutively entangled.[9] This antiessentialist approach to matter understands things, objects, and bodies not as pregiven but as unstable, inseparable from and dependent in their existence on the sociomaterial practices that produce them and the sociomaterial networks in which they circulate. Objects therefore are not discovered or socially constructed but are "practiced," "enacted," and "performed."[10]

Whether as historical praxiography or as historical ontology, both methods belong to a spectrum of approaches that seek to determine the relationship between knowledge and the world differently from traditional historiographies of science, because they favor a broader, deeper historicization.[11] If objects, bodies, and matter are not just there, then their emergence

[8] Annemarie Mol, *The Body Multiple: Ontology in Medical Practice* (Durham, N.C.: Duke University Press, 2002); Annemarie Mol, "Ontological Politics: A Word and Some Questions," *Sociol. Rev.* 47, no. 1 (1999): 74–89. On historical ontology, see Caroline Arni's study on the materialization of the "unborn" in the human sciences during the nineteenth century in Arni, *Pränatale Zeiten: Das Ungeborene und die Humanwissenschaften (1800–1950)* (Basel: Schwabe, 2018; English translation " *Of Human Born: Fetal Lives, 1800–1950*, New York: Zone Books, 2024). For other accounts of historical ontology, see Michelle Murphy, *Sick Building Syndrome and the Problem of Uncertainty* (Durham, N.C.: Duke University Press, 2006); Ian Hacking, *Historical Ontology* (Cambridge, Mass.: Harvard University Press, 2002).

[9] John Law and Annemarie Mol, "Notes on Materiality and Sociality," *Sociol. Rev.* 43, no. 2 (1995): 274–94. On the concept of sociomateriality, see Wanda J. Orlikowski, "Sociomaterial Practices: Exploring Technology at Work," *Organ. Stud.* 28, no. 9 (2007): 1435–48. On the difference between sociomateriality and material culture accounts, see Amiria Henare et al., eds., *Thinking through Things: Theorising Artefacts Ethnographically* (London: Routledge, 2007).

[10] Mol, *Body Multiple* (n. 8), 29–36. See also Ingunn Moser, "Making Alzheimer's Disease Matter: Enacting, Interfering and Doing Politics of Nature," *Geoforum* 39 (2008): 98–110.

[11] Studies in the history of science and medicine that use or discuss ontological or praxiographic approaches include, for example, Geertje Mak, *Doubting Sex: Inscriptions, Bodies and Selves in*

in sociomaterial practices has to be explained, which is to say, historicized. Thus, in contrast to traditional epistemological approaches, it is not only the changing knowledge of a stable body that is always already there that is historicized.

This text studies the historical emergence of an experimental birthing body that was supposed to represent the prototype of a normative, abstract body, the embodiment of a law of nature which determines the course of normal (physiological) births and thus also defines and even explains deviations and pathologies. However, in Sellheim's experiments, in his objects and practices, we can observe the process of physiologization not as an abstraction, but as a process of materialization. Historical praxiography can show how this highly abstract body must first be made concrete.

Since objects and bodies are unstable, different practices produce different versions of them.[12] This text studies the historical emergence of an experimental birthing body that appeared alongside other versions, such as the female, clinical, birthing body at the

Nineteenth Century Hermaphrodite Case Histories (Manchester, Manchester University Press, 2012), and Iris Clever and Willemijn Ruberg, "Beyond Cultural History? The Material Turn, Praxiography, and Body History," *Humanities* 3 (2014): 546–66. In Switzerland, Caroline Arni, inspired by anthropological studies on the ontological turn, has proposed 'recursive historiography' in the context of historical anthropology, see Caroline Arni, "Nach der Kultur: Anthropologische Potentiale für eine rekursive Geschichtsschreibung," *Historische Anthropologie* 26, no. 2 (2018): 200–223. For an overview of the different versions of the ontological turn in several disciplines (philosophy, STS, anthropology) and the crucial anthropological works of Philippe Descola, Eduardo Viveiros de Castro, and Marilyn Strathern, see Martin Holbraad and Morten Axel Pedersen, *The Ontological Turn: An Anthropological Exposition* (Cambridge: Cambridge University Press, 2017); Pierre Charbonnier, Gildas Salmon, and Peter Skafish, eds., *Comparative Metaphysics: Ontology after Anthropology* (London: Rowman & Littlefield, 2017).

[12] This instability prevents an essentialist view of objects and situates praxiography firmly beyond essentialist views of objects or bodies. See Clever and Ruberg, *Humanities* (n.11).

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University Women's Clinic. Giving birth at home, which was standard in Germany at the time of Sellheim's experiments, would again enact a different version of the birthing body.[13]

Ontological investigations raise new and important questions about bodies, matter and their agency. In the case of Sellheim's obstetrical objects and the experimental birthing body, these are questions about their stability, composition and duration: What has stabilized these objects? What relationships do they consist of? How were these objects held together? Did they disappear, and if so, under what circumstances? Because historical praxiography is primarily interested in research practices, rather than outcomes, different stories and different narratives emerge. In this investigation, then, it is less about answering Sellheim's question of *why* fetuses rotate in the birth canal and more about *how* this question materialized in experimental settings and beyond. The next two sections give the historical background to Sellheim's experiments and to the question of internal rotation as an object of research. This is followed by a more detailed examination of three objects from Sellheim's experimental system.

Obstetric Objects

After the unification of the German Empire in 1871, obstetrics and gynecology had become a single subject at German universities and was represented by one chair with a strong surgical orientation.[14] Hence, structural knowledge of anatomy, pathology, and histology was

[13] In his research, Sellheim alone distinguished several forms of birth and birthing bodies that had emerged through his different research practices. One of these, in stark contrast to the experimental, abstract birthing body, centered on femininity as its central aspect, because female bodies urgently needed pregnancy and birth as a developmental function, see Hugo Sellheim, *Das Geheimnis des Ewig-Weiblichen* [The secret of the eternal feminine] (Stuttgart: Ferdinand Enke, 1924).
[14] Hans-Heinz Eulner, *Die Entwicklung der medizinischen Spezialfächer an den Universitäten des deutschen Sprachgebiets* (Stuttgart: Ferdinand Enke, 1970), 283–94.

extremely important in this newly unified discipline. As we will see, however, this emphasis was not opposed to the physiologization of the subject. Already from the mid-1860s, a debate arose among German obstetricians about the form, nature, and characterization of the mechanical forces of the uterus in labor, that is, about which mechanical forces caused the onset and expulsion of the fetus, or whether this was the result of a genuinely fetal activity (which most obstetricians doubted).[15] Some scholars believed that the birth process itself was best explained with the help of the laws of hydraulics.[16] With this turn, birth was still conceptualized as mechanical, but rather than the mechanics of solid bodies or of bony structures such as the pelvis and skull, it now followed the mechanics of fluid bodies, which is to say, the proportion of water and fluid in the tissues, the amniotic fluid in the uterus, and the malleability and flexibility of the muscles and soft tissues. The goal was to find a natural law to elucidate the mechanism of birth, one that would also explain, among other things,

[15] On the changing understanding of birth mechanics, see the extended overview on the international literature until 1888 in Richard Werth, "Die Physiologie der Geburt," in *Handbuch der Geburtshülfe*, vol. 1, ed. Peter Müller (Stuttgart: Enke, 1888), 513–25; on the period from 1890 until 1904, see Max Stumpf, "Der Mechanismus der Geburt," in *Handbuch der Geburtshülfe*, vol. 1, pt. 2, ed. Franz von Winckel (Wiesbaden: Bergmann, 1904), 1028–109.

[16] Fluid mechanics as the underlying science of hydraulics is concerned with the transmission of power through compressed (pressurized) liquids. Machines, mechanics and especially hydraulic knowledge belonged to the leading sciences of Germany's industrialization at the end of the nineteenth century and it might have been self-evident for obstetricians to think with this important type of mechanical knowledge through birth mechanics and obstetrical machines. For an argument in favor of hydrodynamics, see Friedrich Schatz, *Der Geburtsmechanismus der Kopfendlagen* (Leipzig: Wigand, 1868); Heinrich Lahs, *Die Mechanik der Geburt* (Berlin: Hirschwald, 1872); Lahs, *Die Theorie der Geburt* (Bonn: Cohen, 1877). For an argument in favor of the mechanics of solid bodies, see Carl Schröder, *Lehrbuch der Geburtshülfe* (Bonn: Cohen, 1870); Robert Olshausen, *Beitrag zur Lehre vom Mechanismus der Geburt auf Grund klinischer Beobachtungen und Erfahrungen* (Stuttgart: Enke, 1901). A summary of these debates in English can be found in John Whitridge Williams, *Obstetrics: A Text-Book for the Use of Students and Practitioners* (New York: Appleton, 1903), 218–26.

why fetuses rotated during birth. Was it the various birth forces that were the focus of hydraulic research, or was it the shape of the pelvis, as the "old" mechanics claimed?

Although obstetric research was slowly physiologizing, at the beginning of the twentieth century it had not yet found a satisfactory, physiological explanation for internal rotation. It was precisely this lack of explanation that incited Sellheim's work. His goal was to finally "unveil the child's still mysterious [internal] rotation."[17] Sellheim was not a scientific outsider. As part of the hydrodynamicist thought collective he would succeed in finding a scientific explanation for this unanswered question and would make a name for himself with his mechanical explanation of the birth process. His research did not go unchallenged, however, and he was repeatedly embroiled in controversy. Sellheim, born in 1871, was "a highly gifted man with a strong inner drive."[18] In 1895, he completed his medical studies and joined the University Women's Clinic in Freiburg as an assistant under its well-known director Alfred Hegar (1830–1914). Before that, however, Sellheim spent almost a year at the University of Breslau (now the University of Wrocław in Poland) working as a trainee under Emil Ponfick (1844–1913). There, he learned all the important pathological-anatomical dissection techniques, which he then used to research birth mechanics.

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[17] Hugo Sellheim, *Die Beziehungen des Geburtskanals und Geburtsobjekts zur Geburtsmechanik* (Leipzig: Thieme, 1906), 7.

[18] This is an assessment by today's gynecologists of Sellheim's research achievements. See Andreas D. Ebert and Matthias David, "Hugo Sellheim (1871–1936) und das 'Gesetz des geringsten Zwanges,'" *Geburtshilfe und Frauenheilkunde* 73 (2013): 691–92, quotation on 691. Sellheim habilitated in 1898 (after only three years of residency) and became the director of a gynecological clinic at the age of thirty-four. When he died in 1936, he had published more than four hundred papers. He was revered by his colleagues as a "magister mundi" for his explanation of the mechanism of birth. See the obituary by his former "birth object" August Mayer in "Hugo Sellheim," *Zentralbaltt für Gynäkologie* 60 (1936): 1506–31, esp. 1509.

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Back in Freiburg, Sellheim conceived a comprehensive experimental program to find out what kind of mechanical and expulsive forces were at work in the birthing process. This gave rise to a large variety of objects, including anatomical models of physiological processes, models that were thought to embody the mechanical properties of a fetus (or birth object), measuring devices, new physical instruments for testing mechanical objects, and birthing machines. These objects embodied a wide range of scales—from human-sized birthing machines to small models that could fit into the pocket of a student—and were made of clay, plaster, wire, wood, flesh, bone, muscle, and glass, to name just a few of the materials used. Some were held together by screws, nails, pins, and bolts; some needed to be pushed or crawled through; and some had to be set in motion by pressing a button or turning a crank. The mechanism they had to perform was facilitated by butter, soft soap, and body heat, but also by pain, ambition, and death. By paying close attention to these objects and the practices that gave rise to them, this article is able to show *how* the shift to physiology in obstetrics became real. Sellheim's experimental practice reveals that there was no boundary between theory and practice in obstetrics. Rather than passive demonstrations of a theory, the objects that emerged from these experiments were actively involved in concept formation and knowledge production, usually in the form of further objects.[19]

The significant role played by objects in obstetrics has been extensively researched in historiography. A particular focus here has been on the collecting activities of eighteenth- and nineteenth-century obstetricians and the collections of instruments and anatomical models

[19] According to Ludwik Fleck, very few research experiments obey the logic of the philosophy of science. Experiments that can be reproduced serve mostly the purpose of demonstration, after a field of knowledge has been well established. Research experiments, in contrast, could not be clear at all, because then one would have to know their result in advance. See Fleck, *Genesis and Development* (n. 6), 84–87. See also Hans-Jörg Rheinberger, *Toward a History of Epistemic Things: Synthesizing Proteins in the Test Tube* (Stanford: Stanford University Press, 1997).

and specimens resulting from these activities.[20] Since the eighteenth century, teaching models, also called obstetric machines, on which students and midwives could learn the birth process practically, played a special role. These models, their origins, and their modification from the eighteenth century to the twentieth have been meticulously described by historians.[21] Recent studies have examined not only the machines themselves but the activities of those who designed, financed, or used them. Jürgen Schlumbohm and Hans-Christoph Seidel, for instance, show exactly what the practical instruction of the students in the eighteenth century looked like, describing, among other things, how much time the students were able to spend at the machines.[22] Lucia Dacome has studied how the models were used to examine and test midwives and the networks that existed between those commissioning, making, and using the models.[23] Nina Gelbart has determined the distribution

[20] On collecting as a passion and professional desire of the "acchoucheurs," see Jürgen Schlumbohm, "Eine 'lichterloh entfachte Begierde': Der Göttinger Geburtshelfer Friedrich Benjamin Osiander als Sammler," *Medizinhistorisches Journal* 58, no. 1 (2023): 14–45. On the instrument collection in Göttingen, which also includes birthing beds and objects used in the care of women in childbirth, see Walter Kuhn and Ulrich Tröhler, eds., *Armamentarium obstetricum Gottingense: Eine historische Sammlung zur Geburtsmedizin* (Göttingen: Vandenhoeck & Ruprecht, 1987). On the collections of pelvises from the perspectives of the history of collecting, the history of science, social history, and ethics, see Ulrich Mechler and Karen Nolte, "Das weibliche Becken: Sammlungs-, wissenschafts- und sozialgeschichtliche Zugänge," *Medizinhistorisches Journal* 58, no. 1 (2023): 3–13.

[21] Gerhard Ritter, "Das geburtshilfliche Phantom im 18. Jahrhundert," *Medizinhistorisches Journal* 1 (1966): 127–43; Ritter, "Zur Entwicklung des geburtshilflichen Phantoms im 19. und 20. Jahrhundert," *Medizinhistorisches Journal* 1 (1966): 224–34. See also Urs Boschung, "Medizinische Lehrmodelle," *Medita* 10, no. 5 (1980): ii–xv (on wax models); Boschung, "Geburtshilfliche Lehrmodelle: Notizen zur Geschichte des Phantoms und der Hysteroplasmata," *Gesnerus* 38, no. 1 (1981): 59–68.

[22] Jürgen Schlumbohm, *Lebendige Phantome: Ein Entbindungshospital und seine Patientinnen* (Göttingen: Wallstein, 2012). See also Hans-Christoph Seidel, *Eine neue "Kultur des Gebärens": Die Medikalisierung von Geburt im 18. und 19. Jahrhundert in Deutschland* (Stuttgart: Franz Steiner, 1998).

[23] Lucia Dacome, *Malleable Anatomies: Models, Makers, and Material Culture in Eighteenth-Century Italy* (Oxford: Oxford University Press, 2017).

of the machines on the basis of the travel activities of the famous French midwife Madame du Coudray.[24]

In their book on 3D models, Soraya de Chadarevian and Nick Hopwood point out that these models have often been misunderstood in science studies as mere display and teaching objects. In fact, they have often served simultaneously as research objects, research tools, and teaching aids.[25] This article follows de Chadarevian and Hopwood's argument by examining Sellheim's machines, models, and objects in their many uses. Sellheim was an enthusiastic teacher and used classical obstetric machines to instruct his students in how to imagine birth as a spatial process. Indeed, he was convinced that, without this imaginative capacity, one could not become a good obstetrician. Sellheim not only taught his students with the obstetric machines but also designed his own research model.[26] This consisted of a bony pelvis connected to a child's skull. For years, he used this machine to simulate the birth situations he experienced daily in the delivery room. However, these simulations did not provide him with any explanation of internal rotation.

The constitutive entanglements of material objects, theory, and practice have a long history in obstetrics. They find their expression in obstetric skills, which are mainly tactile, manual, and sensory and are often combined with the use of instruments (forceps being the best-known example). Sellheim designed his own pedagogical method to introduce medical students to obstetrics, especially to what he called obstetric feeling, or "seeing with the

[24] Nina Rattner Gelbart, *The King's Midwife: A History and Mystery of Madame du Coudray* (Berkeley: University of California Press, 1998).
[25] Soraya de Chadarevian and Nick Hopwood, eds., *Models: The Third Dimension of Science* (Stanford, Calif.: Stanford University Press, 2004), 3–4.
[26] Hugo Sellheim, "Neues geburtshilfliches Phantom," *Beiträge zur Geburtshilfe und Gynäkologie* 2 (1899): 482–90.

hands," and thus learning to imagine three-dimensional spaces.[27] The first step in this learning process was to wean students off two-dimensional images, which Sellheim felt would only confuse them and prevent them from developing their own spatial imagination. The experimental objects studied in this article are part of these embodied skills and are closely related to mechanical reasoning in the form of three-dimensional models.[28]

Internal Rotation as a Research Object

The special challenge of Sellheim's research lay in its elucidation of the mechanical movement of the fetus, a movement that his younger colleague August Mayer failed to replicate: the so-called internal rotation that was "absolutely essential for the completion of labor," as Sellheim's American colleague John Whitridge Williams (1866–1931) writes in his 1903 textbook on obstetrics.[29] Mayer would certainly have agreed with him, having experienced firsthand what it meant not to be able to complete the actions of labor.

Why did fetuses rotate around their own longitudinal axis at the pelvic floor? Was it due to the shape of the female pelvis or to the muscles and soft tissue that form the so-called

[27] Hugo Sellheim, *Das Auge des Geburtshelfers* (Wiesbaden: J. F. Bergmann, 1908).
[28] Alfred Hegar and Rudolf Kaltenbach, *Operative Gynäkologie mit Einschluss der gynäkologischen Untersuchungslehre* (Stuttgart: Ferdinand Enke, 1897). On tactile sensation, see Victor Henri, *Über die Raumwahrnehmungen des Tastsinnes: Ein Beitrag zur experimentellen Psychologie* (Berlin: Reuther & Reichard, 1898). See also Sellheim's paper on how to control the intrauterine use of instruments in Hugo Sellheim, "Grenzen der Gefühlskontrolle bei intrauteriner Anwendung von Instrumenten," *Zentralblatt für Gynäkologie* 48 (1924): 1458–66.
[29] Williams, *Obstetrics* (n. 16), 233. In accordance with the general teaching of birth mechanics, Williams names the sequence of mechanical movements that children must undergo as "engagement," "descent," "flexion," "internal rotation," "extension," "external rotation," and "expulsion." These are distinguished mainly for research or pedagogical reasons; some of them occur simultaneously during birth. Of the nine pages Williams dedicates to these movements, half are devoted to internal rotation alone. This is a clear sign that there was no real agreement on the reason for this movement and that different theories were in competition with one another, all of which are referred to by Williams. See ibid., 229–38.

birth canal? Did rotation depend solely on pelvic muscles, or were completely different forces at work? The urgency to answer these questions was manifold. On the one hand, there were quite tangible practical reasons: to be able to fully explain the mechanics of childbirth would certainly help to better assess and control birth processes and their risks—especially in times when cesarean section had not yet been fully established as a routine surgery to end complicated births and was still used as a last resort. On the other hand, there were scientific-academic reasons: the recognition and fame that would come with finding the proof of a natural law, and the satisfaction—for Sellheim, as a passionate teacher—of giving students a thorough answer to their questions on birth mechanics.[30]

The unsolved problem of internal rotation was a very mixed research object: both practical and of great theoretical importance, it combined an abstract, epistemic concept of birth mechanics with the very concrete bodily physicality of rotation, its ontological materiality so to speak. In its heterogeneity, invisibility, and difficult accessibility, rotation presented a major methodological challenge. In his research and experiments, Sellheim merged in a unique way anatomical modeling with physical and physiological experiments, clinical examinations, and mechanical calculations to enact a new version of internal rotation.

Sellheim wanted to move away from the construction of pelvic planes and from relying on two-dimensional images toward objects, machines, and models that would allow him to study the birth process as a spatial one. This focus created different images whose purpose was not to illustrate the phenomenology of rotation but to show the experimental steps that were necessary to prove his assumptions. Sellheim divided his research into three main areas, each of which he investigated using different methods:

[30] Sellheim of course emphasized the practical reasons and the importance for teaching. See Sellheim, *Die Beziehungen des Geburtskanals* (n. 17), 7.

1. The study of the so-called birth canal, or female pelvis, which focused on the topography of the soft tissues and relied on anatomical dissection techniques. Sellheim also used frozen sections as a guide; however, his intention was not to stop at two-dimensional images but to create a model of a birth canal with the help of anatomical studies (Figure 1).[31]

2. The study of the so-called birth object, or fetus. Preliminary work on this had already been carried out by Friedrich Schatz (1841–1920) and Hegar's longtime assistant Rudolf Kaltenbach (1842–1892).[32] Sellheim took a similar path. He experimented with newborns as surrogates for the fetuses, subjecting them to various binding experiments (Figure 5) as well as to extensive measurements that were supposed to allow statements about the mobility of the fetal spine (Figure 4).[33]

[31] Sellheim dealt intensively with the studies of Johannes Veit in his *Anatomie des Beckens im Hinblick auf den Mechanismus der Geburt* (Stuttgart: Enke, 1887). On frozen sections, see Salim Al-Gailani, "The 'Ice Age' of Anatomy and Obstetrics: Hand and Eye in the Promotion of Frozen Sections around 1900," *Bull. Hist. Med.* 90, no. 4 (2016): 611–42.

[32] Rudolf Kaltenbach, "Über die Bedeutung der fötalen Wirbelsäule für den Austrittsmechanismus," *Zeitschrift für Geburtshilfe und Gynäkologie* 21 (1891): 263–87; Friedrich Schatz, "Die Ursachen der Kindslagen," *Archiv für Gynäkologie* 71 (1904): 541–651.

[33] For Sellheim's experiments with newborns as surrogates for fetuses, see the "Mechanical Translations" section below. Arni, in her study of the unborn as a new object of research in the human sciences in the nineteenth century, points to the liminal status of the newborn as an extremely productive object of research that would provide insights into fetal physiology. See Arni, *Pränatale Zeiten* (n. 8), 154–59. The twentieth century saw the establishment of the concept of the perinatal threshold, which has since become a medical discipline in its own right. See Lorna Weir, *Pregnancy, Risk, and Biopolitics: On the Threshold of the Living Subject* (New York: Routledge, 2006).

3. Finally, the verification of hypotheses about expelling forces by means of physical experiments and by building different birthing machines (Figures 6 and 7), each of which embodied a certain form of the forces.[34]

Since the focus of this text is on historical-ontological questions, relationships play a major role. While Western epistemics insists on a strict separation between researchers and their objects, claiming an insurmountable distance between them, historical praxiography makes it clear that Sellheim, like the objects of his experimental system, was indeed never alone. For it is the relationships and connections between objects, and between people and objects, that give meaning and stability to each other. Sellheim's later fame as the one who found a scientific explanation for the birth mechanism was based on the objects of his experimental system and they stabilized his reputation.

Below, I examine in more detail three sociomaterial objects from Sellheim's experimental practice, each falling into one of the three main categories and sections into which Sellheim divided his investigations: the soft tissues and muscles of the pelvis, the mechanical properties of the fetus, and the birth forces. The first section investigates experiments on the birth canal in the expulsion phase. It studies how boundaries between life and death were experimentalized and how specific versions of the birthing body were enacted and stabilized. The second section focuses on the experiments that translated the fetal body into a mechanical object. The final section brings us back to birthing machines, to the

[34] For research on birth mechanics and expelling forces, see, for instance, the work of Richard Werth and Max Stumpf (n. 15) and the debate between the "hydrodynamicists" and those who believed in the mechanics of solid bodies in childbirth (n. 16).

mechanical relationship between the birth object and the birth canal, and to the question of why and how August Mayer got into the birthing machine.

Mechanical Enactments: Performing and Embodying the Birth Canal

Starting in 1902, Benninghoven and Sommer, an institute for anatomical models located in the Moabit district of Berlin, Germany, offered papier-mâché models of a birth canal for sale.[35] Three different versions were available: an external posterior view, a lateral external view, and a lateral internal view. The specimens were intended to embody the birth canal in the expulsion phase, the moment of the utmost expansion and tension of the muscles. However, if anatomical preparations were supposed to be the most accurate possible representations of a body structure, there were reasons to doubt the accuracy of these particular models, or to wonder how on earth they could have been produced at all. The models enact an organ that has never existed—at least not in the form represented by the models, or in that extension—and the tiny bits of it that do exist do so only for very short moments. Thus, in contrast to other anatomical specimens, it was impossible to produce the models based on simple anatomical dissection. Furthermore, it was an exceptional methodological challenge to produce a model capturing a process or a movement in a medium made for representing fixed anatomical structures (see Figure 1). The originals for

[35] Hugo Sellheim, *Das Verhalten der Muskeln des weiblichen Beckens im Zustand der Ruhe und unter der Geburt* (Wiesbaden: Bergmann, 1902), 14. There is little information on this company. However, see Sandra Mühlenberend, "Die anatomischen Lehrmodelle des Deutschen Hygiene-Museums," in *Erkenne Dich selbst! Strategien der Sichtbarmachung des Körpers im 20. Jahrhundert*, ed. Sybilla Nikolow (Cologne: Böhlau, 2015), 198–211; Wolfgang Schwan, "Marken: Ein Beitrag zur Unterstützung der Sicht auf die Provenienz von Objekten in Sammlungen," in *Spiegel der Wirklichkeit: Anatomische und Dermatologische Modelle in der Heidelberger Anatomie*, ed. Sara Doll and Navena Widulin (Berlin: Springer, 2019), 3–17; Henrik Eßler, *Krankheit gestalten: Eine Berufsgeschichte der Moulagenbildnerei* (Bielefeld: Transcript, 2022), 106–7.

the papier-mâché models came from Hugo Sellheim's experimental practice, and Sellheim was fully aware of the doubts that the models might cause. However, it had not been his intention simply to create a model of the exact course of birth as a process. The models served an additional purpose: providing an overview of the space in which the process of birth took place so that it could be better imagined.[36]

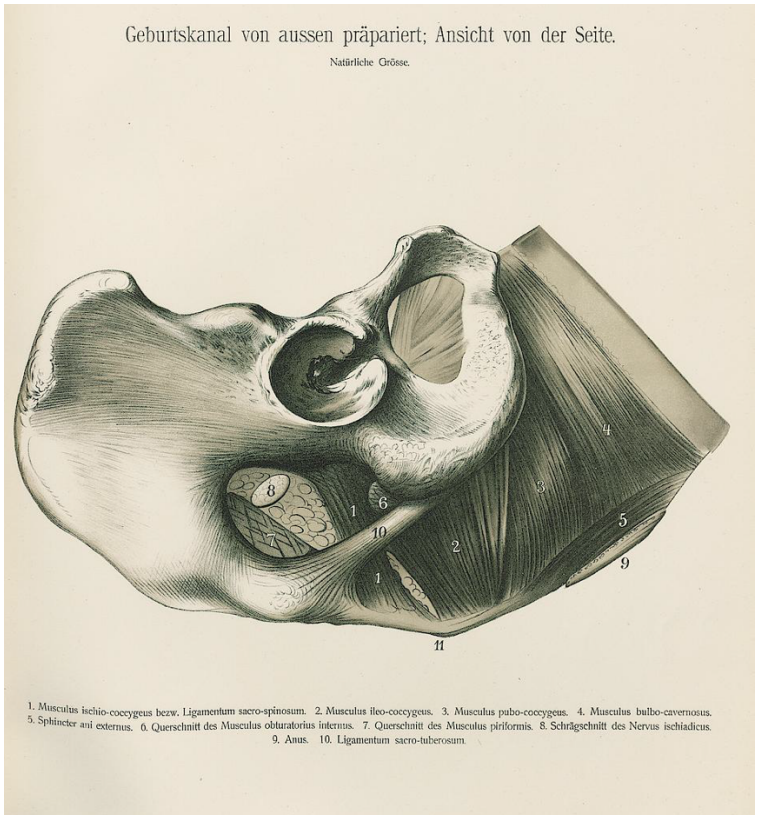

Figure 1. Birth canal during the expulsion stage of labor (lateral external view). Drawing of Sellheim's original anatomical specimen published in an atlas on the behavior of soft tissues and muscles during labor. Hugo Sellheim, *Das Verhalten der Muskeln des weiblichen Beckens im Zustand der Ruhe und unter der Geburt* (Wiesbaden: Bergmann, 1902), plate 8.

[36] Sellheim, *Die Beziehungen des Geburtskanals* (n. 17), 24 ("A birth canal with approximately equal lumen does not exist in reality at any time"), 35 ("If one were to take the finished birth canal as a given, one would have the great advantage of a better spatial idea and an overview of the entire process without committing a fundamental mechanical error").

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So how did he go about building these models? According to Sellheim, the best-known anatomical technique for gaining insight into the different stages of labor was the creation of so-called frozen sections.[37] He used some well-known ones in his studies.[38] But in order to gain an overview of the anatomical conditions in the expulsion phase, a series of women would have had to die at various stages of giving birth so that frozen sections could have been produced from them.[39] Since this was very unlikely, Sellheim felt obliged to actively build the birth canal himself. To do this, he combined "clinical experiences with experiments and anatomical preparations."[40] First, he measured the extension of the pelvic floor muscles of women in labor in the delivery room with his fingers and hands.[41] He then filled the interior of a bony pelvis of normal dimensions with soft modeling clay and deposited extra clay at the pelvic outlet. Afterward, he drove, according to the rules of the birth mechanism, a plaster replica of a normal fetal head through the pelvis and the clay mass at the exit until the measure of the greatest elongation that he had determined in the delivery room (roughly

[37] On frozen sections as an anatomical technique (established in Germany around 1870), see Al-Gailani, "'Ice Age' of Anatomy and Obstetrics" (n. 33). Sellheim habilitated on the topography of suppurations in the pelvis and presented an extensive topographical atlas on this subject. See Hugo Sellheim, *Topographischer Atlas zur normalen und pathologischen Anatomie des weiblichen Beckens* (Leipzig: Arthur Georgi, 1900). Topographical anatomy was particularly relevant to clinical questions because it focused on the spatial relationships of body regions in order to trace pathological changes therein.

[38] Frozen sections appear in all of Sellheim's publications on birth mechanics. He gives an overview on his use of the most famous ones (by Wilhelm Braune [1831–1892], Paul Zweifel [1848–1927], Hans Chiari [1851–1916], and Ernst Bumm [1858–1925]) in Hugo Sellheim, "Die normale Geburt," in *Biologie und Pathologie des Weibes: Ein Handbuch der Frauenheilkunde und Geburtshilfe*, vol. 7, pt. 1, ed. Joseph Halban and Ludwig Seitz (Berlin: Urban & Schwarzenberg, 1927), 213.

[39] On British obstetricians fostering very similar ideas, see Al-Gailani, "'Ice Age' of Anatomy and Obstetrics" (n. 33), 632.

[40] Hugo Sellheim, "Das Becken und seine Weichteile," in *Handbuch der Geburtshülfe*, vol. 1, pt. 2, ed. Franz von Winckel (Wiesbaden: Bergmann, 1904), 971.

[41] See also Henri Varnier, *Du détroit inférieur musculaire du bassin obstétrical* (Paris: Steinheil, 1888), in which Varnier establishes this method and to which Sellheim refers. See Sellheim, *Die Beziehungen des Geburtskanals* (n. 17), 25.

fifteen centimeters) had been reached: "In this way, I dug into the clay the space that the head occupies during birth," Sellheim reported.[42] This space was then completely filled with plaster.

Finally, he took advantage of a coincidence. A woman who had given birth to a healthy child eight hours earlier died in the Freiburg clinic. She had apparently been brought to the hospital as an emergency patient from her village after an accident involving carbolic poisoning. Instead of a normal dissection, Sellheim opened her womb. Using the warmth and malleability of her body, he slowly inserted various objects to re-expand the birth canal enough to insert the plaster replica of the birth canal. Whose permission did he ask to do this? Was the body sold to him? Was there anyone who wanted the body back to bury it? On all of these questions, Sellheim remains silent. The plaster core was anchored to the pelvis by pins, wires, but also rubber bands, so that the soft tissues of the pelvic floor were stretched to the maximum over the replica of the birth canal.[43] The pelvis was then dissected and fixed in formol for six weeks. On this rigid specimen, the muscles were carefully prepared and modeled in plaster before, finally, an artist carved wooden replicas of the plaster replicas, which served as models for the factory-made papier-mâché models.[44]

"Even though a lot of people will criticize me for the way I constructed the canal, I am sure that I came very close to nature," Sellheim later wrote about his research.[45] The

[42] Sellheim, *Das Verhalten der Muskeln* (n. 37), 14.
[43] Ibid.
[44] On the history of papier-mâché anatomical models, see Audrey Davis, "Louis Thomas Jérôme Auzoux and the Papier-Mâché Anatomical Model," in *La ceroplastica nella scienza e nell'arte* (Florence: Olschki, 1977), 257–79; Anna Maerker, "Papier-Mâché Anatomical Models: The Making of Reform and Empire in Nineteenth-Century France and Beyond," in *Working with Paper: Gendered Practices in the History of Knowledge*, ed. Carla Bittel, Elaine Leong, and Christine von Oertzen (Pittsburgh: University of Pittsburgh Press, 2019), 177–92.
[45] Sellheim, "Das Becken und seine Weichteile" (n. 42), 972.

criticisms he refers to would have been made not on ethical but on epistemic grounds, that is, regarding the manipulation involved in the construction of the model. Forced to dance a thin line between epistemic and ethical problems, Sellheim was well aware of the precarious space in which he performed his experiments: for ethical reasons, he could not work with living bodies; for epistemic reasons, he often could not work with corpses. Through his experimental practice, he attempted to cross elementary boundaries—in this case, a temporal boundary between life and death; later in his research, he crossed the local/spatial boundary between the interior and exterior of a woman's body by using newborns as a means to examine fetuses that were not directly accessible for experiments. Sellheim used the short period between a woman's death and the moment all signs of life had vanished to use the warmth and extensibility of muscles and tissues still present in this period for the construction of his anatomical specimens or models.

Sellheim sought embodiment and spatial thinking (3D modeling) in obstetrics and was strictly in favor of all techniques that led from two-dimensional to three-dimensional thinking.[46] Inspired by the plaster casts of the pelvic cavity first published by the American obstetrician Hugh Lenox Hodge in his textbook *The Principles and Practice of Obstetrics* in 1864 Sellheim created his own plaster models of the pelvic cavity. Hodge himself came to a new conception of the shape of the pelvic cavity as a cylinder with a truncated apex. While Sellheim's superior, Alfred Hegar, had earlier made plaster casts of so-called deformed

[46] Sellheim, *Die Beziehungen des Geburtskanals* (n. 17), 11: "But to bring the three-dimensional into the two-dimensional undoubtedly undermines a correct understanding. This is especially harmful to the understanding of birth, where everything depends on a proper conception of the body [*körperliche Vorstellung*]."

pelvises for teaching purposes, Sellheim was mainly interested in "normal" ones.[47] His plaster casts of the pelvis and the plaster model of the birth canal belonged together and were part of his practice of enacting the birth canal as a mechanical space on the foundations of physiology. In her push for enacted realities, Annemarie Mol claims that performed objects never come alone; instead, "they carry modes and modulations of other objects with them."[48] This is also true for the models of the birth canal. They have material relatives, so to speak, and fit into a style of mechanical practice that favored three-dimensional modeling as the royal road to an adequate understanding of birth mechanics.

Sellheim's most important finding during his examinations with plaster casts of the pelvis led to a new understanding of the curve of the birth canal. Contrary to former assessments, the birth canal was not curved in its whole length; instead, there was a straight axis in the pelvic entrance and cavity that bent concavely only in the pelvic outlet and joined the straight part at an obtuse angle. Sellheim called this angle the "knee" of the birth canal (Figure 2).[49] The angle, situated at the pelvic floor, was precisely where fetuses had to perform their internal rotation. In order to find out whether it was the shape of the birth canal (the "knee"), or characteristics of the fetus, or certain birth forces that caused the internal rotation, he had to conceptualize all of them. Sellheim's experiments served this very

[47] Hugo Sellheim, "Hilfsmittel zur Förderung der räumlichen Vorstellung in der Geburtshilfe," *Beiträge zur Geburtshilfe und Gynäkologie* 10, no. 1 (1905): 121–33 (here, Sellheim reports on Hegar's collection of casts of pelvises and children's heads in the collection of the Freiburg University Women's Clinic); Alfred Hegar, "Zur Geburtsmechanik, Teil 1: Die Beckenaxe," *Archiv für Gynäkologie* 1 (1870): 193–223.
[48] Mol, "Ontological Politics" (n. 8), 81.
[49] Sellheim, *Die Beziehungen des Geburtskanals* (n. 17), 27–35.

purpose; they were heuristic tools that would lead to embodiments of an invisible and difficult-to-access space: the female pelvis during childbirth.[50]

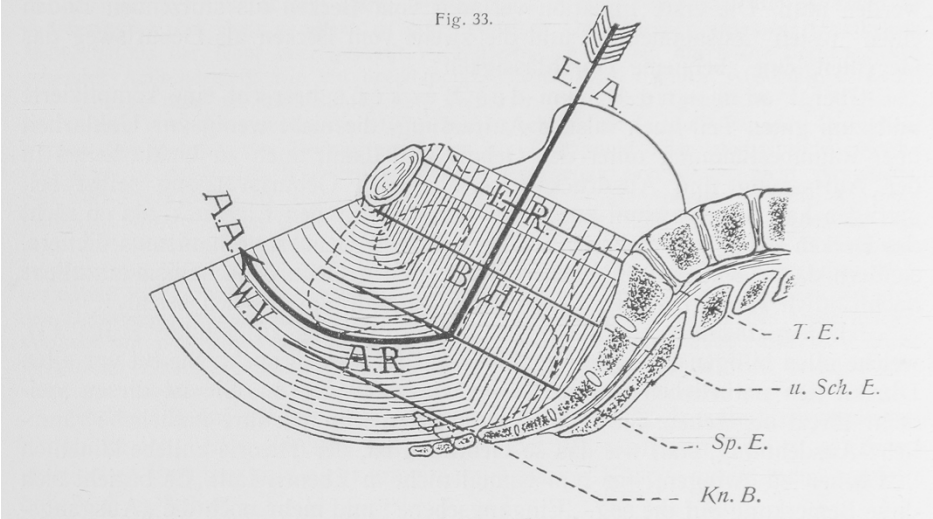

Figure 2. A drawing of the "knee" of the birth canal, which emerged as a crucial part of Sellheim's revision of the pelvic structure. Hugo Sellheim, "Die normale Geburt," in *Biologie und Pathologie des Weibes: Ein Handbuch der Frauenheilkunde und Geburtshilfe*, vol. 7, pt. 1, ed. Joseph Halban and Ludwig Seitz (Berlin: Urban & Schwarzenberg, 1927), 94.

The models of the birth canal embody the mattering potential of sociomaterial practices and enact Sellheim's workshop or lab not as a place where reality is represented but as a place where "reality is transformed, and where new ways of doing reality are crafted."[51] What new realities were enacted by the birth canal model? When an object gave a satisfactory answer (i.e., produced evidence and concepts), he often had it marketed as a teaching tool. By distributing the papier-mâché model of the birth canal in the last phase of labor, a very specific version of birth mechanics and the female body was disseminated and stabilized. Even if many parts of women's bodies were present in the model (pelvis, muscle stretches,

[50] Ibid., 34: "Alle Untersuchungen bezweckten, einen brauchbaren Begriff des Geburtskanales für das Studium der Geburtsmechanik zu gewinnen" (All investigations were aimed at gaining a useful concept of the birth canal for the study of birth mechanics).
[51] Mol, "Ontological Politics" (n. 8), 75.

birth pains), they disappeared from the concept of the canal and its embodiment. The birthing body that these models of the birth canal enact appeared as a technical-mechanical body that surprisingly did not seem to embody any sex at all. The model of the birth canal was enacted through chains of material translations that zigzagged between the delivery room, the workshop (lab), and the dissection room, thus connecting parts of the different versions of the body and materializing an anatomical model of a space that did not really exist in that form. However, this model was the first step in the performance of a new, experimental version of the birthing body. During this process, Sellheim reenacted the birth process twice: once to create the negative form of the channel by driving a child's head through clay deposits, and the second time to insert this negative form into the body of a recently deceased woman. The model of the birth canal (Figure 1) is a very heterogeneous object, "born" inside a dead woman, whose pelvis then became the prototype of the object.

In German, all sorts of obstetric objects (machines as well as anatomical models) have been called phantoms (*Phantome*). The term refers to the fact that these machines and dolls are images of a reality that cannot be seen or observed directly because the process they embody is hidden inside female bodies. Machines and phantoms allow to perform, reproduce and practice this hidden process. At the same time, the term suggests something illusory, ghostly, incomprehensible; it occupies a space between imagination and imitation, and includes the affective side of birth practices and research. As much as the phantoms are meant to bring something to light, they also hide something, for instance, other versions of the birthing body, or rather make them unperformable. In this sense, women's bodies disappear in Sellheim's phantom of the birth canal. Instead, their labor and their bellies are staged as a canal, as part of a transportation route. Other phantoms, which originated as models in the nineteenth and twentieth centuries, are still used today in obstetric education

throughout the world. They represent a very specific historical version of the birthing body, but one that is staged as universal and ahistorical. What ghostly absences and presences do they carry with them? What is past, what remains in their material presence, and how do we want to enact them today?

Sellheim's objects, some of them marketed as mass-produced items in medical stores, some simply remaining in the laboratory or continuing to be used in the lecture theatre, conceal the practices that made these models real and effective. The "ethical gap" in Sellheim's publications, his lack of reflection on his research practices puzzle us today. Although we would call them violent, they did not provoke rejection among his contemporaries; on the contrary, his objects and results were enormously admired. Historical praxiography helps to make these practices and their inherent contradictions visible. Thus, it helps us to ask how we want to deal with the materializations of these practices today, with the objects that do not fall under the heading of "human remains," such as obstetric pelvic collections. What historical ontological politics are we confronted with in the face of Sellheim's objects? Which politics do we choose today when we study or teach bodies in medicine? If objects and bodies are not pregiven, then it is up to our ontological politics to decide which reality we want to enact and which not. [52]

[52] John Nott and Anna Harris provide excellent examples of how the past is enacted in contemporary medical education and how practices from the past "stick" to current enactments of obstetric machines and simulators. They also study the impact of these "material histories" in different teaching environments in the Netherlands and Ghana today. See Nott and Harris, "Sticky Models: History as Friction in Obstetric Education," *Med. Anth. Theory* 7, no. 1 (2020): 44–65; Mol, "Ontological Politics" (n. 8).

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Mechanical Translations: Enacting the Birth Object

In 1904, Friedrich Schnabel, a licensed physician, was awarded a medical doctorate by the Medical Faculty of the University of Freiburg.[53] In his empirical work, which was supervised by Sellheim, Schnabel had measured the flexibility of the different spinal sections in fifty newborns. The newborns were selected according to physiological criteria, which is to say, none of the children should be ill, because the measurements were intended to determine normal values. What does not sound complicated proved to be quite challenging in practice. The measuring apparatus he used for this purpose had been designed by Hugo Sellheim (Figure 3). It consisted essentially of two wooden boards screwed together, the upper board being shorter so that the end of the lower board was free. Fixed to this free area was an angle meter used for measurement. Measuring points were marked on the skin at the head and pelvis of a naked newborn, who was then placed in the measuring apparatus in such a way that the marked measuring points on the body coincided with the zero point of the angle meter; the child's body was held in this position by sandbags and by a nurse who supported its posture by holding the child's chest and back with her hands so that the head and neck were completely free to move.[54] Schnabel then began his bending examinations; the results were read from the angle meter.

[53] Friedrich Schnabel, "Zur Mechanik der Wirbelsäule des Neugeborenen" (M.D. diss., Albert-Ludwigs-Universität Freiburg, Germany, 1904).
[54] Ibid., 33–35.

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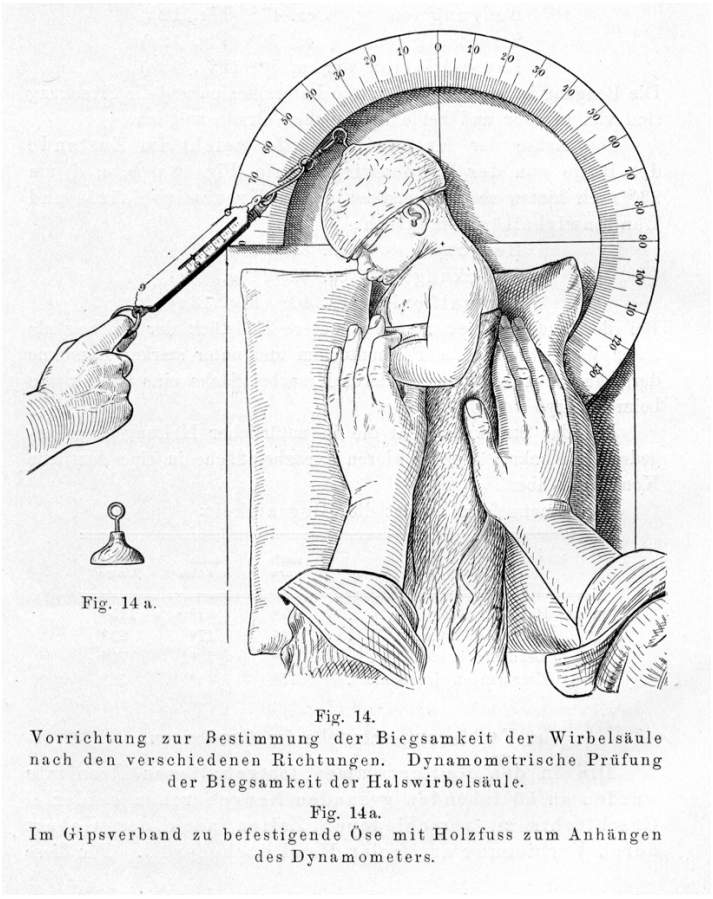

Fig. 14.
Vorrichtung zur Bestimmung der Biegsamkeit der Wirbelsäule nach den verschiedenen Richtungen. Dynamometrische Prüfung der Biegsamkeit der Halswirbelsäule.

Fig. 14a.
Im Gipsverband zu befestigende Öse mit Holzfuss zum Anhängen des Dynamometers.

Figure 3. A drawing of the device for measuring the flexibility of the spine in newborns. Hugo Sellheim, *Die Beziehungen des Geburtskanales und des Geburtsobjektes zur Geburtsmechanik* (Leipzig: Thieme, 1906), 48.

Schnabel had spent the previous weeks practicing his own part in the experiment over and over again so that he would always be able to bend the infants with the same force, moving the children's head and pelvic end until their bodies showed a marked resistance. Yet despite all these precautions, which were supposed to standardize the examinations, the children caused problems. They often screamed at the top of their lungs, which interfered with the measuring process, and time and again he had to wait for them to calm down. With some who did not calm down at all, the measurements could not be taken. To take measurements while bending the newborns in different directions (forward, backward, and laterally), the children had to be repeatedly repositioned. Sellheim himself supplemented the

tests with radiographs, examinations on dead bodies, and checks using a dynamometer, which finally made it possible to objectively determine the force applied for these tests.[55] Having assessed the results, Sellheim came to the conclusion that the flexibility in all sections of the spine was greater in the newborn than in the adult and that this flexibility rapidly decreased after birth. Indeed, Schnabel and Sellheim had measured the children at different intervals after birth (between thirty minutes and forty-six days). Sellheim noted further that the flexibility of the cervical spine was much greater than that of the lumbar spine and that, in the individual sections of the spine, the flexibility differed greatly according to the direction. He called the point of maximum flexibility the "bending facillimum" [Biegungsfacillimum] and the point of least flexibility the "bending difficillimum" [Biegungsdifficillimum]; terms, that can still be found in modern (German-language) obstetric textbooks.[56]

Measuring the spine was not new, but performing it on newborns was. Of course, Sellheim actually wanted to learn something about the flexibility of the fetal spine. But since he did not have direct access to fetuses in the womb, he brought newborns into situations that were supposed to simulate intrauterine states; he just took their properties to be still similar to their fetal state.[57] In his literature report, Schnabel lists various authors who had measured the spine, including gynecologists and obstetricians, but these authors tended to focus on so-called deformities of the pelvis, which they took to coincide with anomalies of the spine.

[55] Sellheim, *Die Beziehungen des Geburtskanals* (n. 17), 48–60.
[56] Karl Knörr et al, G*eburtshilfe und Gynäkologie. Physiologie und Pathologie der Reproduktion* (Berlin: Springer-Verlag, 1989), 207.
[57] Sellheim also used radiographs but could not perform all measurements on a single newborn, as he would have preferred, because the technology was still not sufficiently developed and, due to prolonged exposure time, the newborn would probably have suffered burns. See Sellheim, *Die Beziehungen des Geburtskanals* (n. 17), 42.

Sellheim's questions, on the other hand, referred to normal findings: only in "completely normal newborns" could normal values about the flexibility and mechanics of the spine be determined at all.[58] While his colleagues were more interested in the possible prevention of pelvic disorders, Sellheim was fascinated by birth mechanics. After the birth canal, he devoted all his experimental attention to fetuses because he suspected that the reasons for internal rotation lay in a connection between the "knee" of the birth canal and fetal properties. These properties were now systematically investigated. In this process, Sellheim "translated" the findings, such as the measurements recording the flexibility of the spine, into mechanical properties and reconstructed them in corresponding objects. He thus translated the physiological measurement of the flexibility of the cervical spine into a mechanical birth object equipped with springs performing the respective bending tendency at the cervical spine, while other springs performed the cervical spine. After the mechanization of the birth canal, now as a complementary part, the birth object was also mechanically enacted (Figure 4).

[58] Ibid., 40.

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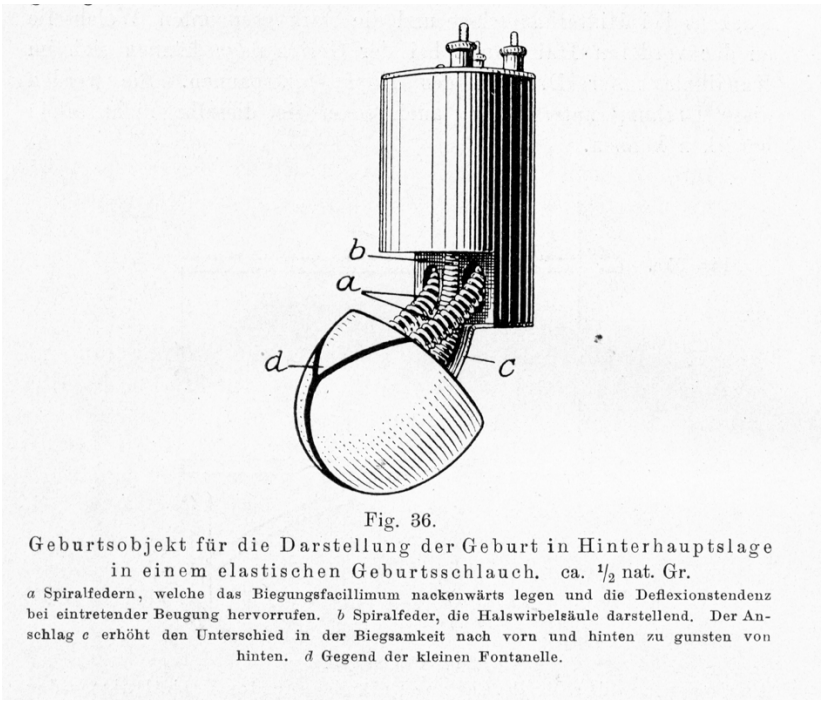

Fig. 36.
Geburtsobjekt für die Darstellung der Geburt in Hinterhauptslage in einem elastischen Geburtsschlauch. ca. 1/2 nat. Gr.
a Spiralfedern, welche das Biegungsfacillimum nackenwärts legen und die Deflexionstendenz bei eintretender Beugung hervorrufen. *b* Spiralfeder, die Halswirbelsäule darstellend. Der Anschlag *c* erhöht den Unterschied in der Biegsamkeit nach vorn und hinten zu gunsten von hinten. *d* Gegend der kleinen Fontanelle.

Figure 4. Drawing of a birth object embodying the vertex position. The mechanical properties of springs *a* and *b* follow Schnabel's and Sellheim's measurements on newborns. Hugo Sellheim, *Die Beziehungen des Geburtskanales und des Geburtsobjektes zur Geburtsmechanik* (Leipzig: Thieme, 1906), 118.

At the same time, Sellheim translated the mechanical properties of the birth object back into the organic body of fetuses. For this purpose, he first resorted to frozen sections, especially to the preparations of Hans Chiari (1851–1916).[59] Here, Sellheim observed "that the upper arms [of the fetus] are compressed in the narrow, elastic birth tube by the binding birth forces [*Schnürzwang*]."[60] However, no one had ever recognized the birth-mechanical significance of this phenomenon. Sellheim explored it thoroughly by carrying out binding experiments on the dead bodies of fetuses. He tied strips of gauze around the chests and loins of the fetuses and fixed the bodies in a strong solution of formol. From his results, he

[59] Hans Chiari, *Über die topographischen Verhältnisse des Genitales einer inter partum Verstorbenen Primipara* (Vienna: Toeplitz & Deuticke, 1885).
[60] Sellheim, *Die Beziehungen des Geburtskanals* (n. 17), 87.

deduced that fetuses changed shape during birth and assumed what he called the "transport form," or, in a mechanical translation, the "fetus as a roller," or "cylinder fetus" (*Fruchtwalze*) (Figure 5).[61]

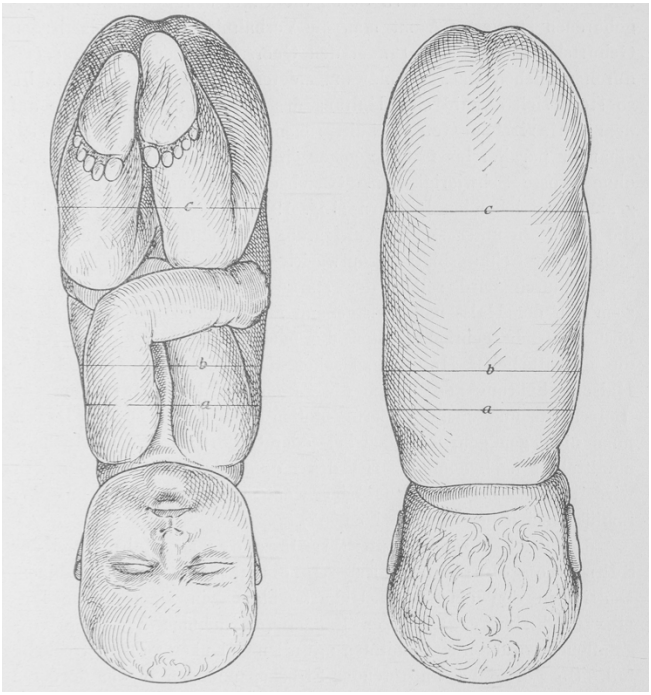

Figure 5. Drawings of an anatomical model enacting the cylinder form of fetuses after binding experiments using gauze. Hugo Sellheim, *Die Beziehungen des Geburtskanales und des Geburtsobjektes zur Geburtsmechanik* (Leipzig: Thieme, 1906), 87.

Fetuses had to pass through the birth canal with the least friction, and for this purpose they assumed the shape of a cylinder. When passing through the so-called knee of the canal, the cylinder (the fetus, the object) had to bend. Since the cylinder fetus was not equally flexible at all points, as the spine measurement tests had shown, a fetus could be conceived as an "unevenly flexible, rotatably mounted cylinder."[62] Sellheim regularly discussed his work

[61] Ibid., 81–102.
[62] Ibid., 10.

in the laboratory with acquaintances, especially with an engineer and a maths teacher. With the help of a specially built device, Sellheim was able to prove through physical experiments that this kind of cylinder, when it had to bend, always rotated around its longitudinal axis as a result of the occurring stresses until the direction in which it was most flexible coincided with the direction of bending. For Sellheim, this was the mechanical explanation of the internal rotation, the content of the natural law that determined the birth mechanics.

Various sociomaterial networks were necessary to mechanize fetuses as birth objects. The fetal spine interested Sellheim so much because it was the most flexible part of a fetal body and, unlike the configurations of the head, it had scarcely been explored. This meant that the measuring devices, equipment, and helpers first had to be sought out or built and the various enacted objects had to be connected. The *physiological-statistical* network consisted of serial examinations of healthy newborns with marked skin, a measuring device (made up of wooden boards and an angle meter), a doctoral candidate, the securing hands of a nurse, sandbags, and completed charts (with the measurements, etc.); the *mechanical-physical* network comprised an engineer, a mathematics teacher, wooden blocks, metal, and springs; and the *anatomical-clinical* network consisted of frozen sections, dead bodies, and strips of gauze for binding. Of course, many things are missing from this cursory list to name the networks completely. The different practices and networks stabilized the mechanization of the fetus. Sellheim presented evidence for each of the partial objects—the physiological-statistical, the mechanical-physical, and the anatomical-clinical birth object—corresponding to their respective sociomaterial networks: statistics (numbers), mechanical objects, anatomical specimens. Like the model of the birth canal, the birth object is very heterogeneous, enacted by the addition or combination of different sociomaterial practices.

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The mechanization of the birth object was the second step that helped to enact the new birthing body that the new physiological mechanics enacted. Whereas the fetus had been granted almost no agency in the traditional enactments of birth mechanics, this changed with Sellheim's claim that internal rotation was by no means due solely to the shape of the female pelvis. Rather, he claimed that there was a shared agency between mother and fetus that arose from the interaction between the shape of the birth canal with its so-called knee and the cylindrical shape of the fetal body.[63]

As with the birth canal, Sellheim was attempting to overcome an insuperable barrier through experimentation. In this case, it was not the boundary between life and death, but the boundary of the womb, by equating the unborn with the newborn. Sellheim's attempts to overcome this boundary extended the birthing body or, in other words, experimentally distributed the process of birth to more bodies, all of them beyond the maternal body.[64]

Mechanical Relations: August Mayer in the Birthing Machine

What was it that persuaded August Mayer to get into the birthing machine? It was probably a mixture of fear of and admiration for his supervisor as well as personal ambition. Indeed, in his report on the experiment, he noted that Sellheim, "as a born leader, by the determination of his appearance and the matter-of-factness of his demands, [had] the gift of enlisting people for certain purposes and forcing them under his spell."[65] So, Mayer had spent hours drawing

[63] Hugo Sellheim, *Die Geburt des Menschen nach anatomischen, vergleichend-anatomischen, physiologisch-physikalischen, entwicklungsmechanischen, biologischen und sozialen Gesichtspunkten* (Wiesbaden: Bergmann, 1913), 251–61.

[64] Sellheim was by no means alone in his practice of using the newborn as an extension of research on the unborn; see Arni, *Pränatale Zeiten* (n. 8).

[65] See Mayer's collection of papers in the University Archive, Tübingen University, NL Mayer, 150/1 "Klinik Hegar."

embryos for Sellheim's lectures and publications and long nights helping him with experiments to explain the mechanism of birth. Eventually, as he wrote, Sellheim built this huge birthing machine "through which I kept coming over and over again into the world as a birth object."[66] Mayer had finally agreed to these "laborious and not always painless attempts" because Sellheim had promised him a trip to an international congress where he would be born as a "wunderkind" in front of the astonished colleagues.[67] The trip came to nothing, however, because the birthing machine did not work.

Sellheim was determined to use birthing machines to embody the definition of internal rotation that he had found with the help of physical experiments. Birthing machines were not classical obstetric machines; rather, they were built to test the expulsive forces of the birth process. Thus, the machines were set up in such a way that each embodied only one of the dominant forces that were held responsible for birth mechanics. Having found a viable rationale for internal rotation, Sellheim did not enact the birthing machines as heuristic tools; rather, they were intended for hypothesis testing. Sellheim wanted to prove that the assumption of his colleagues that the expulsive forces had an influence on the birth mechanism itself was totally wrong. But in order to show that none of the assumed forces made a difference, the birth objects had to perform internal rotation in *all* machines.

The mechanical birth object with its springs and the embodied flexibility of the cervical spine, for example, was inserted into a machine that embodied the general content pressure ("allgemeiner Inhaltsdruck"). The pressure was created by an air pump. The birth canal was enacted by various shapes and materials, such as a curved and a straight elastic tube. In his account of an experiment carried out in the former tube (see tube *b* in Figure 6), Sellheim

[66] Ibid.
[67] Ibid.

described how the object first moved through the straight part without rotating during the individual impacts of the air pump, while it then rotated around its longitudinal axis in the bend of the tube.[68] Other machines embodied gravity as the major expulsion force, and here too the rotation was caused without any problems. Most important to Sellheim was a machine that embodied concentrated pressure ("konzentrierter Druck"), not because it produced a different result but because of its usefulness for demonstrations.[69] For this purpose, very elaborate mechanical mannequins, which were necessary to enact the different presentations, were built. The prompt occurrence of the internal rotation in all these machines served Sellheim as proof that none of the individual forces alone could produce the internal rotation, but the vivid impression made by the rotation in the manikin machine (whose natural occurrence could never be shown) caused Sellheim to sell this machine for educational purposes through Das Medizinische Warenhaus (Medical Department Store) in Berlin (Figure 7).[70]

[68] Sellheim, *Die Beziehungen des Geburtskanals* (n. 17), 120.
[69] Ibid., 122–24.
[70] Ibid., 125.

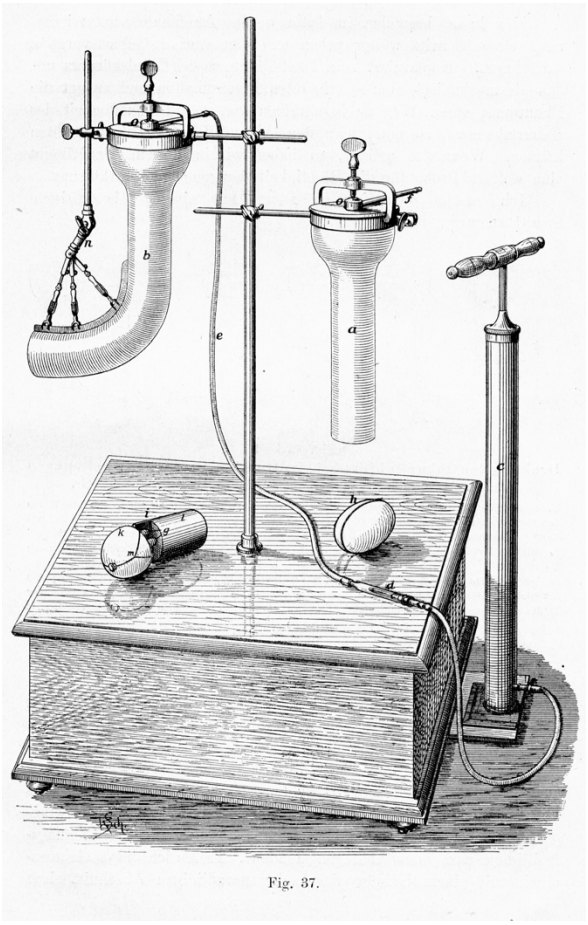

Figure 6. Drawing of a birthing machine with an air pump for testing the general content pressure. Hugo Sellheim, *Die Beziehungen des Geburtskanals und Geburtsobjekts zur Geburtsmechanik* (Leipzig: Thieme, 1906), 119.

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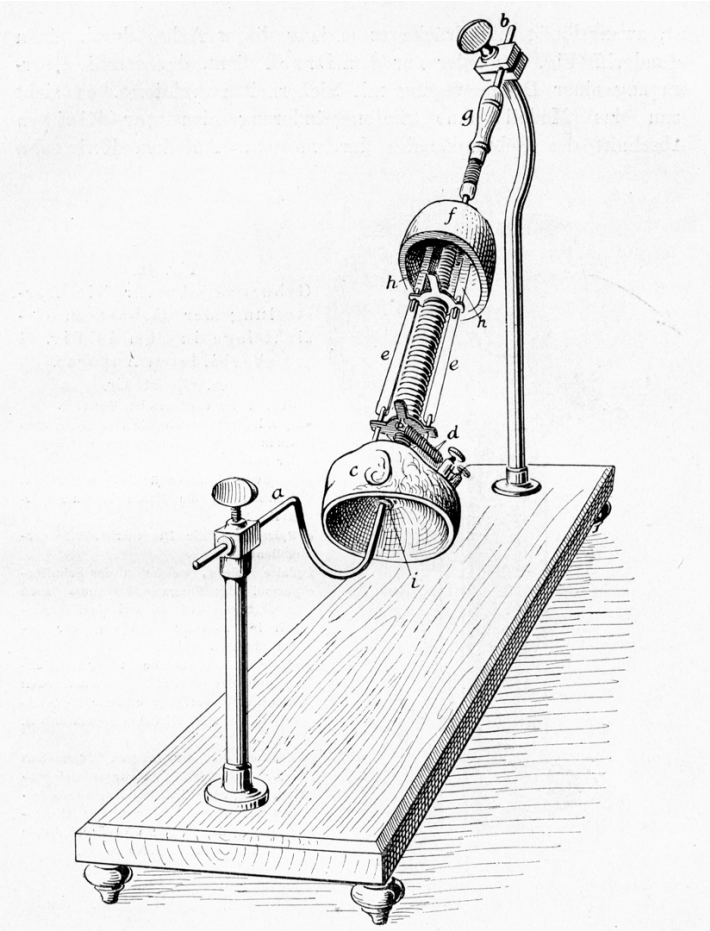

Fig. 41.

Geburtsmaschine zur Demonstration des Ablaufes der Kopfdrehung bei Hinterhauptslage und Gesichtslage aus jeder Stellung, der Schulterdrehung und der Beckendrehung bei Steisslage unter dem Einfluss der Deviations- und Haltungsspannungen.

a b Achse des Geburtskanales, im oberen Teil gerade, im unteren nach vorn oben gebogen; *c* Kopf. Durch die beiden Spiralfedern bei *d* (die untere ist auf der Zeichnung zum Teil zugedeckt) wird ein Biegungsfacillimum der Halswirbelsäule nackenwärts und eine Deflexionstendenz des Kopfes hervorgerufen. Durch die platten Federn *e e* wird ein Biegungsfacillimum am Schultergürtel lateralwärts und ein Biegungsdifficillimum senkrecht dazu bedingt. Geht der Steiss *f* voran, so liegt dort infolge der Anordnung der platten Federn *h*, *h* das Biegungsfacillimum hüftwärts und das Biegungsdifficillimum senkrecht dazu. Der Handgriff *g* gestattet nur einen Schub, die Übertragung einer Drehbewegung ist ausgeschlossen; *i* ist eine kleine öfter zu erneuernde lose Gummischeibe mit engem Loch, welche auf der Stange *a b* die notwendige Reibung unterhält.

Figure 7. Drawing of a birthing machine with a mechanical doll for testing concentrated pressure. Hugo Sellheim, *Die Beziehungen des Geburtskanals und Geburtsobjekts zur Geburtsmechanik* (Leipzig: Thieme, 1906), 123.

Like the other two objects, the birthing machines are characterized by their heterogeneity. Through Mayer's extended birth process, by crawling “over and over again" through the machine, the two shaped each other: Mayer became an obstetrician, which Sellheim had vehemently doubted during Mayer's first failed attempt, and the machine became the one in which fetuses and their numerous embodiments must rotate as uneven

cylinders. Mayer thus epitomized Ludwick Fleck's ontological revision of traditional Western epistemology, because Mayer experienced research not as painless, passive, and solitary contemplation from a distance, but as a close (sometimes too close), lively, and active relationship with his research object. Rather, subjects and objects shape each other in the process of becoming, of being associated with each other in new forms, of establishing new relationships, of creating new realities. [71]

Mayer's accounts shed light on the extent to which the machines evoked, reinforced, and enacted social and disciplinary bonds. His report, written about thirty-five years after these events, provides a vivid description of a typical (German) academic community of the time, which Mayer calls a "family." Indeed, the internal historiography of the obstetricians lists both Sellheim and Mayer as "sons" of Hegar, thus indicating a common ancestry, turning them into "brothers". Mayer appears a second time in the same family tree as Sellheim's "son/student" (Figure 8).[72]

How to enact this family tree in a sociomaterial way? Like the other objects, we need to unfold the family tree as an object, to translate the genealogical lines of relationships from the realm of elective affinities into the material practices that first enacted these connections, and to understand the genealogical lines as the outermost abstraction of, for instance, crawling through birthing machines and measuring upset newborns. In this way, we see the

[71] See Ludwik Fleck, "On the crisis of 'reality'," in *Cognition and Fact. Materials on Ludwik Fleck*, ed. Robert S. Cohen and Thomas Schnelle (Dordrecht: D. Reidel Publishing, 1986), 47–57, here p. 49.
[72] Carl Joseph Gauss and Bernhard Wilde, *Die deutschen Geburtshelferschulen: Bausteine zur Geschichte der Geburtshilfe* (Munich: Banaschewski Verlag, 1956), table 7. This book certainly deserves its own article on genealogical practices as part of disciplinary formation through uncritical historiography. It consists of 1,208 short biographies, going back to the seventeenth century grouped around nine family trees. It is interesting to note who does not appear here, namely midwives and female doctors.

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family tree unfold as a socio-material network in which knowledge and skills, objects and affects circulated and entangled the participants in a multitude of relationships. In this way, the discipline of obstetrics and gynecology grew historically as an all-male family based on female matter.

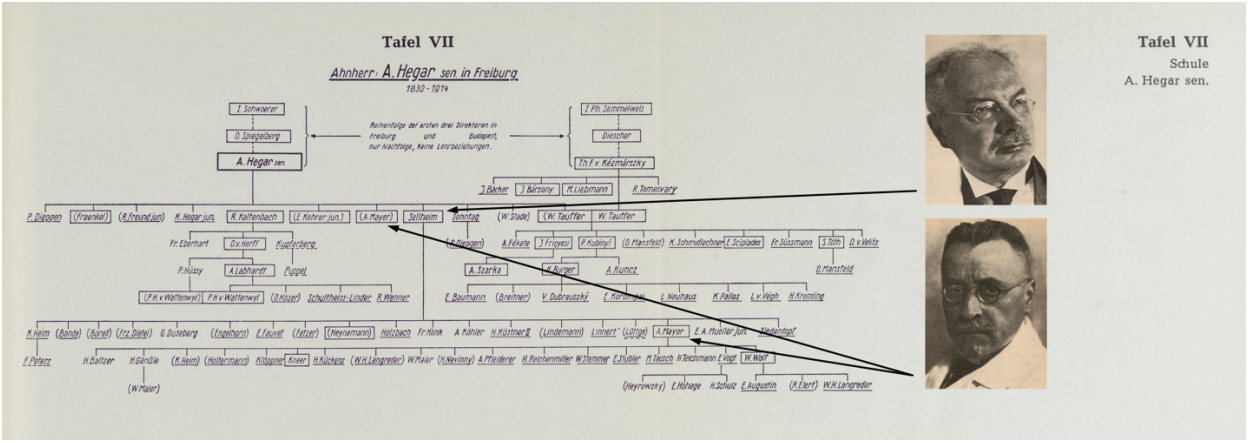

Figure 8. Academic kinship of Sellheim and Mayer as displayed in one of the nine pedigrees of the German obstetrical schools (families). Carl Joseph Gauss and Bernhard Wilde, *Die deutschen Geburtshelferschulen: Bausteine zur Geschichte der Geburtshilfe* (Munich: Banaschewski Verlag, 1956), table 7. For the portraits of Sellheim and Mayer, see *Lehrer der Heilkunde und ihre Wirkungsstätten. Festbeigabe der Münchener Medizinischen Wochenschrift anläßlich ihres 80jährigen Bestehens 1853–1933* (München: J. F. Lehmanns Verlag, 1933), p. 71 (Sellheim) and p. 90 (Mayer).

Conclusion: All That Comes-Into-Being and Becomes World

In this article, historical praxiography and sociomateriality were used to examine the phase of physiologization of obstetric research at the turn of the twentieth century. In this period, functions and processes became increasingly important in scientific research. Hugo Sellheim's experiments on birth mechanics can be seen as paradigmatic for this research and this phase of physiologization. The objects resulting from the experiments were unfolded in a reverse origami or, in the second example about the birth object, folded up, so that—as

intended in an ontological-praxiographic investigation—it is possible to examine the complexities and the full amount of relations the objects are made of, namely of a specific historical mixture of materiality, sociality and emotions.

Understanding material (matter) not as a thing in itself but as a collection of relationships helps to overcome the separation and assignment of material and social aspects to different registers. History and its stories can be told differently: Mayer getting stuck in the birthing machine is not just a funny or oppressive anecdote, but an essential part of the enactment of the mechanical birthing body, just as it helps him in his birth process as an obstetrician and gynecologist, as an academic member of a discipline. This discipline and its history are analyzed and told through the sociality of shared research practices not only through its texts, academic honors, appointments, and institutional positions.

Every time we have looked at matter in this text, whether as birth canal, birth object, or birthing machine, we have witnessed how it was entangled with sociality, whether as screaming newborns, sweating students, helpful nurses, birthing, dying, and dead women and fetuses, future obstetricians and their discipline-in-the-making that wanted to give itself a scientific basis at all costs.[73] These heterogeneous, composite, sociomaterial objects enacted haunting, tangible, and tactile realities. They became historically effective as an operative part of the world, for example as teaching tools. They enacted new realities; they were world making. By focusing on obstetric objects and their constitutive entanglements with practices, this article has drawn attention to the history of clinical research.[74] From this material,

[73] "When we look at materials, we are witnessing the production of the social." Law and Mol, "Notes on Materiality and Sociality" (n. 9), 274.

[74] Particularly helpful here is Hiddinga's study, which examines the relationship between medicine and science, the place of medical research, and medical science using obstetrics as an example. See Anja Hiddinga, "Changing Normality: Pregnancy and Scientific Knowledge Claims 1920–1950" (Ph.D. diss., Universiteit van Amsterdam, 1995).

conclusions can be drawn about the relationship between anatomy and physiology, particularly the role of mechanics (rather than biology) in driving the process of physiologization in certain clinical subjects. The study of experimental practices in obstetrics contributes to the historical ontology of experimentation in a clinical setting, an area that has received little attention. The mechanical birthing body enacted through these experiments is an important finding for the history of reproduction, feminist science studies, and body history.

Turning to historical praxiography opens up new possibilities for studying and narrating these scientific practices differently. What matters here is not so much a history of the knowledge produced by scientific practices, but rather the history of the realities that have been activated and enacted by these knowledge-producing practices, the way in which the research was done, and all the relationships that were entered into. The mechanical, abstract, asexual, hydraulic birthing body that materialized in these experiments was extracted from all the living and dead bodies of women, fetuses, and newborns that were crucial participants in these experiments. The striking gender neutrality of the experimental body and the absence of female bodies contrasted with the community of brothers in which experimental birth took place, of which August Mayer was both a reporter and a special member.

Performing different versions of birth can enact multiple realities, including those in which, surprisingly, women were entirely absent and those in which, without female bodies, there would be no actual birth. But these versions of birthing bodies were never completely separate. Clinical measurements repeatedly entered the experimental objects: for example, in the production of the model of the birth canal or in the attempt to determine the flexibility of the fetal cervical spine. Ontological multiplicity thus did not enact a complete or even holistic

body nor did it entail incommensurability since the multiple versions of the birthing body were at least partially connected.[75]

One task of historical praxiography, which can only be hinted at here, is to examine the historicity of the multiple bodies of birth. When did Sellheim's version of the highly mechanized birthing body, which moves and rotates according to the laws of hydraulics, cease to be enacted? What kind of bodies were enacted afterward? The broader historicization that praxiography offers us suggests that the experimental body enacted through Sellheim's experiments did not exist forever, at least not in its expansion and its purely mechanical functioning. For already in the 1940s, the purely mechanical body retreated—although it has not disappeared completely. The mechanics of childbirth is still an important part of modern obstetrics, as a glance at textbooks will confirm. However, Sellheim's name is no longer mentioned even in German textbooks, although some of his terminology is still used. The purely mechanical birthing body has become less prominent, it is fading. Birthing bodies became endocrine—that is, increasingly biological—bodies that had to be practiced and performed differently to become real.

*

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[75] For an approach to dealing with the differences, gaps, and overlaps between the multiple bodies, see Mol, *Body Multiple* (n. 8).

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