Approaching diagnostic messiness through spiderweb strategies: Connecting epistemic practices in the clinic and the laboratory

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A R T I C L E   I N F O

Keywords:
Diagnosis
Messiness
Clinical medicine
Tacit knowledge
Rheinberger

A B S T R A C T

Scientific and medical practice both relate to and differ from each other, as do discussions of how to handle decisions under uncertainty in the laboratory and clinic respectively. While studies of science have pointed out that scientific practice is more complex and messier than dominant conceptions suggest, medical practice has looked to the rigour of scientific and statistical methods to address clinical uncertainty. In this article, we turn to epistemological studies of the laboratory to highlight how clinical practice already has strategies for dealing with messiness. We draw on Hans-Jorg Rheinberger’s Toward a History of Epistemic Things, in which he invokes the metaphor of a spider’s web to explain the role of tacit practices in experimental biochemistry for helping practitioners manage messiness. We argue that diagnostic practices in clinical medicine employ similar, albeit codified, procedures to evaluate epistemic significance, ensure sensitivity to the unforeseen, and allow focused inquiry for potential missed information. We end by suggesting that while philosophy of medicine may learn from laboratory epistemology, the sciences may learn something from medical practice.

1. Introduction: messiness and epistemic significance in the clinic

In the past decade terms like messiness, complexity and entanglement have become widespread in fields such as philosophy of medicine, philosophy in biology, medical humanities and social studies of medicine. This terminology indicates an increasing interest in understanding medical practice in its full, nuanced, and at times convoluted form. In this article, we suggest that furthering understanding of messiness in the clinic requires a shift away from traditional late twentieth century movements in philosophy of medicine and into practice-oriented laboratory epistemology. We focus specifically on the experience of messiness in regard to epistemic significance. We do so by looking at diagnostic practice in the clinic and the way in which clinicians manage cases that are simultaneously overly saturated, underdetermined and limited in time, options of inquiry and resources.

Clinical medical practice is – among other things – an epistemic activity. It starts from a concrete but urgent knowledge-gap. Typically, a patient presents a complaint, and a doctor needs to figure out what to do about it, while being mindful that erroneous decisions or delays may have severe consequences. In this solution-aimed inquiry, deciding on a direction of inquiry and, subsequently, a possible diagnosis, is often the first step. This step requires practitioners to navigate the non-modular interplay between several challenges: the translation between generalized knowledge and the individual patient; the unpredictability of acting on insufficient and incomplete information; the need to combine information from the full biomedical scale from subcellular to sociological level; the time restraints; the communicative challenges; and the social

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https://doi.org/10.1016/j.shpsa.2023.08.006
Received 15 October 2021; Received in revised form 10 May 2023; Accepted 22 August 2023
Available online 16 September 2023
and psychological factors of the clinical encounter (Ahlzén, 2010; Engelhardt & Towers, 1979; Montgomery, 2006; Upshur & Chin-Yee, 2017). The interplay of these challenges amounts to what we will refer to as a sense of messiness on the clinician’s side that comes out of having to navigate and decide which aspects and elements to focus on. We take the term ‘mess’ here to indicate epistemic conditions: the combination of complexity and urgency, and the impossibility of following all lines of inquiry, not just because of time and resource constraints, but also because some lines of inquiry might obscure others or even cause direct harm to the patient. In these circumstances, knowing which paths of inquiry will turn out to be significant for figuring out the question at stake becomes both uncertain and unpredictable – be it a question of information on family history, a certain blood test, knowledge of a recent change in patient diet or medication, or some other element.

This specific use of the term messiness can be related to the more classical notions presented by Jutta Schickore, that is, the epistemic notion of messiness (that scientific method is messy, i.e., non-standardizable) and the ontological notion (that the world is fundamentally messy and cannot be finally ‘sorted’) (Schickore, 2020). As the process of diagnosing, given the uncertainty and the unpredictability, cannot be fully determined in advance, it may be a messy process methodologically; and the complexity and unpredictability of this practice may be an expression of an underlying ontological messiness in the interplay of the disease, the patient’s body, the patient’s life situation, and available test options – though it need not be. We also note that not all clinical encounters invoke this sense of messiness. In the literature on the diagnostic process, some texts distinguish between consultations that are sorted through ‘pattern recognition’ (‘see it and recognize it’, Kennedy, 2013; or ‘primary diagnostic reasoning’, Thompson & Upshur, 2018); and those that require further inquiry, where questions of epistemic significance become more pressing. Here, we focus on the practices that help clinicians navigate the latter type of encounter.

In the following we begin by outlining different approaches to overcoming the epistemic challenges in clinical medicine and propose that developments in science studies may offer a useful addition. We then direct attention to pragmatic strategies found in our source material of medical reports, manuals and handbooks. We interpret these in the light of Rheinberger’s insights into tacit procedures in experimental laboratory science and his metaphor of a spider’s web. We end by suggesting that looking to science studies directs attention to pragmatic processes in the clinic, and that these in turn may have something to offer to scientific practice. The article bases its claims about clinical practice with best evidence from systematic research; and in section 2.3 the particular roles played by statistics in the sciences and in clinical judgement with best evidence from systematic research; and in practice the integration was meant to be mediated through clinical guidelines (Hanemaayer, 2019, p. 4; Sackett et al., 1996, p. 71). Applying these guidelines, however, proved challenging, and the strategy was seen as wanting from the point of view of both science and the humanities. In practice, critics argued, clinicians were forced to follow abstract, rule-based guidelines that rested on (too) broad categories and decontextualized results, and EBM was described in negative terms as ‘cookbook medicine’ (Feinstein & Horwitz, 1997; Solomon, 2015, p. 3).

Moreover, deciding which guideline to follow in a given clinical encounter itself depended on determining epistemic significance, and thus the fundamental issue of messiness persisted. Meanwhile an

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1 The challenges are considered in the referenced literature, but more colourful descriptions of concrete messy situations of medical practice may be found in the recent wave of medical memoirs where messiness, disorder and exhaustion are at the centre such as Gawande’s Complications (Gawande, 2008), Marsh’s Do no harm (Marsh, 2014), Clarke’s Your Life in My Hands: A Junior Doctor’s Story (Clarke, 2017), and Kay’s This is going to hurt (Kay, 2018).

2 The relation between medicine, biomedical science and statistical methods is complex, but they are closely intertwined as statistical methods are introduced in both laboratory sciences and medicine up through the late nineteenth and twentieth century, causing tensions relative to professional judgement of both medical doctors and laboratory scientists (Mathews, 1995). As we clarify in section 2.3 the particular roles played by statistics in the sciences and in medicine is not pertinent to the point we are making, and hence we will not elaborate further here.

3 This is paralleled in positivistic accounts in history of science contemporary with Feinstein, where mistaken scientific theories were often ascribed to influences from the cultural context, while correct theories were seen as deriving from evidence; Collins & Pinch, however, forcefully denied that mess can be delimited in this way (1993).
alternative movement emerged suggesting that clinical medicine practice should draw its scientific practice from laboratory medicine rather than epidemiology. This so-called ‘translational medicine’ sought, partly as a response to the challenges faced by EBM, to open up clinical inquiry to scientific creativity and discovery by setting up a research framework across the laboratory and the clinic (Berwick, 2005).

Summing up, clinimetrics, EBM and translational medicine all attempt to base clinical decision on imported scientific foundations whether from methodology, statistics or laboratory tests in order to standardize and legitimize medical practice. But in doing so, they introduce the problem of navigating and translating between these firm foundations and the much less firm everyday of the clinical practitioner. EBM guidelines for instance – despite their intended function to combine individual considerations with research results – highlight features that lend themselves to large clinical trials and thus do not account for how to use the entire breadth of information gathered in the clinical encounter, nor for how to take specific needs of particular patients into account, nor for how to deal with rare cases or comorbidity. The clinical case cannot be neatly delineated from its context, as Feinstein originally imagined. The context with all its ‘messy’ challenges creeps into decision-making from the outset.

2.2. Suggestions from philosophy of medicine: adding to and adjusting the use of science and statistics in medicine

We will now consider different responses to the challenges raised by EBM in particular, as found in the philosophy of medicine literature. These responses suggest ways of adding to or modifying the idea that science can secure a clean-cut clinical encounter, and they aim to integrate local and individual knowledge and thereby navigate more situated aspects of the clinical situation than the guidelines allow.

First, ‘humanistic approaches’ argue that something has gone amiss in strict notions of objective observation and the application of EBM guidelines and scientific tests. They advocate for the introduction of a humanistic element in diagnostics, directing attention to non-measurable aspects of the clinical encounter. Narrative medicine, for instance, suggests that the pauses and narrative structure in patient accounts are epistemically significant, and attention to them should be incorporated into clinical guidelines to understand the full nature of the ailment and thus afford better care (Charon, 2006; Charon et al., 2016; Spencer, 2017). An early proponent of narrative medicine, Rita Charon suggests for instance adding a ‘parallel chart’ for the doctor’s narrative reflections to complement the traditional record of patient history and results of the physical examination in the ‘SOAP chart’ (see section 3.0) (Charon, 2006). This suggestion indicates that messiness – affiliated here with the patient as a whole person – must be dealt with through additions to standard practice. It here reflects the broader movement of medical humanities as adding elements – often with the patient at the centre – which are viewed by medical humanities as overlooked or even made inaccessible by science-based medicine (Ahlén, Evans, Louhiala, & Puustinen, 2010).

A second group of approaches addresses the ‘medical decision-making’, showing how relying on statistics need not force the clinical situation into pre-formed guideline boxes (Kennedy, 2017). Here, the idea is that information from individual patients informs the probabilities of certain outcomes in mathematical decision strategies – mainly Bayesian reasoning, but also ‘intelligent decision support systems’ – based on knowledge of the epidemiological statistics and the reliability of tests. Uncertainty and messiness are entered into the calculation in the shape of probabilities, and the hope is that the multitude of factors that make the clinical situation messy can be encompassed in the statistics. While examples of such calculations encompassing probabilities based on individual factors are given in the literature, these are rarely performed in the clinic. As Ashley Kennedy notes, Bayesian-type reasoning ‘can be done informally (which is what is usually done in busy clinical practice)’ (Kennedy, 2017, p. 386 and 388). Kennedy thus acknowledges that there may be something other than strict probabilistic reasoning going on when clinicians ‘informally’ weigh different aspects of the specific case.

Both of the above approaches apply methods external to the basic clinical encounter in order to incorporate more of that which was excluded by the positivist scientific ideal (e.g., EBM). This is the case both in the ‘humanistic approaches’ which add elements to take the patient’s narrative or experience into account, and in approaches that apply other – more agile – kinds of scientific methods in the shape of ‘medical decision-making’, Bayesian reasoning, or artificial intelligence systems.

Taking all of the above on board, some authors go full circle and return to the notion of clinical judgement, the concern over which lay at the heart of the attempts to clean up clinical practice sketched above. In its new version, clinical judgement is reclaimed as an approach capturing clinical experience and the values and virtues of medical practice without distancing itself from scientific methods and the use of EBM guidelines. It does so by recognizing the contribution of scientific – including automated – decision procedures, but at the same time stating that there remains an irreducible element of weighing facts and evaluating uncertainties that calls for a particular virtue of practitioners (Montgomery, 2006; Upshur & Chin-Yee, 2017). This is that, while we can support and improve clinical practice by way of science – just as we can in cycling or cooking – there remains an elemental tacit dimension without which we cannot understand medical practice, let alone practise it. The solution to messiness is thus located in the clinic, within the individual practitioner, as a form of tacit know-how in dealing with a whole (Montgomery, 2006, p. 30; Polanyi, 2009 [1967], 2013 [1958]). Different accounts denote this form of knowledge as ‘virtue’, ‘judgement’, or ‘phronesis’ respectively (the latter drawing on the ancient Greek concept of practical reasoning in moral judgement or medicine (e. g., Braude, 2017)), indicating a sort of clinical X factor that allows the doctor to determine and weigh epistemic significance (as well as to act in the patient’s best interest); thus solving the problem of navigating the Scylla of overly generalized science and the Charybdis of idiosyncratic care.

2.3. Shifting focus towards practice-oriented laboratory epistemology

While laboratory tests, as a paraclinical guarantor of scientific rigour, have taken on an increasingly prominent role in medical practice (along with quantitative methods from EBM), the laboratory is presented differently in science studies, as a place of explorative inquiry and tinkering, and this allows for a more nuanced account of messiness. Approaches to scientific methods may – courtesy of science studies – be seen as having completed the opposite journey to that of medicine in the latter half of the twentieth century. Medicine was seen as practical, uncertain and tinkering, but ideals of a positivist science and statistics were applied to clinical practice in an attempt to make practitioners adopt more rigorous, quantitative methods. Meanwhile science – in its idealized positivist form – was seen as exact, rigorous, quantitative and unambiguous, and taken as a model by philosophers of science; but science studies revealed the centrality of tinkering and uncertainty in scientific practice. We take on the insight that the idealized, rigorous scientific methods that were supposed to get medicine out of the mess – through experiments or trials – have been shown to rest on practices that are themselves messy (notably Collins & Pinch, 1993).

In our attempt to address messiness in diagnostics, we locate the epistemic work in the clinic as do the proponents of phronesis and clinical judgement, but we follow the recent practice turn in philosophy of science (Soler et al., 2017). We thus move beyond the notion of an ineffable ‘X factor’ of the clinician towards concrete practices of the clinic, shared among clinicians, in which the act of navigating attention and calibrating openness in uncertain epistemic situations is taught as codified tools of attention.

In philosophy of science and science studies, it has been clear for the
past 50 years or arguably longer that decisions in complex and messy situations – such as determining which factor of a conjoined experimental and theoretical set-up gives rise to an errant data point – cannot be resolved by rigorous application of logical methods. A curious similarity exists between the notion of phronesis or clinical judgement in medicine and the classic account by philosopher of science Pierre Duhem, who envisaged a ‘scientific X factor’ – the ‘good sense’ – that allows the scientist to judge between two theories, both of which are consistent with the data, and thus to progress from a state of indecision (Duhem, 1991, pp. 217–218 [1914]). The ‘good sense’ unites – according to Duhem – the best from two modes of doing science: one rich or cluttered with concrete detail and prone to ad hoc explanations and corrections (close to old-fashioned clinical practice), and the other systematic, logical and simple, but prone to stiffened logic (akin to EBM or logical decision-making). Duhem’s ‘X factor’ – like clinical judgement – thus balances intuition and logic to determine what is important. And just as clinical judgement is meant to be trained by experience and case studies, the ‘good sense’ is honed by studying history of science, and is described as a personal virtue of an ideal scientist (Ariew, 2020; Ivanova, 2010). While Duhem may offer a framework in explaining how scientists take decisions when logical reasoning falls short, his ideas were followed by scientists shifting focus from virtue and methodology to practice. It is the latter we draw on.

We thus echo Miriam Solomon in noting that medicine has often adopted a positivist notion of science, emphasizing objective observation, logical rules, and the application of general mechanisms to specific cases, while underplaying the insights from science studies that science is also a messy practice – a practice characterized by tacit, social and contextual assumptions (Montgomery, 2006; Solomon, 2015, pp. 7, 11 and 17). Such a positivist view of science and medicine risks overlooking key aspects of scientific inquiry. We will therefore draw on the scholarship from science studies with its focus on daily epistemic practice (e.g., Landecker, 2018; Rheinberger, 1997, 2010; Schickore, 2020; Schickore & Hangel, 2019) to look at ways in which medical diagnostic practices employ pragmatic procedures in the clinic. These everyday practice procedures constitute, we propose, a main tool for navigating the messiness of the diagnostic situation.

We draw in particular on Hans-Jörg Rheinberger’s practice-based conceptualization of science. He captures everyday scientific practice not by critically ‘outing it’ as messy, but by attempting as a scholar and ex-practitioner of science to understand how science proceeds in the changeable, messy reality of the laboratory. Messiness in determining significance – and its concomitant consequences of occlusion as well as openness – is one of the central themes in his work. Most famously perhaps, this is captured in Rheinberger’s notion of epistemic things, but it is also at play in his less elaborated metaphor of spiderweb methods for laboratory practice, to which we return in section 3.2 (Rheinberger, 1997, 2010). The notion of the spiderweb helps us understand how basic practices in the clinic support the navigation of mess by negotiating a balance between solution-oriented inquiry and opportunities for unexpected finds. These practices, as we show in the next section, are procedures that operate both to minimize mistakes and to intentionally keep inquiry open and flexible. We argue that these practices already incorporate and address many of the concerns motivating the movements sketched above: they calibrate the scientific instrument that Feinstein saw the doctor as; they allow openness and pragmatism akin to the scientific openness emphasized by Berwick; they capture the breadth of different kinds of clinical experience; and they pragmatically weigh up different diagnoses. Summing up, we draw on a view of science that includes messiness, but tries not to leave the navigation of it at a ‘good sense’ or an X factor of clinical judgement.

To get at concrete practice, we look at clinical procedures as described in guides and textbooks – used when introducing new practitioners to clinical life – and thus we focus on tools of attention that, despite aiming towards tactility, are made explicit in clinical training.

3. Tools of attention in diagnostic practice

In the clinical encounter, a broad range of activities and procedures are in play. Considering just the diagnostic element, the patient tells the doctor about their complaint, the doctor examines and orders tests or refers the patient onwards in the system, and the doctor and patient discuss different possibilities and courses of action, aiming to bring them both closer to an understanding of the ailment, with the goal of treating or relieving the patient. In all these elements there is a multitude of possible directions to take, details to focus on, details to leave out, and interventions to try.

For practical purposes, the content of the clinical encounter has been structured into sections deriving from those used for taking a medical record, known as SOAP notes or chart (Podder et al., 2021) also referred to by Charon (see section 3). This structure is meant to ease information transfer between practitioners, but also helps structure the clinical consultation into four elements. First, (S) taking Subjective accounts; typically accentuated in the first part of the consultation, where doctors talk to patients and gather details about them, including their chief complaint, their symptoms and their history – medical, family and social. Then follows (O) Objective observations, which range from direct impressions of the patient (e.g., complexion – pale, reddened, etc. – or voice tonality), over observations made from physical examination (e.g., body temperature, heart rate, knee stability, or pain response), to clinical tests (e.g., urine dipsticks or blood tests). The assessment (A), is based on both of the prior parts, including differential diagnoses – to which we return in section 3.2. And last (P) the plan sums up the actions to be taken such as referral, further tests, treatments or waiting. The final two elements often involve the clinician sharing their analysis with the patient and obtaining consent or agreement from the patient about the next steps of the plan (to which we return in section 3.3). While not unchallenged (e.g., Lenert, 2016), SOAP notes function as the dominant model for documentation of a medical consultation, and it is the practical teaching tool that medical students follow when they first learn how to conduct a clinical consultation (Bowen, 2006).

We draw on this model to situate the procedures we consider to be tacit strategies of constrained openness, that is, tools of attention, in diagnostic practice. It is perhaps worthwhile to note that while the model entails progression between the elements, and the narrative of the medical record will take this form, there is not necessarily such neat temporal separation between the elements in the actual clinical encounter.

3.1. Strategy one: casting a web through structured anamnesis

In accounts of clinical reasoning as well as in clinical guidelines, the notion of information gathering – anamnesis and examination of the patient – is emphasized as a fundamental diagnostic step (e.g., Guyatt et al., 1992; Hunskär et al., 2014; Thompson & Upshur, 2018). This typically involves (1) taking the patient history, (2) conducting a physical examination, and (3) ordering tests (see also Balogh et al., 2017).

4 This ties into a classical and debated distinction between symptoms and signs which we will not discuss here (for the distinction see King, 1968; also Podder et al., 2021; for discussions see for example Eriksen & Riser, 2014; Reiss & Ankeny, 2022). A similar account of medical practice is found in the Oxford Handbook of Clinical Medicine with a distinction between ‘history’ and ‘examination’ (Wilkinson et al., 2017).
5 For a qualitative example of this structure in the clinic see Scott-Fordsmann (2022).
6 Other ways of dividing up the clinical encounter exist, e.g., in discussions of clinical communication (see Kurtz & Silverman, 1996, p. 85). However, we have found that the SOAP note division helpfully conveys the points of this article.
7 For a more historical approach to anamnesis which emphasizes its central role in medical knowledge, see Tybjerg (2023).
inquiry and need not be an anamnesis, examination and testing is navigated through structured openness towards sources of significant, but unforeseen information (e.g., Hunskær et al., 2014). One particular worry in modern medicine is that clinicians move on to ordering tests before having ‘cast a wider web’ that can determine the best type of test and could help interpret test results (Balogh et al., 2015). Thus, clinical teaching books and guidelines also emphasize – repeatedly – the importance of maintaining openness towards sources of significant, but unforeseen information (e.g., Hunskær et al., 2014, p. 72).

We argue that the ‘mess’ of potential information overflow from anamnesis, examination and testing is navigated through structured inquiry with inbuilt encouragement to broadness and openness that codify a procedural openness. This occurs in two ways.

(1) As part of the guideline for S (the so-called subjective element) – gathering the patient’s history (anamnesis) – there is a subdivision that lists the types of information that practitioners should inquire about. For example, beyond ‘chief complaint’ and ‘history of current illness’, there is an emphasis on the broad medical, social and family history, as well as a general review of bodily functions – such as recent weight change, changes in agility, pains, fatigue or changes in digestion. This ensures that symptoms that the patient may have deemed unimportant or embarrassing are ‘captured’ and can be noted (Podder et al., 2021). Similarly, baseline observations and examinations, such as vital signs or observations about posture, movement, or pain response, are performed and recorded as a standard part of ‘O’ (for objective). It is worth noting here that the kind of openness suggested here might be seen already to cover the kind of attention to patient narratives and experiences suggested by humanities scholars. These thus form part of the SOAP practice and need not be an addition to it in a ‘Parallel Chart’ (see section 2; Charon, 2006; Spencer, 2017).

(2) Several instruction books emphasize the importance of not ‘cutting patients off’ and of allowing them to share openly – even if on first instinct the clinician suspects what they say will be irrelevant – as well as checking back in towards the end of the consultation to allow ‘late additions’ (e.g., Hunskær et al., 2014; Saxtrup, 2019). That is, keeping inquiry – particularly the patient’s contribution – open throughout the consultation, as crucial information may come unexpectedly late (such as information not initially deemed relevant or ‘embarrassing’ information, e.g., change in digestive flow or unprotected sex).

We think of the first aspect as casting a web, ensuring broad orientation; and of the second as allowing the phenomenon at hand to unfold by not interrupting, and by maintaining continuous sensitivity and returning to information gathering throughout the consultation. That is, the main feature of these strategies is to ensure inclusivity and openness – including the kinds sought by humanities scholars and by scientists with an eye to scientific discovery.

3.2. Strategy two: calibrating through anchoring and adjusting

Moving from information gathering into analysis and towards making a diagnosis is a task suspended between two challenges: the need for grounds for action, and the frequent lack of certainty. In particular, doctors cannot wait till the phenomena under investigation have run their course. And while Kennedy makes the point that there are good epistemic (and ethical) reasons to suspend judgement (Kennedy, 2013) to avoid overlooking important symptoms or options for testing, or performing potentially harmful treatments – a lack of judgment may be just as harmful, and inconclusivity or ‘starting over’ is highly undesirable. As phrased by R. Paul Thompson and Ross E. G. Upshur, we cannot expect a diagnosis to be based in justified true belief to the same degree that we demand of scientific findings; rather, we must rely on ‘pragmatic belief’, that is, ‘belief that provides sufficient ground to take action’ (Thompson & Upshur, 2018, p. 131 referencing Kant’s Crítica of pure reason; see also Stanley & Nyrop, 2020, p. 163).

Notably, it is not only a matter of acting on incomplete knowledge, but also of acting on a host of signs and symptoms the relevance of which we do not know; of acting within a situation which is simultaneously supersaturated, under- and overdetermined. Uncertainty in epistemic significance expands from matters of where to look for information, to questions about which information to attach significance to, and how. Thus, while there is a need to maintain openness, there is also a need to restrict openness sufficiently to provide grounds for action.

In this process, we want to highlight the notion of differential diagnosis – the task of organizing signs, symptoms and test results into a list of all possible diagnoses that could explain these, with the aim of making decisions as to prognosis, possible treatment options, and/or helpful further tests (Jain, 2017; Kennedy, 2017; Scordo, 2014). From such a list, information already at hand can be given meaning, and new or more specific paths of inquiry or treatment strategically chosen. The differential approach ensures a fundamental alternatives-approach in medical reasoning. It maintains, as medical doctor Bimal P. Jain notes, not only a view of what is the most likely explanation, but also of which more unlikely illnesses should be considered, if the case is urgent, the possible consequences severe, or progress wanting (Jain, 2017). Importantly, just as the circumstances in which clinicians operate are dynamic, so, in this approach, is the process of diagnosis. Nursing scholar Kristine Anne Scordo calls this epistemic strategy ‘anchoring and adjusting’ (Scordo, 2014).

While ‘probabilistic reasoning’ (as described in section 2) is important, considerations reach beyond mere prevalence. For example, for a patient presenting typical symptoms of bladder infection and reporting a positive outcome of treatment in two prior infections in the past year, the most likely diagnosis will be cystitis. However, while unlikely, such frequency of infection can also be a sign of underlying diabetes, a condition that can be severe if untreated, and thus prioritizing the ruling out of diabetes may be clinically warranted, both because of severity, and because testing for this is relatively easy, risk free and inexpensive (i.e., performing a urine dipstick test). Clinical recommendations thus stress the importance of evaluating the need for further inquiry into diagnoses in respect to (1) likelihood (probabilistic), (2) seriousness if untreated (prognostic), and (3) responsiveness to treatment (pragmatic) (Guyatt et al., 2008). As more information comes in – from time passing, and from the effects of lines of inquiry chosen – both the list and the approach are adjusted, and the inquiry thus remains both actionable and

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8 In general practice this is emphasized as a strategy for locating the ‘real problem’ that brought the patient in. Typical cases in the literature include young patients first listing minor concerns, and only towards the end asking for an STI test. For such cases, it is often noted that studies show better results when doctors do not interrupt patients (e.g., Hunskær et al., 2014, p. 73).

9 This is sometimes captured by characterizing diagnostic reasoning as based in abduction (Stanley & Nyrop, 2020) or inference to best explanation (Stengenga, 2018). And the provisional character of any diagnosis is stressed by philosophers (Thompson & Upshur, 2018), as well as practitioners (Balogh et al., 2015).
open. Such multiplicity of ‘input’ is recognized in for example Bayesian reasoning (see section 2; also Kennedy, 2017), and – like the contemporary clinical judgement literature – we recognize the importance that tools such as Bayesian methods can play. However, what we are after here is the ‘doings’, the procedure of anchoring and adjusting, more than the modes of reasoning; not knowledge statements or algorithms, but ‘systems of practice’ (Chang, 2017). That is, we suggest that medical practitioners navigate mess, in part, by anchoring in one point of particular salience, while maintaining sensitivity to the unexpected through continuous awareness of alternatives, and by ongoing adjustment in the face of new information. They thus create a dynamic looping between analysis and information gathering – or in terms of the SOAP model: A → SO (where A is the Assessment).

Thus, clinicians cast a broad web through open anamnesis, expanding the field of inquiry (as per section 3.1) – and then sharpen focus and sensitivity through the use of diagnostic lists, helping them navigate epistemic significance, and setting up threads of inquiry that ensure sensitivity. We should note here that the risk of course remains that the web is set up wrongly from the beginning – and in fact, it seems that one of the most decisive factors determining whether patients will end up with a correct diagnosis, is whether or not that specific diagnosis occurs in the initial list of differential diagnoses (Scordo, 2014). This, however, is why procedures such as those mentioned in section 3.1 are in place to ensure proper orientation before the ‘first anchor’ is cast.

3.3. Strategy three: synthesizing and re-sensitizing through shared decision-making

The third strategy we want to highlight is tied to the move from analysing (A) towards planning (P), and the looping back to still further information gathering (S and O) and continued anchoring and adjusting. Typically, at the end of a consultation, the clinician will summarize the findings and important information that have gone into that particular analysis, as well as possible courses of action, sometimes recommending a specific course of action, and sometimes asking what the patient would prefer (‘explaining and planning’ in Kurtz & Silverman, 1996; see also Hunskåar et al., 2014, p. 72). This is often framed as an ethical issue and a communication tool that empowers the patient, establishes trust, and ensures patient understanding and compliance (Charles et al., 1999; e.g., Whitney et al., 2004), as well as a preventive measure to protect the doctor from malpractice suits and patient complaints (Posner et al., 2015). We suggest that this shared open summary and discussion of options and evidence – shared decision-making – also holds an epistemic role and does so in two ways.

(1) The vocal articulation itself affords processing and integration of pluralistic evidence. Studies from cognitive psychology indicate that explaining something to others – or to oneself – supports a more detailed and systematic engagement with the evidence at hand (Williams & Lombrozo, 2010). In making the diagnosis, clinicians must draw together a vast amount of widely different types of evidence – tests, images, patient accounts, medical examinations (sound, sight, smell, touch), and even then, the step from information selection to plan requires incorporating uncertainty about variability and individuality of the patient as compared to the groups investigated in scientific studies, as well as patient preferences and expectations. For example, while evidence suggests equally good (but uncertain) outcomes of surgery for two patients – one being a single mother with no social support system, and the other having few commitments and family members ready to assist – the rest period demanded after surgery may mean that this is not the right solution for the first patient, but desirable for the second. Processing and integrating all these aspects can require cognitive scaffolding. While literature on decision-making already addresses cognitive support through particular algorithms for reasoning (e.g., Kennedy, 2017, p. 389), we highlight the practice of speaking with the patient as an act of integration. Sharing the analysis in the clinical encounter provides an occasion for the doctor to go over all the various evidence, sort it in a meaningful manner, and articulate explicit reasons for including or excluding certain findings or options – even if no coherent explanation is found.

(2) This sharing of the analysis also provides an opportunity to check that crucial information has not been omitted. The patient is invited to share their thoughts on potential worries about the analysis or add information that can alter the interpretation, for example by reminding the doctor of symptoms that have been left out, or by providing further information if the patient suspects something of relevance has not yet been accounted for or considered. For example, they may add information about practical circumstances (e.g., being a single mother), or they may find something in the analysis at odds with their experience (e.g., the doctor may emphasize the presence of stomach pains, and the patient may object that the stomach pains only came after other, more dominant, symptoms). That is, the sharing of information serves as a fixed point for feedback from the patient, particularly with information that potentially conflicts with the analysis or treatment direction suggested by the doctor. Thus, it provides the opportunity to reopen inquiry even in the final phase and serves as a quality assurance of the epistemic work of the physician.

Summing up, we take the abovementioned procedures to be pragmatic, codified procedures that support clinicians in navigating mess and in directing and maintaining orientation towards epistemic significance. First, the initial anamnesis and examination enable clinicians to cast a wide web and maintain sensitivity through active listening and continuous information gathering. Second, the technique of differential diagnosis allows the clinician to find paths of meaningful action through anchoring and adjusting. And thirdly, the shared decision-making – that is, the sorting and integrating of information that takes place when the clinician articulates their medical explanation, and the re-recruitment of the patient as a quality assurance partner – guards against having omitted important information. None of these three strategies provides a failsafe mechanism, however, and as we shall see, this is not the intended aim of these strategies. For the remaining part of the article, we want to discuss how we might conceptualize these practices as epistemic procedures.

4. Understanding tools of attention as spiderweb strategies

By paying attention to practices, we note that the diagnostic process in medicine shares the use of procedures for calibrating and restricting openness with the laboratory sciences in ways that the idealized positivistic image of science leaves out and cannot account for. To make better sense of these practices as epistemically relevant, we thus turn to recent epistemological studies of the laboratory and in particular to Rheinberger’s work on experimental biochemistry. In this work, lab-}

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10 We recognize that a broad notion of ‘modes of reasoning’ can include practices, and conversely that in a narrow reading of reasoning, a more cognitively loaded notion would still be part of Chang’s ‘systems of practice’. However, our point here is not to exclude or deny the role that Bayesian reasoning can play in the clinic, but to foreground socially engrained and much less technical everyday clinical practices.

11 In fact, one of the recurrent critiques of the SOAP notes model, is that it fails to formally recognize this reflective fluidity between the elements (Lenert, 2016).

12 We use this term – ‘shared decision-making’ – in a very broad sense to capture the sharing with the patient of information and possible actions, as well as reasons for these. We are aware that this term is disputed and discussed in philosophy of medicine. For a brief introduction to this, see Kennedy (2017, p. 389).

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metaphor which he introduces in his description of tacit and embodied elements of experimental practices in biochemistry (Rheinberger, 1997, pp. 77–79). Rheinberger invokes the notion in his book on protein synthesis to frame strategies for ‘measured sloppiness’ (referencing the biophysicist Max Delbrück for this notion). The term covers a set of learnt laboratory procedures which function as tacit strategies to ensure a balance between focus and openness, between the act of rigorous examination and sensitivity towards the unexpected.

4.1. Organized groping and spiderweb strategies in Rheinberger’s laboratory studies

For Rheinberger, an indispensable part of exploratory laboratory science is what he calls ‘feeling one’s way’ – an organized ‘groping and grasping for difference’ (Rheinberger, 1997, p. 75). This, he says, is an ability that comes with *Erfahrung* (‘expertise’, as distinct from mere experience) (Rheinberger, 1997, p. 77), meaning that the more one has groped around, the more acquainted one is with the pragmatics and intuitions of effective groping, so to speak. This is similar to the idea of *clinical judgement*, as an idea of managing diagnostic messiness through some accumulation of ineffable knowledge situated in the practitioner. However, Rheinberger then continues to say that even if this ability improves with experience (i.e., *Erfahrung*) and is to be understood as a tacit – that is, implicit – component of epistemic work, it does not mean that it is in principle ineffable. Rather, he points to a set of *principles* which are not necessarily known as such to the practitioners (they are subsidiary), but which are performed as a habitual element of experimental protocol (Rheinberger, 1997, p. 78). And this set of principles – we assume – he takes to be responsible in large part for effective ‘groping’. In this move, Rheinberger’s text seems to slightly conflate two types of tacit knowledge: (1) on the one hand, tacit, ineffable groping abilities (personal), embodied in the practitioner with time and practice, as it were, tied to the notion of *Erfahrung*, and on the other hand, tacit, culturally prescribed practices, which are not placed in the practitioner, but rather as procedures which can – if attempted – be formulated into principles of practice and more readily transferred to new practitioners or distributed between practitioners. Where the philosophical medical literature has picked up on the first strategy (personal skill) for navigating messy epistemic situations, we focus on the second: on the culturally prescribed practices (the procedures) that help practitioners to find their way in daily practice and to balance openness and focus as they evaluate epistemic significance.

Rheinberger offers three examples of tacit epistemic procedures, or strategies in biochemistry that he analogizes as a spider’s web, that is, as sensitizing filters: (1) *The symmetry principle*: ‘testing all possible combinations of different components within a multicomponential assay’; (2) *The homogeneity principle*: to ‘never change the batch of [prepared cellular compound] within a single set of experiments, and always repeat the last assay when you try a new batch’; and (3) *The exhaustion principle*: to ‘never leave out one of the compounds because you think it does not work anyhow’ (Rheinberger, 1997, p. 78). These, we understand, are tacit in the biochemical laboratory in the sense that they are not explicated as rules or justified when employed (or even formulated as principles) but passed on from one generation to the next – ‘learnt through action’ (ibid.) – as part of how you set up an experiment, unarticulated best practice principles that you simply always abide by. Importantly, the principles that Rheinberger brings out are principles of actions; things that biochemists do (rather than ‘methods of justification’) that are cast like a broad spider’s web, ‘meshed in such a way that unknown and unexpected prey is likely to be caught’ (ibid).

Taking up the spiderweb metaphor, Rheinberger argues that these practices are set in place like a spider’s web to create a mesh fine enough to capture elements that the researchers did not foresee, and flexible enough to allow dynamic exploration, supporting a pragmatic direction of attention (Rheinberger, 1997, p. 78). It thus creates conditions for serendipity, that is, sets up circumstances that allow the scientist to anticipate and explore unexpected (‘lucky’) findings (Artini et al., 2020; Copeland, 2019). In the spiderweb metaphor, the scientist (for Rheinberger) or the doctor (for our purposes) attempting to navigate complex and messy realities would be the spider navigating an uncertain world, ready to respond to vibrations. The spiderweb strategies – to Rheinberger, the best-practice epistemic procedures of the laboratory – become an extended perceptive organ of the spider/scientist/doctor; a ‘materialized and exteriorized system of imagination’ (Rheinberger, 1997, p. 78). That is ‘the web must “see” what the spider is actually unable to foresee with its unaided senses’ (ibid.). To do this job, Rheinberger adds, ‘the web must not become too rigid’ (ibid.). The strategies should – like a spider’s web – be malleable to a variety of contexts and bendable to forces of the situation. While the procedures function as baseline, they should not be thought of as firm grids; their role is that of ‘connivance rather than stubborn rigor’ (ibid.); they are extensions of the senses, invoked to indicate points of interest, not to mechanically sieve through input. At the same time, the web should have the properties of a mesh, as opposed to a catch-all, to avoid supersaturation; allowing some things to pass at least. In the laboratory, a web too finely meshed will have the scientist unproductively suspending belief and following every possible line of inquiry (potentially infinite). In the clinic – even worse – this would amount to unnecessary suffering, or even the death of the patient, before appropriate action can be taken. Hence, inquiry – as marked by spiderweb strategies – should employ tacit protocols for calibrating openness (the web) to ensure the possibility of noting the unexpected, but also provide grounds for reasonable action and further inquiry. It should set up a web which is not so loose that nothing sticks, yet not so finely meshed that it captures everything. Following Rheinberger’s focus on and account of standard practices or procedures for calibrating openness, we frame the practices described in section 3 as epistemically valuable because they make up part of the spiderweb that allows clinicians to navigate messiness in diagnostic work.

4.2. Spiderweb strategies and diagnostic practices

It might seem odd to compare tacit principles of practice from laboratory science to practices of clinical diagnosis. The two fields are different, for instance in the aim of the epistemic effort. Biochemical laboratory science seeks to gain knowledge of biological processes with the aim of articulating scientific knowledge, while clinical practice tries to uncover the pathologies of a patient with the aim of alleviating or preventing suffering. This means that a scientific experiment gone wrong or being inconclusive will be ignored, while a patient receiving the wrong treatment must be investigated and errors reported. Further, scientific activities can often (though not always) be put on hold as other options are investigated, or judgement can be suspended while scientists attempt to recreate unclear findings or perform further tests. In the clinic, patients tend to suffer or deteriorate if a practitioner remains...
indiscrete. Hence, the immediate risk may be higher in medical practice, and equally so the time pressure and the requirement to be productive, although – as we indicate further down – neither risk nor pressures are absent from the laboratory. However, we still think there are grounds for comparison between the settings as they both consist of concrete, epistemic circumstances within which epistemic significance is messy and the practitioner operates on the basis of targeted examination and practice protocol.\footnote{See also Müller-Wille & Kronfeldner, 2011 who link investigations of biological experimental practices and diagnostic practices, although they do so, they do it to discuss causality.}

While we highlighted three strategies from the clinic and Rheinberger notes three principles from biochemistry (symmetry, homogeneity and exhaustion), we do not wish to draw parallels between the individual strategies/principles. The argument of this article is not that the clinic and the laboratory are identical enough to draw on the same principles, nor that there exists universal or generalizable principles for navigating mess in any epistemic situation. Rather, we argue that the function of the procedures noted by Rheinberger, and of the strategies highlighted by us, is shared across the clinic and the laboratory. In both contexts mess may be navigated through spiderweb strategies, that is, practices that aim at calibrating openness and allow for a serendipitous potential, while providing grounds for action, rather than delineating the situation to eliminate mess. We draw on the spiderweb metaphor to make sense of the three clinical strategies as follows. First, the anamnesis and initial examinations ($S + O$) cast a broad web and ensure that the clinician becomes sensitive to disturbances in areas that may seem fringe at first. Further, the continued openness provides the flexibility of the spiderweb. Second, to navigate ‘within the web’ so to speak, clinicians employ anchoring and adjusting ($A \simeq SO$), allowing them to ‘go to’ the place in the web that most urgently calls for attention, while keeping an awareness of the rest of the web (other diagnoses). Third, moving towards a plan (P), clinicians share their findings in order to regain the overview. This pausing to explain and synthesize the layout of all the disturbances in the web also reopens the analysis to further input, even as the conversation narrows around one or several conclusive target points in the web and the concrete actions that can follow. All of this increases the chance of successful inquiry in messy situations – what Rheinberger denoted ‘organized groping’.

Some principles may be seen as shared across the laboratory and the clinic. For example, we could say that the use of anchoring and adjusting (differential diagnoses) – prescribing possible alternative routes – relates to Rheinberger’s ‘symmetry principle’ in that it provides an overview of a whole set of options, although in the case of the clinic, testing all possible combinations is ethically and economically inadvisable. It may also relate to the ‘exhaustion principle’ in that it encourages clinicians to include rare, and thus unlikely, conditions in the evaluation of the patient. However, these are not the most helpful ways to make sense of the medical practices, and the argument we want to put forward in this article is a higher-level argument about the usefulness of looking towards concrete practices for calibrating openness and action in the face of messiness.

Returning in brief to the approaches suggested in the existing literature on reaching a diagnosis in the clinical encounter (as laid out in section 2.2), we note that our focus on tacit, pragmatic practices does not conflict with them. In fact, aspects of what the approaches aim to do are reflected and – we argue – partially addressed in the pragmatic procedures for daily practice that we have discussed. First, we find that the humanistic approaches calling for a renewed focus on patient narratives and experience as a countermove to the threat of scientification of medicine, are warranted. However, while Charon suggests adding a separate category to the standard SOAP model (Charon, 2006), we suggest that this openness already exists in the clinical practice of anamnesis that casts a broad web at the beginning of the process of inquiry – as well as in the final summaries in consultations, where clinicians re-sensitize their assessment to input from the patient. Second, approaches based on probabilistic reasoning – which encompasses uncertainty in probabilities – are closely related to the practice of collating lists of differential diagnoses. Proponents, especially of Bayesian reasoning, recognize that the process of assigning probabilities and calculating the likelihood of different diagnoses is rarely followed explicitly by doctors, and that choices to investigate particular diagnoses are also based on other factors such as ruling out diseases of high risk (Kennedy, 2017). We have suggested taking the acknowledgement of informality a step further: directing attention less to reasoning and calculation, and more to concrete, pragmatic practices (e.g., making lists and choosing and adjusting). Finally, concerning the idea of clinical judgement as an internal $X$ factor of the doctor – or in the section on Rheinberger an ineffable Erfahrung of the practitioner – we argue again for focusing more on practices. While recognizing the role of tacit skill, we suggest that clinical judgement can – at least in part – be understood as existing as codified spiderweb strategies exactly in the practices we describe. So, we propose that philosophers concerned with messiness in medicine turn their attention more to situated practices and basic ‘principles of practice’ as already taught in guides and handbooks. This is instead of looking, as humanistic approaches do, to add something to the daily practice of medicine, or of attempting to encompass the whole of clinical practice in probabilistic reasoning; and indeed to avoid relying too much on an elusive form of clinical judgement or $X$ factor internal to the practitioner. It was suggested to us that the highlighted strategies may work as ‘scaffolding strategies’ (originally coined in Wood et al., 1976) for learning to navigate messiness in the clinic – the implication being that once the appropriate expertise or phronesis has been built up, the external practice-based strategies can be abandoned. While it may be true that we can think of spiderweb strategies as ‘supportive’ or heuristic in creating knowledge (i.e., finding the diagnosis), and they could thus be considered scaffolding for the individual patient cases, they are in fact central to the epistemic practice as such: the practices we have described should be a consistent part of the epistemic encounter, whether in the clinic or the laboratory – and should be maintained throughout the lives of the practitioners, whether scientists or doctors. While the practices may become more flexible with experience, for example, the detailed anamnesis may be more spread out over the encounter, or the summary at the end may turn into more of a conversation than an explanation, they are not made superfluous. And while some clinical encounters may shift from a ‘messy encounter’ to a ‘clear case’, the clinician will still need to employ these strategies in messy encounters. Clinicians who abandon these practices with the justification that they now have the expertise to navigate and know the answers without taking a proper anamnesis or making a list of possible differential diagnoses would be considered arrogant and, potentially, a danger to their patients. Hence, we resist the ‘scaffolding’ terminology for the role of the practices in terms of navigating messiness (although we do use it for the cognitive role of vocal articulation in shared decision-making, see section 3.3).
strategies for navigating messiness in terms of epistemic significance in the sense that they are not articulated as strategies for this. In fact, while they are articulated, this is as codified pragmatic practices – memorizable, and often in easy-to-remember acronyms so that they can be brought into the busy clinic, where justified epistemic strategies may fall by the wayside. Their articulation, then, serves a similar purpose to the habituated, tacit knowledge of skilled practice: to allow easy integration into epistemic actionability in a highly ‘messy situation’. SOAP is one example of an easily memorizable acronym, subdividing practices into steps. Another classical acronym is the ABCDE approach to acute patient care (Airways, Breathing, Circulation, Disability [neurofunction], Exposure [other injuries] (Soltan & Kim, 2016)). The acronyms serve both as teaching tools, to pass basic elements of practices on to medical students, and as a black-boxing tool for clinicians to easily recall and monitor that they have gone over all necessary elements. For example, when Scott-Fordsmand asked a doctor how medical records were taken, he replied ‘there are different types of records, but I always have the SOAP model at the back of my head’. Likewise, Scott-Fordsmand’s empirical work shows that when doctors were faced with disruptions such as horrific accidents or strong nauseating smells – or other messiness obstructing the workflow – thinking through guidelines enabled them to continue (Scott-Fordsmand, 2021). The codified practices – basic pragmatic actions in the shape of simple rules – rather than the hard-to-define clinical judgement or Erfahrenheit – help clinicians act and ‘get a grip’ on the situation, as it were. Codified practices thus do not just encourage openness, but also provide a safety net when the messiness becomes disruptive. Ironically, in this sense, having ‘recipes’ or ‘cookbooks’ is not an obstacle to acknowledging the individuality and messiness of the situation (as such is implied in the derogatory naming of EBM as ‘cookbook medicine’), but a tool that helps calibrate openness. Codified acronyms may rather be ‘cookbooks’, not as rigid mechanical instructions, but as procedural frameworks of practice, to guide and aid memory, not to control actions.

As already pointed out, medicine – more so than laboratory science – needs to act under uncertainty and under time and economic pressures. It also operates on a much larger training scale than laboratory science, with more doctors in training passing through and many doctors at work on the same patient case. The pressures of time, resources and fast turnover may contribute to the traditions of articulating and codifying ways of navigating more openly and pragmatically. However, these features are also becoming part and parcel of modern scientific life, and young scientists, in particular, are subject to similar pressures (Schickore & Hangel, 2019). Indeed, when focusing in on the everyday of the laboratory, the often-highlighted gap between the generalizing drive of science and the particularizing need of medicine diminishes. In both cases there is an inquirer attempting to understand the concrete puzzle in front of them, often under pressure to decide on the next line of inquiry. Looking at the codified medical practices and the way they are shared between practitioners might inform laboratory science in terms of more explicit recognition of protocols for dealing with uncertainty and of explorative approaches (a current issue as pointed out by Schickore and Hangel (2019). We might therefore end up not just taking insights from science studies to the clinic, but also taking insights from this analysis of clinical practice to laboratory science. The very open acknowledgement in medical practice of a need for pragmatic tools and procedures that deal with messy epistemic situations, resulting in easy-to-access guidelines, teaching books and rotas could serve as an example for scientific practice where these strategies are rarely articulated, as Rheinberger notes.

While discussions of messiness, as per medical knowledge creation, recognize that mess can take on both a disruptive and a productive role, the consensus – as we hope to have shown in sections 2.1 and 2.2 – seems to be that medicine struggles to handle it. In this article we have aimed to argue that while dominant discourses on the ideals of medicine have tended to model medicine after a somewhat sanitized image of science that has no clear way of handling messiness other than to eliminate it at great cost, medical practice – particularly diagnostic practice – already has an arm of pragmatic yet sophisticated ways of navigating messiness that do not depend on ‘translating’ it into ordered datasets or neat categories: daily pragmatic tools that walk the fine rope between allowing, on one hand, focused intervention, and on the other, openness and the potential to discover something we might not have been looking for – whether due to bias or to the complexity of the case. We suggest that looking towards these practices might, for philosophers of medicine, provide a pragmatic bridge between ideas of medicine as a science, and ideas that medicine is more than that in the shape of narratives, patient experience and clinical judgement.

We end up turning the problem on its head. Trying to understand messiness in clinical practice, we looked to the way messiness has been dealt with in the science studies literature which affords a fuller picture of scientific practice than does the positivist version discussed in medical contexts. But looking for the equivalent of the tacit laboratory practices – the practices in which Rheinberger located a pragmatic method of maintaining both openness and directionality – we found that such procedures not only exist, but are actually more codified, in medicine than in the sciences. Clinical medicine is, we argue, so overtly messy and complex, and the need to act and collaborate so pressing, that the ‘tacit’ practices are out in the open, and the equivalent to ‘learning the ropes’ in the laboratory is made explicit for clinical work. This final point bears out a general insight: that it is the messiest practices – such as clinical medicine – that yield the key to the pragmatic handling of messiness.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

Both authors wish to thank the Museion Research Group for comments on an early draft, as well as Thomas Bonnin for editorial support, and two anonymous reviewers for comments that improved the structure of the article substantially. Furthermore, Helene Scott-Fordsmand wishes to acknowledge the Carlsberg Foundation for funding during the editing phase of this article, and Karin Tybjerg wishes to acknowledge support from the unrestricted donation from Novo Nordisk Foundation (NNF18CC00034900) funding the Novo Nordisk Foundation Center for Basic Metabolic Research (CBMR).

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