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Protocols, practices, and the reproduction of technique in molecular biology*

ABSTRACT

Protocols are one of the main organizational resources in molecular biology. They are written instructions that specify ingredients, equipment, and sequences of steps for making technical preparations. Some protocols are published in widely used manuals, while others are hand-written variants used by particular laboratories and individual technicians. It is widely understood, both in molecular biology and in social studies of science, that protocols do not describe exactly what practitioners *do* in the laboratory workplace. In social studies of science, the difference between protocols and the actual practices of doing them often is used to set up ironic contrasts between 'messy' laboratory practices and the *appearance* of technical order. Alternatively, in ethnomethodological studies of work, the difference is examined as a constitutive feature, both of the lived-work of *doing* technical projects, *and* of the administrative work of regulating and evaluating such projects. The present article takes its point of departure from ethnomethodology, and begins with a discussion of local problems with performing molecular biology protocols on specific occasions. The discussion then moves to particular cases in criminal law in which defense attorneys cross-examine forensic technicians and lab administrators. In these interrogations, the distinction between protocols and actual practices animates the dialogue and becomes consequential for judgments in the case at hand. The article concludes with a discussion of administrative science: the work of treating protocols and paper trails as proxies for actual 'scientific' practices.

KEYWORDS: Ethnomethodology; social studies of science; laboratory protocols; forensic practices; expert evidence

The term 'protocol'derives from the Greek, originally referring to an early version of a table of contents: a leaf glued to the front of a manuscript, which adumbrates the contents. Contemporary definitions of the term include: a set of customs and regulations associated with etiquette or diplomatic affairs; an initial draft of a treaty; and a supplement to an international agreement. A more technical use of the term in analytic philosophy of science – 'protocol statement' or 'protocol sentence' – refers

British Journal of Sociology Vol. No. 53 Issue No. 2 (June 2002) pp. 203–220
© 2002 London School of Economics and Political Science ISSN 0007-1315 print/1468-4446 online
Published by Routledge Journals, Taylor & Francis Ltd on behalf of the LSE
DOI: 10.1080/00071310220133304

to an exact formulation of the sequence of procedures followed in an observation. Such a statement is supposed to describe the observational procedure without adding any interpretation.

Protocols also are perspicuous ethnomethodological objects. They formulate and instruct members' methods. Members compose protocols and use them to guide their own and others' actions. Moreover, members (and, in many hierarchical organizations, administrators) hold workers and their practices accountable to protocols. This paper focuses on protocols used in molecular biology, and also on police protocols that supply the evidential samples for molecular biologists to analyse in forensic laboratories. It should be clear from the discussion that protocols also have a place in countless other activities.

Analytic philosophers and sociologists have long held out the hope of using protocols (and related artifacts like rules, laws, plans, maps, propositions, norms, and programmes) as stable, reproducible, and adequate accounts of individual reasoning, social action, and social structure. This theoretical hope has to do with the advantages of treating orders of text as proxies for (or even privileged representations of) orders of lived activity. Unlike dispersed and recalcitrant orders of action, orders of text more readily afford the analyses and extrapolations favoured by accountants, managers and philosophers. Skeptics and disillusioned enthusiasts point to the tacit, informal, inchoate, and intuitive grounds of practice, which are never exhausted, or even touched, by the formulations in which such hopes are invested. Endless arguments between proponents of formalist and anti-formalist theories of language and action are familiar fixtures of philosophy and social science. The arguments and examples in this paper offer an ethnomethodological alternative to any formalist/anti-formalist opposition. The aim is to examine the relationship between protocols and practices, both as a topic of empirical study and as a theme that is explicitly used in particular settings for organizational and rhetorical purposes. This paper provides a brief glimpse of some of the ways in which protocols, far from reducing orders of lived activity to formulae, are themselves placed at the disposal of such orders.

PROTOCOLS IN BIOLOGY

In biology, protocols are written instructions that specify ingredients, equipment, and sequences of steps for preparing and analysing research materials. Unlike protocol statements, laboratory protocols are not limited to experimental observations, as they cover a broad range of genetic engineering practices. Molecular biologists tend to be less strict than positivist philosophers in their insistence on descriptive completeness and exactitude. Some protocols are published in widely used manuals, such as Maniatis et al. (1989), which was referred to as *The Bible* by some practitioners interviewed in the early 1990s (Jordan and Lynch 1992: 80).

Often laboratory scientists and technicians compile and circulate their own hand-written variants of standard protocols. Even these locally designed variants do not pretend to describe precisely what practitioners *do* when they attempt to enact the procedures the protocols formulate. Unlike positivist philosophers, laboratory scientists also are more attuned to the necessity to 'interpret' a protocol in relation to the context of its performance. This sense of the word 'interpret' is exhibited in a performance, much in the way a concerted musical performance 'interprets' a familiar composition. The original sense of the word 'protocol', as a written note or draft that adumbrates a more complicated text, has some relevance to the vernacular conception of protocols in biology, except that the relationship in question is not between a shorter and longer text, but between a text and a singular embodied performance.

Analogies with household cooking are often mentioned in connection with molecular biology, and these analogies work remarkably well. A lab is like a kitchen, with cabinets stocked with ingredients, drawers full of utensils, and countertops and shelves fitted with appliances for supplying water, washing glassware, measuring ingredients, heating preparations and venting fumes. According to the analogy, a laboratory protocol is like a recipe. It lists the ingredients, specifies measured amounts of each ingredient, and gives step-by-step instructions for combining them. Trends underway in biology also follow the path of the modern household: commercial firms supply packaged 'kits' in the manner of a Betty Crocker cake mix, and external services now supply the laboratory equivalent of fast food (complete with similar promises in trade advertisements for speedy delivery and a high standard of quality). Members of the 'family' (or, in the well-heeled household, the staff of domestic servants) no longer perform the labour; instead, anonymous machines and employees of service franchises perform the work.

Like a recipe, a protocol is a set of instructions that precedes its enactment. Although it is likely to be based on prior experience with the relevant procedures, a laboratory protocol is ideal-typical. Unlike the philosophical concept of protocol statement, a molecular biological protocol does not aim to prescribe the exact sequence of a particular performance. Like a recipe, a protocol often takes the form of a sketchy instruction which leaves considerable discretion about how it is to be 'followed' on any particular occasion. Consider, for example, the first two steps in a standard recipe for 'purification of closed circular DNA by centrifugation to equilibrium in cesium cloride-ethidium bromide gradients'

1. Measure the volume of the DNA solution. For every milliliter add exactly 1 g of solid cesium chloride. Mix gently until all the salt is dissolved.
2. Add 0.8 ml of solution of ethidium bromide (10 mg/ml in H20) for every 10 ml of cesium chloride solution. Mix well. The final density of the solution should be 1.666 g/ml (n = 1.3860), and the

> concentration of ethidium bromide should be approximately 600 μg/ml. *Note.* The furry, purple aggregates that float to the top of the solution are complexes formed between the ethidum bromide and bacterial proteins. (Maniatis et al. 1989: 93)

The recipe includes several more steps, which for reasons of length are not reproduced here. Without delving into specific details, we can begin to notice some ordinary features of its recipe version of practice

1. It picks up the action in the course of an ongoing project. Not only is the recipe as a whole broken down into constituent steps, it also implies that it is situated within other procedures. 'The volume of DNA solution' in the first step implicates prior procedures for extracting DNA from cells and placing the product in solution.
2. The description of the steps can be broken down into an indefinite number of sub-steps and contingent repairs that specify, for example, how exactly to *mix* the preparation so that 'all the salt is dissolved' (Step 1), or what to do if the final density of the solution in Step 2 is not 1.666.
3. The description contains numerous adverbial modifiers like 'exactly', 'gently', and 'approximately' which require judgments on the part of the practitioner that may or may not require further instructions in any given case.

These features of the description presuppose competencies on the part of practitioners. Some of the competencies can be said to be 'technical' in the sense that they require training and experience with 'techniques like this', whereas others have to do with comprehending ordinary language and applying it to a situation at hand. There is considerable interplay between understanding 'ordinary' terms like 'gently' and 'approximately' and developing local competencies that establish just what those terms mean for the technical task at hand. Some of the procedural requirements recall Garfinkel's (1967: 20–22) list of *ad hoc* practices (*viz.*, 'the etcetera clause', and 'enough's enough'), and while these terms have no specific reference to molecular biology, the competencies they gloss can be highly specific, not only to a science but also to a singular laboratory technique.

The recipe includes numerous cross-references to generic types and trademarked models of equipment, as well as types and amounts of chemical reagent. The mention of actions and quantities implicates a set of containers and measuring instruments. In other words, though presented as a discrete protocol, the recipe situates itself in the midst of an assemblage of competencies, materials, and other procedures.

DOING PROTOCOLS

There can be several reasons for writing a protocol, and for writing a protocol in a particular way. The obvious reasons are that writing enables

a procedure to be preserved, recalled, disseminated, and improved upon. If it is an especially effective protocol, it can be used to embody the collective wisdom of a community and improve the general quality of performance and product. Increasingly, in molecular biology, the writing of protocols is used for proprietary purposes: claiming priority and filing (or blocking others from filing) patents.

A familiar distinction is associated with the use of written protocols. This distinction comes into play with respect to a broad array of instructions, rules, guidelines, and formulae. It is the distinction between formal instructions and particular attempts to 'follow' them. The distinction should be familiar to anybody who has attempted to prepare a dish from a recipe, operate a new software program, or follow the 'troubleshooting' directions in an automobile owner's manual. In contemporary urban life, written instructions are everywhere. They cover an extraordinary array of commonplace and specialized practices. Especially when we attempt to do something new, instructions are a common source of complaint, ironic commentary, and practical remedy.

In social studies of technical work, the difference between protocols and performances is often used to set up ironic contrasts between idealized accounts of method and actual 'messy' workplace practices. Alternatively, in ethnomethodological studies of work, the difference is used to motivate investigations of the lived-work of *doing* technical projects.[1] The present article takes its point of departure from ethnomethodology, but with a particular twist. In addition to drawing attention to orders of singular practice that are glossed over by the ideal-typical instructions in protocols, this study examines organizational occasions in which the contrast *itself* – the contrast between protocols and actual practices – becomes thematic. The point of the study is to develop a critical ethnomethodological account of the production and reproduction of social order and, specifically, an account of the dissemination of laboratory discipline to the political culture of the criminal justice system.

REPRODUCING PCR

Protocols for widely used procedures like the polymerase chain reaction (PCR) are subject to endless variation, depending upon the specific aims of a preparation, the equipment and ingredients at hand, the degree of precaution felt necessary, and many other circumstantial considerations. PCR is ubiquitous as a technique for 'amplifying' DNA samples. 'Amplifying' in this context means greatly increasing the amount, and facilitating the analysis, of DNA in a sample. The story of the invention of PCR is very interesting and contentious (Rabinow 1996), but the technique itself rapidly became a humdrum feature of laboratory work in a broad array of fields. PCR is used in diagnostics, archaeology, population genetics, and forensic science, among many other fields. Although PCR is named and

patented, just how it is performed in any given instance depends upon which genetic patterns are of interest, how much sample is needed for available applications, and what consequences (including legal consequences) may arise from false-positive or false-negative results.

Partly because of the open-ended range of variation, it can be difficult and frustrating to develop effective PCR protocols. Standard tools, packages, and instructions are never completely tailored to singular applications. Even within the confines of a single laboratory, practitioners work out different sequences of steps (Jordan and Lynch 1992: 93). Some practitioners prefer to leave out specific precautions, while others prefer more elaborate checks against error and contamination. Practitioners freely acknowledge that their preferences often lack 'scientific' rationality, and are developed through local, and even personal, regimes of trial and error. In a playful way, they often speak of the 'black magic' (Cambrosio and Keating 1988) involved in getting the techniques to work, or when faced with continued failure they speak of 'PCR Hell' (Jordan and Lynch 1993: 170). No single formulation of the PCR protocol gives a precise description of the range of techniques performed under its name. Nor does it exhaustively describe the actions involved in a singular attempt to reproduce the technique. Practitioners also acknowledge that they have limited control over how the procedure works, and that efforts to contend with problems that arise from one performance to another of 'the same' variant inevitably result in further variations in performance. At times uncontrolled variations can lead to discoveries of new, and arguably better, ways to perform the procedure. Consequently, the dissemination of protocols within and between laboratories involves local rewriting, adaptation and tweaking. Even in the case of a named, patented, and commercially available protocol, the transfer of the technique from one application to another is as much a matter of dispersion and reinvention as it is of the diffusion of a stable technical object from one site of practice to another. Nevertheless, protocols have a central place in biology, as they are used for administering, criticizing, defending, and claiming ownership of workplace practices (Jordan and Lynch 1998).

Exchanges among practitioners in a biotechnology news group provide vivid testimony about the contingencies of protocol application. Strings of communications among participants textually preserve such communications. Take, for example, the following string addressed to a problem with using a DNA extraction method:[2]

A: *Hello, I was wondering if any one else has experienced this problem and if so, what they did to solve it.*

I am using a PCR-restriction digestion assay to genotype some blood samples, and I find that one of the polymorphisms is completely undetectable when I use the 'Nucleon' kit from Scotlab to extract the DNA, but when I take the same blood sample, boil for 15 mins, spin out the crud and use the supernatant, there is no problem in detecting this polymorphism.

I've done extensive experiments to ensure that it is not a variability in the PCR or digestion steps. And IT IS NOT.
Please can anyone help me??
Thanks in advance.

B: Hello
I had the same problem of PCR band disappearance after extraction of DNA from blood using Quiagen extration kit. In fact latter I read that Hemoglobine which some time contaminates samples is an inhibotor of DNA polymerase. And it's necessary to heat PCR mixture-samples at 94 C for 10 to 15 min prior addition of nucleotides and enzyme. When I did this, suddenly the bands appeared. So when you boiled your samples I suppose you distroy the hemoglobine and then your PCR reaction is good. In fact recently I shift from quiagen and I use a kit from DYNAL: Dynabeads DNA direct kit. It's very easy to use and I never had problem of PCR inhibition after DNA preparation. I even never need to boild my samples anymore.
Hope this can help you.

C: Hi:
I had a similar problem when I was doing microsatellite typing. Samples extracted with kits did not work so well as samples extracted with phenol. Even when I tested samples sent to me, some extracted with a different kit then mine, and some with phenol, the results were the same.

D: We have also had problems doing human microsatellite typing when preparing the DNA using the QIAGEN blood kit. Sometimes works, sometimes doesn't. After talking to QIAGEN, and trying many variations (at their suggestion), we still have problems with reproducibly preparing DNA that will amplify. We basically solved the problem by simply doing an ethanol precipitation of the QIAGEN prepared material. Add an hour to the procedure, but the DNA always amplifies now.

A's problem involves the use of a PCR kit to 'extract' (isolate and detect) distinct segments of DNA from the cellular chromosomes in blood samples. The word 'polymorphism' refers to a stretch of DNA at a particular locus on a chromosome, which is unusually variable in a human (or other species) population. Polymorphic alleles (alternate forms of a genetic sequence) are inherited, and so extracting and marking them is an extremely valuable tool for population genetics as well as many other scientific, diagnostic, and forensic applications of DNA profiling. When a particular polymorphism has been successfully isolated and marked, it shows up as a discrete 'band' in an autoradiograph (a display of the product of an electrophoresis procedure). The problem, as A describes it, is that a particular polymorphism fails to show up when the 'Nucleon kit'

is used, but it does show up when an alternative, more laborious, procedure is used. To pursue our kitchen analogy, the problem is that the 'cake mix' fails in certain respects, necessitating an alternative method for concocting ingredients 'from scratch'.

B offers two solutions to the band disappearance problem. First, B offers a possible diagnosis: residual haemoglobin in a blood sample from which DNA is extracted, may inhibit the action of polymerase (an agent of DNA duplication that is a key constituent of PCR). B then goes into a remedy for the problem, which consists in a preliminary step of heating the PCR mixture (this is similar to the solution A had already mentioned). However, B then goes on to give a simpler alternative, which is to use a different brand of reagent kit. The citation of the brand name serves to index an unspecified difference between the two kits, and the instruction simply endorses the effect of using the second kit (the makers of the 'Dynabeads' kit would be happy to read this spontaneous endorsement of their product). D offers a different remedy for the problem, but like B's first remedy, it involves adding a further step to the procedure.

The exchanges between A, B, C, and D address the difference between explicit and tacit knowledge. They formulate, and thereby make explicit, problems and solutions that arise in situ when using prepared kits according to standard instructions. In this case, there is no stable division between explicit and tacit knowledge. What is, or was, 'tacit' is not essentially mysterious, ineffable, private, or unconscious. Instead, it is a matter of what is mentioned or unmentioned in a particular written recipe or other formulation, and, correlatively, what is or is not 'grasped' by somebody using the instructions. What is mentioned, and what goes unmentioned, is highly circumstantial and occasionally problematic. Copies of a standard protocol take on a stable form when published in a laboratory manual, and even local recipes circulated informally are copied more or less exactly. However, the form of a protocol is not that of an 'immutable mobile' (Latour 1990): a text or inscription that fixes an experience or technique, thus facilitating its reproduction in remote places and giving it an archival permanence. Local practices and written protocols intertwine and supplement each other. It is common, for example, to amend and supplement the prior text of a protocol, in a Talmudic manner. What had been, or might have been, 'tacit' is then incorporated into the recipe, though evident differences may remain between typed steps and hand-written supplements, or between written instructions and verbally conveyed advice. Note that none of the suggested remedies for A's problem radically breaks with the format of an explicit protocol, and all of the advice employs concise recipe-like instructions that gloss over the laborious work involved in implementing the trademarked kits and patented techniques. There is no separate 'tacit' register, though one can notice a series of amendments, substitutions, and other modifications to the protocol in question, and all of the remedies implicate unformulated understandings of what will be required to 'work out' the procedures.[3]

PROTOCOLS, PRACTICES, AND POLEMICS

The foregoing discussion suggests two proposals about the relationship between formal (often written) protocols and situated practices

(1) Protocols do not, and cannot, fully explicate the work of reproducing them under singular circumstances. Particular practitioners or laboratory teams may accept a protocol as adequate for their purposes, but others with different backgrounds, or who face different conditions of application, may find it incomplete or even unintelligible.
(2) There is no discrete 'boundary' between protocols and practices; instead, protocols are amended, appended, and supplemented with ideal-typical, dialogical, and interactional instructions that involve different literary voices, textual format and marginalia, and targeted and generic advice; all of which explicate previously 'tacit' properties of knowledge and competence. Although never exhausting the 'tacit' field, such explications selectively formulate it.

A third proposal can be added to these two

(3) Proposals (1) and (2) are well known to practicing scientists and others who use protocols routinely in their work. For example, the 'fact' that canonical accounts of scientific method do not describe concrete laboratory bench practices is well known among scientists – so well known as to be proverbial. It is known in the manner of what 'everybody' learns (or fails to learn) through frustrating experience. Such common knowledge requires no special insight or acquaintance with the empirical observations made by ethnographers of laboratory practice.

Evidence cited in support of (3) includes the frequent acknowledgement of 'the fact' by practicing scientists, as indicated by Medawar's (1964) much-cited essay on the scientific paper as a 'lie' that provides a misleading account of methods. Further support can be found in scientists' and technicians' frequent remarks, jokes, and other informal expressions testifying to the difficulties of making procedures work. These can take the proverbial form of variants of Murphy's (or Sod's) laws, tailored to laboratory situations.

Despite the availability of proposals (1), (2), and (3) in communities of laboratory practice, protocols sometimes acquire a normative status for evaluating practices and enforcing standards. When protocols are administrated as normative standards, the difference between specific protocol formulations and actual practices can be made thematic in a way that implicates the adequacy of the practices in question. Court cases in which the prosecution presents forensic evidence and the defense contests that evidence make up a rich resource for examining local discursive uses of the distinction between protocols and practices (Oteri et al. 1982).

For example, the 1994–95 televized double-murder trial of former American football star Orenthal James (O. J.) Simpson, provided a forum in which one forensic scientist after another was called to testify. A key part of the prosecution's evidence was DNA analysis of blood samples collected at the scene of the double murder, and also from Simpson's Ford Bronco and from the vicinity of his residence. According to the analysis, some of the profiles developed from the samples matched those developed from blood samples taken from Simpson at the time of his arrest. Profiles from other samples matched those developed from the victims' blood. Together, the matches appeared to link Simpson to the crime scene, and they also indicated a 'trail' of evidence leading from the crime scene to Simpson's vehicle, and to his residence. The defense disputed the evidence by attacking the 'chain of custody' through which blood samples were collected at the crime scene by police functionaries ('criminalists'), and then placed in vials, stored in police vans, moved to police storage facilities, transferred to forensic laboratories, and handled within the labs by technicians and staff scientists. The Simpson defense team's attack on the integrity of the chain of custody combined allegations of police fraud (deliberate planting of evidence) with charges of forensic incompetence (mishandling and mislabeling of samples, failing to use standard controls, etc.).

The Simpson defense team frequently used formal protocols as a resource for attacking the competence of police and forensic work. The defense deployed a contrast between protocols and practice in an effort to undermine the integrity and weight of the prosecution's evidence. The defense's 'junk-in, junk-out' argument apparently proved persuasive for many of the jurors who voted not to convict Simpson. Unlike skeptical philosophers and social scientists who raise general questions about the relation of rules to practices, the defense employed the protocol-practice distinction with particularistic points of reference. The lawyers did not raise doubts about the general sufficiency of rules or formalisms to define good practice. Indeed, they *invited* the audience to regard specific protocols as normative (and even obligatory) procedures that competent practitioners should follow.

The protocols in question refer to police evidence collection procedures as well as accountably 'scientific' techniques conducted in forensic laboratories. The notion of chain of custody includes the more mundane police protocols and paper trails, covering actions by non-scientists; actions that can 'contaminate' the evidence samples that eventually make their way to the laboratory. A common strategy used by Simpson's lawyers for interrogating forensic witnesses involved two steps: first, solicit the witness's agreement that a particular manual or other written account was a relevant and authoritative account of the practices in question, and, second, extract acknowledgements from the witness of various departures from the letter of the written protocol. This interrogative procedure is a variant of the practice of 'impeaching a witness with a learned treatise.'[4]

In the following interrogation sequence, Robert Blasier, an attorney on

Simpson's defense team, cross-examines prosecution witness Gregory Matheson, head of the serology unit of the Los Angeles Police Department (LAPD). The interrogation is complicated by the fact that, at the time of the investigation, the police had not yet developed a specific manual of procedures for collecting and handling DNA evidence. Blasier is thus unable to solicit simple contrasts between the protocols in the manual and the actions of police agents in the particular case. Blasier makes use of a draft copy of a field manual for LAPD criminalists as a stand-in for the incomplete manual. Although the lack of a singular authoritative text with which to examine the practice is a problem for the cross-examiner, it also is a resource that he uses to suggest that the police practices lacked rigorous foundation.

California v. Simpson (May 3, 1995, Court Transcript, p. 13)

Q: Now, did I understand you yesterday to say that the field unit itself, the unit that goes out to crime scenes and processes crime scenes doesn't have a manual; is that right?
A: Not any one other than the one that is in process, this draft one, that's correct.
Q: But that's not in effect yet?
A: That's correct.
Q: And that has been in process for many years?
A: I believe originally we started working on it in probably mid of 1992.
Q: So there is no formal document anywhere available to criminalists who might need guidance out in the field in terms of the correct procedures to use to collect evidence?
[Objection by prosecution overruled.]
A: There is no manual that they can go to and look up a section that specifies a certain action or something like that. We do have some references around, but there is no manual at this point, that's correct.

With the draft copy of the manual in hand, Blasier questions Matheson about the field unit's practice prior to the production and dissemination of this manual. He elicits Matheson's acknowledgement that the manual is not yet in effect, and that the unit has been working without a manual. In his summary of the just prior testimony Blasier emphasizes 'So there is no formal document anywhere available to criminalists who might need guidance out in the field . . .'. He identifies such a formal document with 'the correct procedure'. The witness acknowledges that there is no such manual, but adds that 'We do have some references around'. The interrogation continues

Q: Is it your opinion that not having a manual for your field unit is an acceptable practice, scientifically acceptable?
Mr. Goldberg: (Prosecutor): Vague, argumentative.
The Court: Overruled.

The Witness: I think it is preferable that we have a manual; However, I believe you can still do good work and provide training and have people do acceptable work out there without having one.

Blasier formulates a rhetorical question: 'Is it your opinion that not having a manual for your field unit is an acceptable practice, scientifically acceptable?' Note the insertion of the term 'scientifically' in the iterated reference to 'acceptable' at the end of the question. The question is rhetorical not because of any essential syntactic feature, but by virtue of its placement in the sequence. The word 'scientific' is laden with significance, not only because of its common associations with rigorous testing and universal knowledge, but also because the US courts accord special status to expert, and specifically scientific, evidence. The very presence of the draft of the manual can be invoked as evidence of the field unit's orientation to the manual's necessity and desirability. Matheson's just prior acknowledgement that the unit had been working without such a manual then can be framed as a *problem* having to do with the absence of strict guidance. The witness does not give a straightforward yes or no answer, but instead acknowledges that it is 'preferable' to have a manual, but he then qualifies this by saying that 'acceptable work' can be done without one. Blasier pursues the matter by eliciting testimony on the relative size of the unit Mr. Matheson directs, and asking Matheson if units of similar size also do not have manuals.

Q: Of the labs that are approximately your size and larger, do you know of any other lab besides yours that doesn't have a manual for field operations?
Mr. Goldberg: No foundation for personal knowledge.
The Court: Overruled.
Q: If you know?
A: I don't know whether they do or not.
Q: Is this a matter of some concern to you as a supervisor of the lab, that there be a manual in effect for everybody to look at?
A: Well, eventually I think it would be great. I think it is a good idea that we have it laid down and in that form. That is why we are working on it.

Blazier's pursuit takes a slightly different tack. Instead of simply implying that the lack of a formal manual indicates unacceptable practice, he tries to elicit further acknowledgement from Matheson that the absence is notable. In effect, he seeks acknowledgement of the *normativity* of what, evidently, is a normative document. He seeks to make the absence of the manual *notable*: both *unusual* and *significant*. The witness professes not to know if other labs of similar size have formal manuals, and again he acknowledges that such a manual would be preferable. That it would be 'a good idea' does not acknowledge deficiency in its absence. The two parties

to this interrogation put forward different metrics for framing the significance of the manual in relation to the practices it formulates: Blasier attempts to secure essential status for the formal protocol, equating absence of the manual with practical inadequacy, whereas Matheson suggests that the formal manual would be among various resources which constitute normal and adequate practice.

Having (arguably) secured the authority of the manual, Blaser then goes on to quote from the draft manual to cover a particular procedure involving the criminalist and photographer at a crime scene. This is a standard instance of a 'documentary method of interrogation' (Lynch and Bogen 1996: 208) for questioning witnesses who represent a profession or expertise. The questioner treats a set of formal instructions or guidelines as a document of adequate practice, and then emphasizes the discrepancies between the document and the actual practices performed in the singular case in question.

Q: Now, please look at page 12. You numbered the pages down in the lower right. Is it your current procedure that it is the job of the criminalist at the crime scene to direct the photographer in the photographer's job?

A: It is the criminalist's job to direct the photographer when it comes to the evidence, the overall documentation and the evidence that is being collected. They do have other tasks besides that, so we are not directing all their activities, but we do direct the things that are associated with what our interest is.

Q: Now, one of the procedures you set forth in here is that ordinarily photograph numbers should correspond to evidence item numbers, correct?

Mr. Goldberg: Calls for hearsay.

The Court: Overruled.

The Witness: Yes, that is what it says. Normally the photographed item number will correspond to the subsequent booking item numbers.

Q: By Mr. Blasier: And is that a current procedure that you do have in operation?

A: Yeah. We try and make them correspond. It doesn't always work out that way, but just to keep things less confusing, you attempt to do that.

Q: The reason for doing that is to keep or hopefully to avoid as many different numbering systems as possible for items that come into evidence, correct?

A: Yes.

Q: That can be a source of great confusion if you wind up with a photo number that corresponds to some other evidence item that is not in that photo?

Mr. Goldberg: Argumentative.

The Court: Overruled.

The Witness: Well, I don't know if it is great confusion. It does complicate

the situation slightly. But there are always references referencing a photo item number to a property item number.

Q: By Mr. Blasier: And that comes from the forms that the criminalists have available to them at the scene?

A: A combination of that, plus the property report that is eventually written, Yes.

Q: So the crime scene checklist and other forms that are available to the criminalist at the scene, one of the purposes of that is to record all information necessary so that you can hook up the photos with the evidence that's collected?

A: Yes.

Having entered into the contents of the manual, Blasier once again pursues a strict, binding relationship between formal protocols and actual practices, while Matheson invokes a less determinate relationship in which practitioners deploy an open-ended array of judgmental resources. Mr. Goldberg's objection ('Argumentative') is overruled by the judge, but whether or not a legal objection is merited there is a sense in which Blasier and Matheson *are* arguing. The interlocutors put forward contrasting accounts of a possible discrepancy between the formal instructions and the relevant practice, and the accounts are consistent with the parties' adversary alignments. Blasier has not yet mentioned a singular discrepancy between the instructions and the photograph numbering practice in this case, but clearly he is setting the table for later questions. The witness again works with the logical connectives supplied by the defense attorney's questions. Note how he rejects the assertion that discrepant numbers between photographic and other evidence items would be 'a source of great confusion'. He suggests instead that the discrepancy 'does complicate the situation slightly', and adds that the connection between photos and property items can be indexed in alternative ways. This alternation continues after Blasier cites a further passage in the manual

Q: Now, let me direct your attention to page 13 at the bottom of the page. Is it your current lab's procedure to have criminalists, when they conduct a search of a crime scene for purposes of evidence detection, use bright lights, ultraviolet lights or alternative light sources or laser lights?

A: These tools are all available to the criminalist if they feel it is necessary.

Again, Blazier's rhetorical questions and commentaries suggest a determinate relationship between protocols and practices that Matheson counters by referring to the individual discretion of the criminalists and other practitioners. In the last line above, Matheson summarily pronounces that 'these tools' – i.e., the procedures Blazier quoted from the manual – are available as the criminalist sees fit. Matheson portrays 'the criminalist' as an autonomous agent who makes use of an array of resources, and exercises

local judgment. Moreover, he asserts that departures from the manual, and actions that lack clear reference to *any* manual, need not be deemed incompetent or untrustworthy. He emphasizes that criminalists do not simply enact, one-by-one, the procedures in a manual: 'they have other tasks besides that'. Moreover, Matheson's responses soften the terms in Blazier's questions that propose strict, necessary, and obligatory relations between the manual and the practices it formulates.[5] For Matheson, having a manual would be 'a good idea' but not an absolute necessity, because the specific provisions for collecting evidence, numbering photographs, and so forth, do not rigidly determine what the criminalist should do. Instead, they are tools to be used in situations that are more complicated than the manual describes.

Matheson's responses again and again invite the jury to credit criminalists and other functionaries with a degree of working knowledge and competence. This, of course, is the very competence that Blazier calls into question by reference to the manual. Matheson's line can make sense, and even appeal, to jurors with relevant work experience, or who otherwise recognize the difference between working to rule and getting a job done. Whether, in fact, jurors will go along with Matheson may depend less on any given discrepancy between formal protocols and acknowledged practices, and more on their reactions to the testimony by a whole parade of witnesses. In brief, the credibility of Matheson's invocation of judgment itself becomes a singular subject of judgment in the context of the trial.

CONCLUSION: PROTOCOLS AND ACCOUNTABILITY

The local reproduction of protocols can be attributed, in part, to the fact that protocols are inscribed and circulated in written form (cf. Latour 1990). Blasier identifies *formality* with *writing* when he attempts to leverage significant discrepancies from Matheson by reference to the written draft of a manual. However, when we examine specific instances in which protocols are performed, we can be led to wonder where writing ends and practice begins. The practices of molecular biology are thoroughly penetrated by inscriptions of many kinds. When police functionaries collect evidence from crime scenes, before sending them to forensic laboratories, they package the bodily traces in sealed tubes marked with labels and bar codes. These tubes are, in turn, sealed in tamper-evident bags, which are also labeled, marked with bar codes, and accompanied by bureaucratic forms and photographs taken at the crime scene. These elements of a paper trail identify the source of the samples, the date, and the agents who collected and handled the materials. These forms include space for signatures that authenticate and corroborate the recorded information. Copies of the forms, records of bar-code scans, and other documents are retained at selected junctures through which the evidence passed on its way from crime scene to lab. The paper trail, with its indices of identity and corrob-

oration, makes up the accountable form of the chain of custody. When, as sometimes happens, a defense attorney challenges the prosecution to demonstrate an unbroken chain of custody, selected elements of the paper trail are reviewed to document the identity and continuity of the evidence. For example, one check on forensic laboratory procedures is a practice called 'witnessing'. When one laboratory technician handles a sample, another practitioner is assigned responsibility to 'witness' the relevant practices. The 'witness' signs a form certifying that a colleagues work was overseen, and that the identity of the sample remained intact throughout the procedure. In the event of a challenge, the signature testifies to the witnessing and implicates a set of identities and continuities, regardless of how closely or casually the 'witness' actually observed the procedure.

When we consider the various forms of writing and inscription that constitute the chain of custody, a different sense of the word 'protocol' becomes salient. Contrary to the picture of a protocol as an exact prescription for a scientific method, we can consider the sense of the word 'protocol' as an adherence to ritual forms and proprieties. A chain of custody is, among other things, an administrative production documented by a required set of forms that make up a paper trail. Forms, signatures, and bar codes supplement one another and stand on behalf of 'proper' procedures. In courtroom inquiries in which judges, lawyers, and jurors have limited acquaintance with DNA and molecular biology, the administrative markers of 'quality assurance and quality control' (QA/QC) become surface indicators of adequate, and even 'scientific', practice. These markers of accountability offer no guarantee of adequacy, and attorneys can challenge them in detail, but until challenged they stand as evidence of adequate practice. Moreover, even when they are challenged, an overlapping, partly redundant, corroboration of bureaucratic forms, records, and testimonies may prove robust enough to withstand the attack. Consequently, the robust existence of a protocol – its formality, permanence, and trans-local accountability – is less a function of a correspondence between normative guidelines and actual practices than it is of the internal coherence and regular administration of formal guidelines independently of how closely they are 'adhered to'. The fact that such normative guidelines do not determine, or literally describe, the actual work they purport to govern is less a testimony to the mystery of tacit knowledge than it is to the 'governance' of work practices through the administration of proxy forms and the analysis of such proxies at considerable distance from the worksite.

(Date accepted: February 2002)

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NOTES

*Research for this article was partially supported by grants from the US National Science Foundation Science & Technology Studies Program (Award #9122375) and the UK Economic and Social Research Council (Award #R000235853). I would also like to thank Kathleen Jordan, Ruth McNally, and Christine Hine for their help with the research that went into this paper.

1. Irony and non-irony in this context is a variant of the arguments about Wittgenstein's (1953) treatment of actions in accord with rules. Influential discussions in the sociology of scientific knowledge (Bloor 1983; Collins 1985) put forward a skeptical reading of Wittgenstein that emphasizes the indeterminate relation between a rule and actions in accord with it; an indeterminacy that is foreclosed by the prevalence of 'blind' habits and social conventions. Ethnomethodologists (Lynch 1992; Sharrock and Button 1999) argue that Wittgenstein is not advancing rule-skepticism, but dissolving the polarity between rule and practice that sets up philosophical skepticism and SSK explanations.

2. I am grateful to Christine Hine for showing me these materials, and for sharing her ideas about their organization. See Hine (2000) for the significance of such materials for 'virtual ethnography'. Note that misspellings, typos, and grammatical errors are in the original messages. I have deleted signature lines that give the writers' names and affiliations, and have substituted the letters A, B, C, and D for these identifying details. For convenience, I have combined four separate messages, but in the original strings, B and C respond to A, and D responds to B.

3. See Bobrow and Whalen (forthcoming) for a study of a knowledge-sharing system 'Eureka' that is designed to incorporate practical know-how and personal 'tips' into an evolving data base that provides on-site instructions for photocopy technicians.

4. This expression was used by Peter Neufeld, one of Simpson's distinguished team of defense attorneys, during his interrogation of forensic scientist Robin Cotton.

5. The play between starkly contrasting and qualified formulations is characteristic of cross-examination of non-expert as well as expert witnesses. See Atkinson and Drew (1979); Drew (1992); Brannigan and Lynch (1987); and Lynch and Bogen (1996) for examples and discussions.

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