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Evaluative Spillovers from Technological Change: The Effects of "DNA Envy" on Occupational Practices in Forensic Science

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Abstract

Most studies of technologies' impact on occupational change focus on occupational groups' adoption and use of particular technologies in a field or workplace. Drawing on an 18-month ethnographic study of a crime laboratory, I focus instead on ''evaluative spillovers'': the comparisons that occupations encounter when technologies change the work of neighboring occupations in their field. I explore what happened when DNA profiling was held up as the ''gold standard'' of forensic evidence, resulting in scientific, public, and legal scrutiny of other forensic science occupational groups. Comparisons with DNA profiling challenged the working techniques and the values of firearms examiners, toxicologists, and narcotics analysts, but each group responded differently, either embracing or resisting changes to their work practices. Their responses were predicated on the institutional pathways that evaluative spillovers traveled through the field in locales such as professional association meetings and court proceedings. These three aspects of the occupational system—technique, values, and institutional pathways—influenced how workers negotiated the impact of technological change in the field of forensic science.

Keywords: work, technology, occupations, legitimacy, occupational change

It is not unusual for changing technologies and techniques to alter structures and practices in fields of work. The introduction of new technologies can create broad institutional change by displacing or creating occupations (Abbott, 1988); the Internet is a contemporary case in point, spawning web designers while devastating travel agents. In addition, technology adoption often alters social structures at the workplace, modifying work, disrupting relationships across groups, and shifting status hierarchies (Barley, 1986, 1990). Scholarship that investigates technology's impact on occupations has focused, however, on the

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direct effects of adopting technologies in fields (e.g., Zetka, 2003) and how their use changes work and relationships in organizations (e.g., Orlikowski, 2000).

In the digital age, it is important to understand how technologies may change even those occupations that do not directly adopt and use them. The world of work is increasingly made up of skilled occupations that accomplish knowledge-based activities (Alvesson, 1995; Barley, 1996; Vallas, 1999; Powell and Snellman, 2004; Gorman and Sandefur, 2011). In the U.S. since 1980, employment in jobs requiring higher-level analytic skills has increased 77 percent (Pew Research Center, 2016). Knowledge workers' tasks, wages, and jobs are those that commentators warn are most likely to be threatened by the adoption of new technologies, particularly digital technologies (Brynjolfsson and McAfee, 2012; Autor, 2015; Susskind and Susskind, 2015). For instance, accounting services have been shifting to mass production as a result of digital technologies (Galperin, 2017), and health care occupations are rife with change as a consequence of technologies such as electronic records and robotics (Susskind and Susskind, 2016; Pine and Mazmanian, 2017).

Widespread adoption of these technologies is predicted to affect the entire knowledge economy; when jobs are replaced and tasks shift, we are likely to see ancillary effects on the workers who remain. For example, in law firms that adopt artificial intelligence to automate case research and documentation done by paralegals (Koebler, 2017), we would expect the change to influence the work of the partners and possibly the clients, neither of whom would be using the technology. Moreover, as digital technologies pervade the workplace, their use has become an indicator of occupational effectiveness. Thus in medicine, with the increasing technological mediation of the doctor–patient interface, patients have begun to evaluate doctors on the basis of their use of technologies such as mobile applications (Samydurai, 2016). This suggests a pressing need to investigate not just direct effects but the indirect impact of technological change on experts' work that is already taking place.

Forensic scientists have been experiencing such a change as pressure has grown to alter their organizing structures and the ways that they create evidence. In February 2009, the National Academy of Sciences released a report that called into question the scientific validity and standards of forensic science, indicating a lack of both standardized operational procedures and a scientific body of research on the measures, variability, and sources of bias for much of the field (National Research Council, 2009: S12). The report frequently compared other forensic science disciplines with forensic biology and excluded DNA profiling from its criticism that many disciplines lack a scientific basis, suggesting that "with the exception of nuclear DNA analysis, no forensic method has been rigorously shown to have the capacity to consistently, and with a high degree of certainty, demonstrate a connection between evidence and a specific individual or source" (National Research Council, 2009: 7).

In this article, I draw on an 18-month ethnography of a forensic science laboratory to investigate what happens when a new technology, DNA profiling, is established in a field of expert workers. I examine how different occupational groups within forensic science responded to the rise of DNA profiling as a gold standard of evidence. I demonstrate how the challenge of comparison to a "more scientific" form of evidence spilled over to influence the work of multiple occupational groups in the forensic science field, even though none of those groups was able to directly adopt the technology. These challenges of comparison, which I call ''evaluative spillovers,'' traveled through multiple pathways in the field: public evaluations and pressure from the legal system were interpreted and navigated through the scientists' professional affiliations and activities. Moreover, forensic scientists' responses to the comparison were conditioned by their own occupational values and techniques, resulting in different changes in evidentiary practices at the workplace.

THE IMPACT OF TECHNOLOGICAL CHANGE ON OCCUPATIONS AND ORGANIZATIONS

Occupational systems often expand, shift, and contract as a result of technological change. New occupations coalesce around emerging technologies, as in the recent rise of web developers (Watson, 2013) and data scientists (Davenport and Patil, 2012). Sometimes technologies erode occupational jurisdictions, as in the case of railway dispatchers and booking agents (Abbott, 1988). In other cases, technologies help revive occupations; for example, the development of the electron microscope gave anatomists a new lease on life and a novel set of tasks (Bucher, 1988: 144), and more recently, librarians' work and identity were revitalized when they adopted Internet search technologies (Nelson and Irwin, 2014).

Technologies alter the boundaries between occupations in a field as well, because task domains and resources shift when technologies are adopted. As Zetka (2003) has shown, new scope technologies altered the purview of medical and surgical specialists in treating stomach ailments. Gastric surgeons were slow to adopt the endoscope and therefore lost control of these lucrative procedures to gastroenterologists; following this, they quickly claimed jurisdiction over video laparoscopy as a technique requiring their surgical expertise. Similarly, in Burri's (2008) study, radiologists' dominion over magnetic resonance imaging (MRI) granted them resources in their competition with cardiologists and neurologists. Placing MRI machines in their departments allowed them to argue for the value of their specialized expertise and gave them leverage to lobby for exclusive agreements with health insurance companies.

The adoption of new technologies also affects the social order of occupational groups inside workplaces. Scholars have shown that the adoption of technology influences and is conditioned on practices and structures in organizations (Barley, 1986, 1990). New technologies disrupt the social structures of work; Cohen (2013) showed how laboratories adopting new DNA sequencers developed different social orders around the employees who ran them. Historical circumstances and work cultures shape the use of technologies (Barley 1988), and therefore adoption is subject to the vagaries of managerial intentions, workers' appropriation and resistance, and other forms of workplace politics (Burawoy, 1979; Wilkinson, 1983; Zuboff, 1988; Orlikowski, 1992).

It is difficult, of course, to predict alterations in the social order: the two hospitals studied by Barley (1986, 1990), for instance, adopted identical technologies, but their social structures evolved differently because they were rooted in expertise, work practices, and relationships. Those with more professional power and authority, however, can be in a better position to resist changes in their tasks. For instance, Barrett et al. (2012) showed that when a pharmacy dispensary robot was introduced to a hospital, the pharmacists collaborated with the technicians to program the machine to accommodate technicians' needs. In contrast, this programming led to delays dispensing drugs to the pharmacy assistants, whose misery went unnoticed as they toiled in a cramped back room littered with piles of unshelvable drugs. The work of Pine and Mazmanian (2017) and Davidson and Chismar (2007) suggested similar patterns of behavior among medical occupations in hospitals. In these studies, when hospitals adopted electronic order-entry systems, they encoded physicians' authority while constricting the work of lower-status nurses and technical assistants.

Thus we have learned that adopting new technologies not only changes the nature of work and task areas but can also create new sources of status and be used to bolster or resist power. In the literature that explores field-level occupational dynamics, scholars analyze professional systems: arenas in which different groups contend for dominion over tasks in which their expertise is worthy of remuneration (Abbott, 1988; Zetka, 2011). In the literature on workplace dynamics, scholars primarily investigate changes to the status and practices of interdependent occupational groups working together with the technology (Barley, 1986; Orlikowski, 1992; Edmondson, 1999; Barrett et al., 2012).

But scholars at both the workplace and field levels have focused predominantly on the occupational groups that directly adopt or use the technology. Zetka's (2003) gastroenterologists and surgeons jockeyed for the legitimate right to practice with the endoscope, Barley's (1986) radiologists and technologists held or lost status on the basis of their mastery of the CT scanner, and Barrett et al.'s (2012) pharmacists were flummoxed by the frustration of the assistants being impeded by the robot's programming. Yet it is reasonable to believe that these occupations are not the only ones affected when new technologies arrive. Even though they may not directly use a technology, related occupational groups' practices in a field may also be influenced by its adoption. For instance, the physicians in Barley's study (1990) noticed which radiologists were CT experts and changed their referral behavior, approaching them for second opinions. Conceptions of technologically induced change should therefore include not only the competitive occupational relationships as in Abbott's (1988) system of professions or the technologically interdependent occupations in studies of the workplace but should consider more broadly the relationships of neighboring occupations in a field.

When occupations work in a common field, as one group adopts a novel technology, its impact is likely to influence the behavior, status, and standing of the other occupations. In the occupations literature, these influences are often explored in the context of claims for jurisdiction over tasks (Abbott, 1988). For instance, Bechky (2003) showed how engineers in one manufacturing firm encoded the legitimacy of their control over the production line into the drawings they created. Such legitimation processes are a key dynamic of social ordering. As Strauss (1978) noted, these processes occur not only when asserting the worth of tasks but also in terms of boundary claiming, standard setting, and evaluations of authenticity and appropriateness. Yet the symbolic dynamics of legitimacy and evaluation have not been well examined among scholars who explore technology's impact on occupations.

A potentially critical effect of new technologies stems from the symbolic aspects of comparison across occupations, which I call "evaluative spillover."

Technologies symbolize progress: they represent efficiency, rationality, and power, and they inspire both awe and expectation (Smith, 1994; Slack and Wise, 2007: 18). As such, new technologies may provide symbolic legitimacy for occupations through their appeal to others in the field. Pharmacists in the hospitals studied by Barrett et al. (2012: 1452) felt that the adoption of a robot would create an image of a ''modern'' pharmacy, increasing their legitimacy. Similarly, Beane (2019) noted that urologic surgeons felt pressure from patients to perform robotic surgeries, which were perceived as ''novel'' and ''high-tech.'' When technologies lend legitimacy to their new users, other occupational groups, feeling potential evaluative pressure, may take action.

Understanding the impact of evaluative spillovers from new technologies requires examining occupational members both at the workplace and in the fields in which they work. Because people respond to the situations they face in their daily lives (Blumer, 1969), their responses to the introduction of a technology at the workplace are influenced not only by interactions with it but also by what colleagues believe about it, what the press reports about it, what their professional association says about it, and how their managers respond to it. These beliefs are situated within the public's notions of progress through science and technology and are linked to occupational legitimacy. This means we must consider how the dynamics of occupations are embedded in the broader field while at the same time understanding the workplace. The inhabited institutions perspective (Hallett and Ventresca, 2006; Hallett, 2010), rooted in interactionist traditions, suggests delving into the work lives of occupations and determining how they encounter new technologies, make sense of them, and adapt their practices in relation to them.

Inhabited Institutions: Meaning-making, Values, and Technology Change at the Workplace

An inhabited institutions approach to occupations and workplaces can help integrate symbolic and evaluative institutional pressures with the social action and interaction of workers. Hallett and Ventresca (2006) noted that this perspective is rooted in interaction and its consequences: how interaction is embedded in organizations and fields, how it facilitates meaning making, and how it is used in negotiating interests. Scholars looking at how institutions are inhabited focus our attention on the ways in which workers interpret and respond to changes in their fields. Zbaracki's (1998) work on the adoption of TQM practices illustrated a complex process in which managers interpret rhetorics about TQM from the field and then adopt specific practices contingent on the technical and practical realities of their organizations. Binder (2007), exploring how a transitional housing organization responds to its external environment, showed how members of different departments draw on different professional commitments, interests, and institutional logics in making daily decisions and taking action. Similarly, McPherson and Sauder (2013), in their ethnography of a drug court, demonstrated how multiple occupational groups employ different sets of logics and norms drawn from their professional affiliations to negotiate local agreements about sentencing.

As Bechky (2011) noted, occupational communities in the workplace are an important frame for the actions and interactions of workers, contributing to institutional meaning making. These communities link to broader field structures through members' participation in professional associations, in which they exchange knowledge and engage in professionalization projects (Reay, Golden-Biddle, and GermAnn, 2006; Chreim, Williams, and Hinings, 2007). Suddaby and Greenwood (2005) showed how occupational actors in the accounting field used distinct institutional vocabularies in their debates about creating multidisciplinary firms, rhetorics that shaped new meanings of accounting.

Occupational communities mold the work lives of their members not only through professional affiliations and activities but also by shaping practices, values, and preferences through interaction (Bourdieu, 1984; Orr, 1996). Occupational meanings and morals permeate the social order of fields and workplaces (Hughes, 1958; Strauss, 1978; Goffman, 1983). Values also underpin the legitimating actions of occupations (Fayard, Stigliani, and Bechky, 2017; Evans, 2018); Anteby (2010) showed how the moral distinctions medical professionals made in the treatment of cadavers, such as their consent practices and handling of the body, prevented other occupational groups, who lacked these values, from gaining jurisdiction in the field. In the workplace, clashing occupational values have also been shown to inhibit cross-occupational collaboration in organizations, as when engineers resist helping marketers launch projects (Truelove and Kellogg, 2016). Most tellingly, in the domain of technology adoption, Zetka (2003) demonstrated how doing endoscopy was rooted in judgments of occupational virtue. When endoscopy was introduced as a diagnostic tool, gastroenterologists, who valued diagnostic skill, avidly adopted it, while surgeons, who valued quick treatment options, were less interested.

Together, these studies demonstrate how occupational groups' changing practices are constituted by how they make sense of institutional demands. These concerns filter into their daily organizational activities, shaping their values and work. A deeper investigation of occupational values and techniques would therefore help us to go beyond power and status dynamics in understanding technology's impact on organizations and occupations. Inspired by these studies linking local meaning making to occupational activity in a broader field, in this study, I trace the evaluative spillover effects of the rise of DNA profiling as the gold standard of evidence in the forensic science field. I explain how evaluative spillovers travel through particular institutional pathways to be encountered by forensic scientists and show how the scientists' values and techniques conditioned how each group responded.

METHODS

Research Context: The Field of Forensic Science

Forensic science is a field in which applied scientists provide judgments and conclusions about material evidence for use in the justice system. Its practitioners are subject to the overlapping institutional constraints of both science and law as they work to create evidence that is recognizable and useful across these domains. Forensic science was recently under scrutiny when the public focused its attention on the National Academy of Sciences' statement that forensics, with the exception of DNA profiling, was "shoddy" science. Therefore, it provided an ideal field to explore how multiple occupational groups responded to a technological change that occasioned evaluation and negotiation around the practices of the work.

The U.S. forensic science field is a patchwork quilt of multiple types of criminal justice agencies supervising crime laboratories in different locales. Public crime laboratories include federal-level FBI and ATF crime laboratories, state-run Department of Justice laboratories, and laboratories that report to local jurisdictions such as city police departments, sheriff's offices, and county district attorneys' offices. These agencies control the budgets of the laboratories that report to them.[1]

The institutional order of forensic science is encapsulated by the motto of one professional organization of criminalists (another term for forensic scientists), ''Fiat justitia per scientiam'': justice done through science. Unlike popular television images of hybrid super scientists/intrepid investigators shown on *CSI* or *NCIS*, forensic scientists rarely go out to crime scenes. They analyze evidence from crime scenes at the bench in the lab, write reports detailing their analyses and drawing conclusions, and testify to these reports in court as expert witnesses. As a part of their regular work at the intersection of science and law, analysts in a crime laboratory interact not only with other forensic scientists but also with attorneys, police officers and investigators, evidence technicians, and judges and juries.

In addition to the system of legal organizations and the laboratories, the field of forensic science includes universities such as John Jay College of Criminal Justice, George Washington University, University of California at Davis, and others that offer master's degrees in forensic science. Forensic science is served by a number of professional associations, including the American Academy of Forensic Science (AAFS), which includes both academic and practitioner members and holds a large annual meeting focused on research in the field. Laboratories have a national association as well, the American Society of Crime Laboratory Directors (ASCLD); its accreditation board certifies laboratories through audits and administers competency and proficiency testing for analysts. Criminalists also join associations at the state level, which hold meetings and local training sessions.

Forensic science occupations also have specialized professional associations, including the International Association for Identification (representing fingerprint analysts), the Society of Forensic Toxicologists, the American Board of Forensic Toxicology, and the Association of Firearm and Tool Mark Examiners. At the time of the study, the National Institute of Justice also supported scientific working groups for many of the forensic science areas, including firearms and toolmarks, DNA analysis, toxicology, document examination, gunshot residue, and fire and explosives analysis, which have boards that meet and decide on standards. Criminalists often subscribe to listservs associated with these groups to keep abreast of developments in their particular field.

Research Site and Methods: Ethnography of Metropolitan County Crime Lab

The main ethnographic fieldwork for this analysis took place from February 2009 through August 2010 in a crime laboratory in a Western U.S. state.

[1] In addition, there are small private forensic laboratories in some states.

Table 1. Demographic Characteristics of Occupations at MCCL

	Forensic biology	Firearms	Toxicology	Controlled substances (narcotics)
Number of members	18	4	9	8
Gender	15 women 3 men	4 men	5 women 4 men	4 women 4 men
Age range	Mid-20s to late-50s	Mid-20s to late-50s	Mid-20s to late-50s	Mid-20s to late-40s
Education	BS in chemistry or biology Some MS in forensic (or a related) science	BS in chemistry or biology Some MS in forensic (or a related) science	BS in chemistry or biology Some MS in forensic (or a related) science	BS in chemistry or biology Some MS in forensic (or a related) science

Metropolitan County Crime Lab (MCCL) is one of the largest crime laboratories in the state and reports to the district attorney's office in a major metropolitan area.[2] According to Hallett and Ventresca (2006: 226), to understand the relationship between institutional environments and the actions of those in organizations, one must recognize ''the local negotiated orders that situate and define how workers view the work,'' as well as be in a position to view the organizations' place within a larger institutional order. Ethnography enables researchers to observe organization members' interpretations and responses to institutional discourse and action while in situ, thereby revealing processes that might be hidden by other methods (Binder and Davies, 2019).

I studied the applied science units inside MCCL, and in this paper I compare four units: forensic biology (DNA), controlled substances, toxicology, and firearms. Criminalists at MCCL were hired in with bachelor's degrees, typically in biology or chemistry, although some also had master's degrees in a basic or applied science such as forensics (a master's degree was required for supervisors). After passing a battery of tests and undergoing a panel interview, they were hired into a specific unit such as DNA or toxicology. As table 1 summarizes, the units were similar in their members' age range (mid-20s to 50s), but the gender composition of the units varied, with mostly women in the forensic biology unit, all men in firearms, and an equal split in toxicology and controlled substances.

The forensic biology unit comprised 18 criminalists, including three supervisors, and was responsible for screening evidence for biological fluids and performing DNA profiling on those samples. This unit also managed and monitored the county's contributions to the Combined DNA Index System (CODIS) database of unknown profiles and profiles of known felons, which is used, for instance, to develop cold hits, in which criminalists reanalyze old case evidence, producing profiles to help develop leads. The controlled substances unit, also known as narcotics, was made up of eight criminalists, including the supervisor who reviewed all of the narcotics cases. This unit analyzed physical drug evidence and also performed comparative and trace evidence analysis,

[2] Metropolitan County is a pseudonym, as are all the names of my informants.

including analysis of shoeprints, duct tape, gunshot residue (GSR), fire debris, pepper spray, and dye packs.

The toxicology unit comprised nine toxicologists, including one supervisor, and was responsible for analysis of drugs in the body. The county's DUI (driving under the influence) program was also under this unit's purview—they managed all the breath alcohol instruments in the police agencies, and some members of the group were also certified to testify in court to alcohol and drug effects on the body. Finally, the four-person firearms unit performed function testing of firearms, firearms identification, and distance determinations and managed the Integrated Ballistics Identification System (IBIS) database of unknown bullets and cartridge casings.

The criminalists I studied belonged to a set of neighboring occupations working collaboratively in the field of forensic science—they identified as separate but closely related occupations and had distinct professional associations and commitments. As described further below, criminalists had similar educational backgrounds but different specific analytic training, and the work they performed in their laboratories varied.

I spent three to six months in each unit doing participant observation three days a week, although due to concerns about maintaining the sanctity of the chain of custody of the evidence, I was more of an observer than a participant. I had access to most areas of the lab except the evidence lockers, but I was not allowed to touch any of the case evidence, which kept my participation to a minimum. Yet I had opportunities to practice some forms of analysis. For instance, I processed my own indented writing, I ran my buccal (cheek) swab through the entire DNA profiling sequence, and I test fired firearms both in the lab and at the sheriff's range.[3] I spent time with every analyst in each unit, many for multiple days, as well as every supervisor, as they all went about their regular duties in the lab (and occasionally in court). I attended unit, supervisor, and all-staff meetings as well as eight training sessions given by lab members to the agency populations, defense attorneys, and the district attorney's office.

Near the end of the fieldwork, I interviewed a subset of analysts in each unit, as well as every supervisor and the director and deputy director of the lab. These semi-structured interviews focused on career histories, experiences testifying in court, and controversies or changes in analytic practices. I also toured three other laboratories in the state and interviewed the director of each of them (during failed attempts to get access to these labs as I began the project). After the field work at MCCL, I visited a county crime laboratory in an Eastern state, where I interviewed the deputy director and spent the day observing the work of the DNA (forensic biology), comparative evidence, and controlled substances units. Finally, I attended three professional meetings: a three-day statewide criminalists' meeting, a two-day statewide laboratory managers' meeting, and a one-day local criminalists' continuing education meeting.

Analytic Approach

I followed a grounded theory approach of comparison and contrast (Glaser and Strauss, 1967; Strauss and Corbin, 1990) in analyzing the data. This approach

[3] Processing indented writing uses electrostatic detection on indentations on paper that is suspected to have been underneath handwritten evidence to reveal what had been written there.

entailed an iterative process of theoretical sampling, comparing and contrasting examples from the data to build theoretical categories that were then compared and interrelated to form the basis for this paper. My initial clue about the evaluative tensions surrounding the rise of DNA profiling came on my first day at the lab, when the DNA supervisors introduced themselves mockingly as the ''DNA princesses.'' The National Academy of Sciences' attention to forensic science during my fieldwork provided opportunities for me to understand the evaluative dynamics further. DNA profiling has become the gold standard for forensic evidence, and the National Academy of Sciences (NAS) report, by exempting DNA analysis from the criticisms it leveled at the rest of the forensic science occupations, intensified the scrutiny on those occupations and increased the sense among their members that their evidentiary practices might need to change. I read the report carefully, noting the images that public scientists held of the forensic science field as well as their substantive comparisons of techniques. As I analyzed my data while in the field, I noticed different responses to the evaluative spillover coming from these comparisons: firearms examiners complained publicly in presentations at conferences, narcotics analysts discussed threats to their favored technique at their benches and in group meetings, and toxicologists excitedly discussed their new reporting practices. I asked questions in interviews to probe analysts' responses to the NAS report and the rise of DNA profiling.

After I left the field, I reanalyzed the data, trying to pinpoint the ways that the significantly different responses of firearms, narcotics, and toxicology analysts to evaluative attention were related to the characteristics of their occupational communities. I examined the work practices and social structure in the lab as well as the larger social structures of the criminal justice system and the forensic science field. I began by developing tables across the groups comparing various dimensions of their material practices, knowledge, and expertise. These comparisons of technique proved descriptively fruitful and rich but did not feel theoretically complete. Reading the science and technology studies literature on changing notions of objectivity, I was stimulated by Galison's work (2000; Daston and Galison, 2007) to think about how epistemology and morality are intertwined. Thus I began a set of analyses that explored the cultural values of the different occupational groups. These categories did not provide a full picture of the dynamics in the field, however—I still needed to understand how these interpretations were filtered through the social interactions and encounters of the forensic scientists. It was clear that some challenges to the legitimacy of particular occupational groups were perceived as more immediate than others—when I realized this, I looked more intently at the institutional and social structures that were most salient to occupational members facing each challenge, and I uncovered the different institutional pathways that evaluative spillovers followed.

As I show next, the NAS report drew heightened attention to the gold standard of DNA profiling, encouraging a climate of evaluation and comparison of the occupations in forensic science. DNA profiling produces a particular form of evidence, and practices and evidence in the other occupational groups varied in their differences from it. Moreover, the work of the firearms, narcotics, and toxicology units led to distinct techniques, values, and motives, which came to the fore when these groups were faced with a social and evaluative structure that imagined legitimate forensic science as just one thing: DNA profiling.

EVALUATIVE SPILLOVER EFFECTS: TECHNOLOGICAL CHANGE INVITES OCCUPATIONAL COMPARISONS

In 2005, Congress authorized an independent committee formed by the National Academy of Sciences to conduct a study of the forensic sciences. The broad charge to this committee of scientific, legal, and forensic experts was to assess the state of forensic science: identify the community's needs, recommend ideas for maximizing its uses, improve and enlarge its staffing, promote best practices and guidelines, and reveal any additional issues (National Research Council, 2009: 1–2). The NAS released its report in 2009, delineating the problems the committee saw with forensic science and laying out recommendations for solving them. Notably, the report pointed to what it saw as the ''limited foundation in scientific theory or analysis'' for much of forensic science, with the exception of DNA analysis (National Research Council, 2009: 133).

The NAS report drew close attention inside the forensic science field. Some of the field's professional associations issued written responses to the report, including the American Academy of Forensic Sciences (AAFS), the general professional association covering forensic sciences as a whole, and the American Society of Crime Laboratory Directors (ASCLD), the main association for laboratories. Both of these organizations professed support for the report's recommendations and promoted particular actions in response, including accreditation of all laboratories, certification of all criminalists, and standardization of terminology. In addition, ASCLD encouraged laboratory directors and managers to ''prepare their staff'' for questions in the courtroom related to the report and ''identify and take the steps necessary to prove the existence of valid, reliable science and interpretations behind the forensic analysis'' (ASCLD, February 19, 2009: 3). Both the International Association for Identification (IAI) and the Association of Firearm and Tool Mark Examiners (AFTE) issued responses to the report, making selected point-by-point refutations of criticisms and promising future study of the recommendations by their respective research committees. At MCCL, the laboratory director immediately e-mailed the initial executive summary to all criminalists and followed this with an announcement at the next all-staff meeting that everyone should read the full report.

The report also garnered significant media attention, including front-page coverage in the *New York Times* and a full episode of *Science Friday* (2009) on NPR, introduced by Ira Flatow saying, ''Up next, it is the not-so-scientific world of forensic science. . . . Our country's forensic sciences 'have serious problems and we need to overhaul the current structure.''' Since the report's release, a number of news outlets have called out forensic science as ''junk science'' (cf. Stern, 2014; Edwards and Mnookin, 2016). In the wake of increasing scientific and public opinion that DNA profiling was the only valid forensic science, other forensic science subfields felt pressure to change their analysis and reporting practices.

Within MCCL, however, the responses of the different forensic science occupations to this pressure varied. DNA profiling acted as what Timmermans and Epstein (2010) would call an informal standard: it drove comparisons as field members used it informally for evaluation, but it did not entail a formal process of rule generation by either the state or professional associations.

Moreover, this new technology included multiple techniques and could be characterized along many scientific and technical dimensions, and as a result it was open to a variety of interpretations by people in the field. The other occupational subfields thus experienced challenges to their legitimacy from the NAS report and comparisons to DNA profiling in different ways. No other occupation in the field could adopt DNA profiling technologies directly; instead, specific aspects of their own techniques and values were perturbed or supported by the pressure to—as one narcotics analyst told me—"be more like DNA." Moreover, the comparison with DNA profiling took different institutional pathways for each occupational group, varying the ways in which criminalists encountered and interpreted the comparison. To understand how other forensic scientists experienced the comparison with DNA profiling, before I describe their responses, I first describe the process of DNA profiling and the characteristics of the evidence created by the DNA unit.

DNA Profiling as the Only Legitimate Forensic Science

Over the last 25 years, there has been a shift in the work crime laboratories do as advances in biology such as polymerase chain reaction techniques have made it easier to analyze and interpret DNA evidence and DNA profiling has become an established investigative tool. After surviving court challenges and being held up as rigorous and scientifically valid by prior National Academy of Sciences reports in the 1990s, the methods used in forensic biology have become the gold standard of forensic science practice (Lynch et al., 2009). The image of the scientific unassailability of DNA evidence is pervasive not only in the media (e.g., Toobin, 2007) but also in criminal justice arenas. As legal scholars Saks and Koehler (2005: 895) advised, "Traditional forensic sciences need look no further than their newest sister discipline, DNA typing, for guidance on how to put the science into forensic identification science."

DNA profiling begins with items of evidence—primarily clothing and swabs from bodies—that may contain biological fluids such as blood and semen. A DNA analyst screens the items for fluids, taking a sample through cutting or rubbing, and extracts the DNA from the sample by chemically breaking down and washing the cells. Then the analyst amplifies the DNA in the sample, isolating and copying regions of the DNA strands by adding enzymes and proteins and by putting it on a thermal cycler that heats and cools the sample multiple times, enabling copying of the segments, called STR—short tandem repeat—fragments. A part of the sample is then loaded on an instrument that performs capillary electrophoresis, in which the STR fragments are separated in a thin glass column, and the amounts of each segment are detected. The amounts are converted and recorded as peaks on an electropherogram (see figure 1).

Each STR is drawn from a particular noncoding region of the DNA strand called a locus in which a known set of alleles occurs in the population. After viewing the peaks shown by the electropherogram, the analyst identifies the peaks as the alleles for each locus and creates a table of 16 loci to present in the final report as the DNA profile for that sample (see figure 2). A second analyst reviews this report, along with the analyst's notes and the original files from the instrument, and asks questions and suggests revisions before the report is sent to a supervisor for an administrative review and then released to be used in criminal justice proceedings.

Figure 1. A sample electropherogram image.*

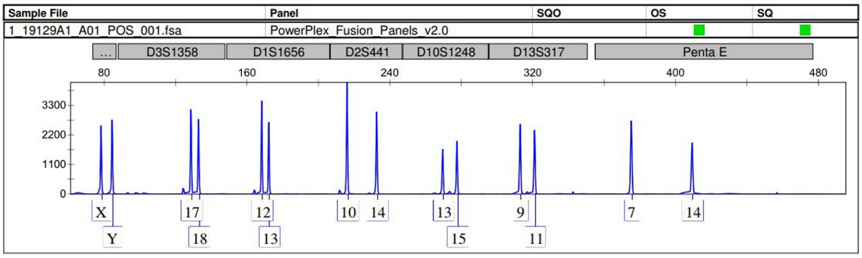


*Image used courtesy of Easy DNA. https://www.easy-dna.com/electropherogram/, downloaded May 16, 2019.

Figure 2. A sample table of alleles at 16 loci for multiple suspects.*

	Evidence bloodstain	Amanda Knox	Raffaele Sollecito	Rudy Guede	Meredith Kercher
D8S1179	13, 16	11, 12	13, 15	14, 14	13, 16
D21S11	30, 33.2	29, 30	32.2, 33.2	29, 29	30, 33.2
D7S820	8, 11	9, 9	8, 11	11, 12	8, 11
CSF1PO	12, 12	11, 12	10, 12	7, 8	12, 12
D3S1358	14, 18	15, 18	16, 17	15, 16	14, 18
TH01	6, 8	6, 8	9, 9.3	7, 9	6, 8
D13S317	8, 13	11, 13	8, 12	11, 12	8, 13
D16S539	10, 14	10, 11	11, 14	9, 11	10, 14
D2S1338	20, 23	18, 20	16, 24	16, 23	20, 23
D19S433	12, 16	13, 16.2	13, 15.2	13, 14.2	12, 16
vWA	14, 16	17, 17	12, 15	18, 20	14, 16
TPOX	8, 11	8, 8	8, 9	8, 9	8, 11
D18S51	14, 15	13, 17	16, 17	14, 15	14, 15
Amelogenin	XX	XX	XY	XY	XX
D5S818	11, 12	13, 13	12, 12	12, 13	11, 12
FGA	20, 21	22, 22	20, 21	19, 23	20, 21

* Image from *Forensic Science Reform* (2017), reprinted with permission from Elsevier. https://www.sciencedirect.com/science/article/pii/B9780128027196000078#f0010, downloaded March 28, 2019.

In court, the analyst presents these tables, along with his or her conclusion, which is an attribution about the source of the DNA profile that refers to population statistics. For instance, the report could contain a conclusion such as, ''The suspect is included as a possible contributor to this DNA mixture. The probability that a person selected from the population at random would be included in the combination of alleles present in this mixture is: 1 in 260,000,000,000 in the Caucasian population.''

The graphs and tables created by DNA analysts produced an impression of scientific objectivity that other forensic evidence lacked, to varying degrees. After its introduction, as DNA evidence was challenged in the courts, the community of forensic biologists established practices for representing evidence in ways that appeared credible, legitimate, and scientifically objective, including calculating statistical estimates and reporting measures of error for various steps in the process. With a DNA profile, the (legal) parties involved could also review the documentation, such as raw data and graphs from the capillary electrophoresis and the tables created by the analyst. These became visible and verifiable scientific evidence.

The tables and graphs constituting DNA profiling evidence look quite neat and objective, but the DNA analysts considered the process to be messy and require judgment, much like the work done in the rest of the lab. Graphs were marred by imperfections—what analysts call stutter, imbalanced peaks, drop-off, and spikes—caused by technical issues with instruments and dirty and degraded DNA samples. Contamination in the lab also created problems, as I learned one day while working with Carly, a veteran DNA analyst. Terri, a junior member of the unit, came over to tell us about the saliva samples she had problems with a few weeks earlier. She reminded us, "Those were the ones where there was contamination in the control sample and an allele showed up. But I reamped the control this week, and now it is clear." After a long technical discussion, Carly concluded, "Oh, yeah, sometimes contamination just happens and you do all this sleuthing and don't find an answer."

These types of anomalies were neatened through the representation process (Jordan and Lynch, 1998). Creating conclusions required multiple rounds of interpretation. The review process not only entailed discussions back and forth between the reviewer and the originating analyst but often drew in other members of the lab to aid in decision making. "It takes a lab to write a report!" Terri explained to me, acknowledging the need for communal judgment to untangle the messiness of the DNA profiling process. In the eyes of the criminal justice system, the media, and the public, however, DNA profiling was a fully legitimate, objective standard to which others should aspire.

One consequence of the privileged position of legitimacy granted to DNA evidence was a pervasive feeling of what I call "DNA envy" within the professional world of forensic science. At MCCL, the "DNA princesses" of the forensic biology unit were envied for the resources they commanded. Members of other units often commented that more equipment, funding, grants, and staff were available to this area than any other. Some resentment also manifested in forensic science professional associations. For example, a group of trace examiners acted on their belief that DNA profiling was getting more than its fair share of attention and resources by forming a new national professional association, issuing a flyer that opened, "Since the wide scale application of DNA has taken hold of the forensic sciences, trace evidence examinations have taken a back seat." Most important for understanding change in the field, however, was that in focusing forensic science on the scientific legitimacy of DNA profiling versus the other disciplines, the NAS report created evaluative tensions that spread throughout the field. These evaluative spillovers took various institutional pathways and were interpreted in light of the different cultures in the occupational communities.

The Occupational Order of Forensic Science: Technique, Values, and Institutional Pathways

Forensic scientists came to the crime laboratory with similar educational backgrounds, and all forensic scientists were expected to have similar skills and were regarded as potentially interchangeable across units. For instance, when the lab director was planning to swap two analysts across the narcotics and firearms units, at the monthly staff meeting he reminded everyone, ''You are all criminalists, and you should be able to work in any unit in the lab.''

Yet while in theory criminalists might be considered one occupational group, in practice they were members of different closely related occupations. Criminalists were trained to use specific types of analysis on different forms of evidence, such as wet chemistry in narcotics to identify drugs or comparative microscopy in firearms to compare bullets. Their training was quite extensive, particularly in forensic biology, where analysts trained in-house for nine months before being certified to work on cases, and in firearms, where examiners attended a statewide training program for a year and then trained in the lab for an additional year before they started casework. Their particular analytic work practices and varying relations with the broader criminal justice system resulted in distinct occupational cultures in the different areas.

These occupational cultures are key to understanding how forensic scientists encountered the evaluative spillovers concomitant with the rise of DNA profiling. For each occupational group at MCCL, I first show how members experienced evaluative spillover as it traveled through unique institutional pathways. Then I describe these occupational groups on the basis of technique, which encompasses what criminalists do to create evidence as opposed to just specific scientific techniques, and values, which represent the qualities that they value in a good criminalist. I create this division for analytic purposes—technique and values were closely intertwined in practice (Galison, 2000). Finally, I show how the institutional pathways, techniques, and values related to each group's response to the evaluative spillover stemming from comparisons with DNA profiling.

Firearms examination. In firearms, the institutional pathways by which the examiners encountered evaluation vis-à-vis DNA profiling included public criticism and legal challenges to the admissibility of firearms evidence. Comparative evidence techniques such as those used in firearms identification bore the brunt of the public criticism as a result of the publication of the NAS report in 2009, which highlighted their lack of rigorous scientific methods. For instance, the first chapter of the report contains the section ''Questionable or questioned science,'' which begins:

> Many forensic tests—such as those used to infer the source of toolmarks or bite marks—have never been exposed to stringent scientific scrutiny. Most of these techniques were developed in crime laboratories to aid in the investigation of evidence from a particular crime scene, and researching their limitations and foundations was never a top priority. There is some logic behind the application of these techniques; practitioners worked hard to improve their methods, and results from other evidence have combined with these tests to give forensic scientists a degree of confidence in their probative value. . . . However, although the precise error rates of these forensic tests are still unknown, comparison of their results with DNA testing in the same cases has revealed that some of these analyses, as currently performed, produce erroneous results. (National Research Council, 2009: 42)

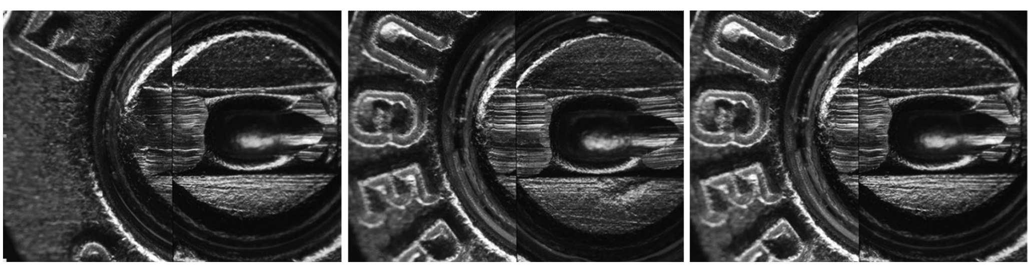
In the public arena, the predominant sentiment expressed was concern that there was no scientific basis for a match of the evidence in these areas, and this created evaluative pressure on firearms examiners.

The concerns raised by the media attention were paralleled in court cases in which defense attorneys tried to exclude firearms testimony from consideration. At a statewide criminalists' meeting, a board member of SWG-GUN, the scientific working group for firearms examiners, noted that an increasing number of attorneys and academics were attempting to bar the admission of firearms evidence during the pretrial phase of proceedings, in Daubert hearings.[4] The credibility and legitimacy of the entire discipline of firearms examination was being scrutinized in courtrooms, and claims of its lack of scientific basis reverberated throughout the forensic science field.

Technique: Comparative microscopy and imaging. A common type of examination in the firearms unit is to compare the bullets and cartridge cases found at a crime scene to a gun found on a suspect or at the crime scene. In this type of comparison, the examiner test-fires the gun in the range at the lab and collects the bullets and cases. When a gun is fired, it creates microscopic marks on the bullets and cartridge cases from the rifling (grooves in the metal design) in the barrel and the other mechanical parts of the gun such as the firing pin. The examiners use a comparison microscope to compare the microscopic marks, called striae, found on the test fires to the striae on the bullets and cartridge cases found at the scene (see figure 3).

Creating a visible record of the matching striae is an important aspect of firearms identification, as it reinforces the examiners' judgments on the stand. Examiners create detailed note packets as they progress through their comparisons over the course of several days, recording digital images of every set of matching (or not matching) striae. As Adam, an experienced examiner, told me, "You want the note packet to support [your judgment] on the stand. Multiple outsiders have seen my work, reviewed it, and it has never been challenged." Firearms examiners pointed out how their practices had changed over time:

Figure 3. Images of striae comparisons on cartridge cases.*



* From https://archives.fbi.gov/archives/about-us/lab/forensic-science-communications/fsc/july2009/review/2009_07_review01.htm, downloaded March 25, 2019.

[4] The Daubert Standard is used by a trial judge to make a preliminary assessment of whether an expert's scientific testimony is based on reasoning or methodology that is scientifically valid and can properly be applied to the facts at issue. Under this standard, the factors that may be considered in determining whether the methodology is valid are (1) whether the theory or technique in question can be and has been tested; (2) whether it has been subjected to peer review and publication; (3) its known or potential error rate; (4) the existence and maintenance of standards controlling its operation; and (5) whether it has attracted widespread acceptance within a relevant scientific community (https://www.law.cornell.edu/wex/daubert_standard, downloaded from Legal Information Institute, March 14, 2017).

"We used to say, 'I know a toolmark when I see it,' and 'I know it like my mother's face.'" This was no longer acceptable for reports or testimony, as one examiner explained: "We can't do that anymore. Now we have to document. In today's lab, you better have the images to back it up."

In each unit at MCCL, colleagues performed technical reviews of the evidence reports to establish the validity of their judgments, but this process differed across units. In the firearms unit a second examiner followed the first through every step of a firearms comparison, looking through the microscope at each set of striae. This examiner signed off on every page of documentation, verifying agreement with the first examiner's assessment. While labeled a technical review, in practice this process resembled a communal judgment made through back-and-forth dialogue between the examiners. This dialogue was not only about the particulars of a set of striae but also about how to create an image that would be more convincing.

For instance, Tom was the second examiner on an identification that Adam was working on, and he came over to look at the striae on the firing pin impression. Tom adjusted the microscope, reversing the image of the firing pin to a different angle. Adam, looking at it on the screen, said, "I looked at it that way, and it is not as good, go back to the way you just had it. It is a challenge to image it, maybe adjust the light." Tom flipped it and pointed at a set of lines on the image on the screen. Adam said, "We're at 40x [magnification], you can see it better, there's a whole section of agreement, light and dark, you can see a whole set of them." Tom replied, "Too bad you can't rotate it more, get light in from the side." Adam said that he wanted to image it first, and then saved the images of these two places to his notes.

Tom then told Adam, "You are almost right there for identification." Adam disagreed: "I think it's an identification already." Earlier that day, Tom had told me that examiners could have slightly different standards for identification, but as long as they agreed on the conclusions, he was comfortable with it. Now, he pointed out to me, "See, Beth? I might do one more picture; he is comfortable already." Adam elaborated, "I don't believe it is random agreement at this point. You want me to do one more?" Tom, moving away, said, "I'm happy with this, and you probably will have extractor and chamber marks too." Adam finished, "I'm happy with the images I took. I'm moving on to the extractor; I will call you over then." This joint work, which was typical of the examinations and technical review process in firearms, incorporated both the examiners' trained judgment of the striae and their interest in creating the clearest and most convincing images to document the case.

Values: Holistic and subjective trained judgment. The techniques used by MCCL firearms examiners included methodical imaging of multiple aspects of bullets and cartridge casings, careful lighting and camera work, and collegial engagement in making judgments. Moreover, firearms examiners placed great value on their expertise and deep knowledge of firearms and their manufacture. The value of applying holistic expert judgment to their analysis markedly manifested when they talked about different methods of identification.

One method used in firearms examination to quantify identifications is called CMS, and it requires examiners to count consecutively matching striae. The threshold number of striae is based on a statistical analysis of "best known non-matches" from guns from the same manufacturer. CMS uses a set of heuristics, such as ''you need two groups of three consecutive striae within the firing pin impression'' before you can identify a match. None of the three qualified MCCL examiners used CMS regularly to identify a match. They were all trained in and conversant with the CMS rules but did not believe these rules were as conservative as their own judgments, which entailed a holistic impression of many more points of comparison. Yet they recognized the appeal of CMS to outsiders. As Tom noted, ''Some people like CMS, because numbers are easy to understand. They are universal; everyone knows what you mean.''

At MCCL, the skilled firearms examiners did not use CMS regularly in examinations and testimony, and the group spoke of it somewhat derisively. Tom labeled CMS as ''more of a tool that I might use when I'm on the fence, when my criteria is borderline. I'm actually more conservative than CMS. I don't go to it immediately.'' Adam described how examiners in other labs used CMS for testifying: ''Some people physically write on their notes, they'll mark up a group of 7 [striae], write next to it in a silver pen on the image, 'times 7.' They think this makes them more objective than me. But [firearms] is a subjective discipline. It is the totality of the mark I am looking at. . . . There are a million factors that create the image, and it comes down to the subjective opinion of the examiner.''

To acquire the knowledge for their judgments, firearms examiners spent two years in training, reading histories of firearms manufacture, visiting firearms factories, and poring over image after image of best known non-matches. Tom pointed to this training in firearms as the source of his expertise:

> Each examiner has built-in criteria for identification from their training and knowledge. And you build these every time you look at what matches and doesn't match, the orientation. You build an understanding of non-match, match, the internal criteria. In training, they show you close ones that aren't a match—what they call the best known non-match. Like bullets from two consecutive barrels from the same manufacturer—they are going to be close but not identical.

Good firearms examiners valued their pattern recognition abilities, subjective training, and experience, and they chafed at the notion that identification could be objectified through standardized heuristics.

Responses to evaluative spillover. Public scrutiny and the courtroom challenges to firearms admissibility caused concern among some firearms examiners, especially in the arena of the professional associations. The AFTE was one of the two professional associations whose leaders issued a point-by-point refutation of some of the criticisms in the NAS report. At a statewide criminalists' meeting attended by members of all the forensic science occupational groups, some firearms examiners also responded defensively to these attacks on their legitimacy by critiquing the critics, citing their lack of training as firearms examiners. One speaker presented photos of academic critics, listing their affiliations and singling out aspects of their participation in pre-trial courtroom admissibility challenges (i.e., Professor Doe at State University ''was the first one to come out against us''). Since the release of the NAS report, he said, it was more difficult to testify, ''especially when it is you going up against a report with 20 Ph.D.s on it.''

Others used these critiques to call for an examination of practice with an emphasis on bias and objectivity. Noting that he had not been barred from testifying as an expert witness, one firearms examiner presented what he learned from his experience with defense attorneys questioning the legitimacy of firearms evidence in court. Before discussing how examiners might guard against bias in their identifications, he pointed out, ''It is easy for us to point fingers at these critics and say 'They don't know how to do firearms examination.' But they are basing their critiques on our own testimony, and it is up to us to be more convincing. . . . Sometimes motivation for change comes from the outside. They are giving us a good kick in the pants to motivate us.''

Thus, although these challenges had yet to successfully exclude firearms evidence from admissibility in court, within the field firearms examiners reacted with concern that their evidence continue to be admissible. In rising tones of frustration, one examiner at the statewide meeting pronounced, ''We can't be like DNA, no matter how much they want us to be, it is just impossible!'' Moreover, members of other occupational groups at MCCL recognized the pressure being brought to bear on firearms. One narcotics analyst told me, ''For firearms, it is, 'Why can't you be more like DNA? We *like* DNA!'''

Yet these broad attacks did not motivate the MCCL examiners to modify the way they worked. Their testimony had not been challenged in Metropolitan County's legal jurisdiction, and they did not respond to this distant pressure by changing their practices. Instead, for the firearms examiners I knew, the exhortation to ''be more like DNA'' coming from public critique and legal challenges in Daubert hearings elsewhere was an insult to their values of holism and expertise, and in terms of technique, it was somewhat baffling. I asked Tom and Pete what it meant to be more like DNA. Pete said, ''One thing is statistics. They want us to be like DNA, but it is different though, because you can't look at every bullet.'' Tom added, ''They want it more objective, but we don't give our results in numbers. Firearms is not objective, not definitive like in narcotics.'' Pete said, ''We can't report a 70-percent match on a bullet, it is or it isn't,'' and Tom elaborated:

> Some people are trying to make it objective, like counting consecutive numbers of striae. But that doesn't really work. . . . Through training, you see so many images, you get an understanding of the best known non-match. From reading and experience, you build your own internal threshold. But there's a big stigma because we can't put numbers on it. For outsiders, they think, ''How do you know that? You aren't telling me it's 70 percent!!''

The MCCL firearms examiners were thus cognizant of the stigma of not having population statistics to support their results, such as their colleagues had for DNA profiling, but they did not see how their technique could provide a similar type of result. DNA profiles used population statistics to generate a likelihood of a match and sampled a particular set of alleles in non-coding DNA for comparison. Given their understandings of how individual guns created striae, firearms examiners were stymied as to how an analogue could be made to a ''population'' of firearms or a set of specific alleles to striae on a cartridge case. And doing so would be a significant departure from their values of holistic and subjective assessments of identification.

The institutional pathway taken by the challenge to firearms was at a physical and social remove from the examiners at MCCL: ''they''—outsiders to the occupation such as academics, the media, and the public—were judging firearms examination to be deficient and doing so in venues the examiners did not personally experience. Firearms examiners' strongly held values of holistic and subjective approaches to judgment and identification of a match led them to resist objectifying their techniques. The examiners also did not see their technique as compatible with the qualities of DNA profiling. Combined with the affront to their values and the distant institutional pathway of the challenge, this led them to dismiss the notion of changing their practices.

Toxicology. In toxicology, the threat of a local and immediate challenge during cross-examination by a defense attorney in an upcoming court appearance propelled a change to their local practices. The institutional path for the comparison of toxicology to DNA profiling began when the NAS report's conclusions were pulled into the domain of the network of defense attorneys who regularly challenged toxicology results in DUI court cases. The NAS report barely mentioned toxicology as a forensic discipline and did not criticize toxicological analysis at all, but it drew evaluative attention to laboratory error in forensic science and in particular to measurement error. The report noted that ''the assessment of the accuracy of the conclusions from forensic analyses and the estimation of relevant error rates are key components of the mission of forensic science'' (National Research Council, 2009: 106).

One defense attorney had begun to win DUI cases in other states by questioning laboratories' omission of estimates of the uncertainty of measurement in their reports and was training and encouraging other defense attorneys and experts across the country to do the same. A specific case in MCCL's jurisdiction arose in which another defense attorney was planning to challenge the toxicology results on this basis and to call an engineering expert from one of these other states to testify.

Technique: Instrumented chemistry. Forensic toxicologists detect and identify drugs and poisons in body fluids, tissues, and organs. The MCCL toxicology unit received multiple boxes a day of blood and urine samples to test for drugs in the body. Each analyst was assigned to an instrument upon arrival in the morning and downloaded a computerized list of cases to analyze for a particular class of drug. The most common analysis toxicologists performed was blood alcohol analysis (called BAC) done through gas chromatography, which separates alcohol from other volatile substances in the blood and compares the alcohol peak to ones obtained with known blood alcohol standards. The toxicologists' work consisted of preparing the samples to be analyzed on the instrument, loading and starting the instrument, making sure the instrument worked properly, and checking the results of the analyses to see whether samples exceeded the chemical threshold for DUI.

For instance, one morning Jason had a set of 40 blood alcohol cases on the computer list when he arrived. He handled these in a batch on the instrument. First, he printed out the list and created a sequence list for the instrument. Then he pulled multiple boxes out of the refrigerator and pulled the samples by number, placing them in a rack in the order they appeared on the list. He labeled all the vials with his initials and date and put them on an instrument to rock them, ensuring that there were no clots when he drew the sample for the instrument. While they were rocking, he set up the instrument, checking the sequence list and choosing the appropriate method for blood alcohol. He then drew samples and added an internal standard for quantification (n-propanol), using a mechanized pipette to draw both together and put a small bit in each small vial in a tray. He did the same for the quality controls and the acetone markers, the results of which told the analyst whether the instrument functioned the same throughout the run and distinguished between alcohol and acetone. Between each sample, he wiped the pipette clean, and after the tray was finished, he sealed all the vials and loaded them into the instrument (checking the vial numbers against the list again). He started the run, which would take about five hours.

The next day, Jason conveyed the list of quantitative gas chromatography results from the instrument to the lab's computerized report system, printed and checked the 100-page report both for sample accuracy and to make sure the instrument performed correctly (noting the internal standards and retention times), and transferred his written information about the standards and instruments to a log the lab kept for traceability purposes. Afterward, another analyst would download the report and technically review the printed results, attach a review checklist, and send the packet to the supervisor, who would release the results to the district attorney's office. The reports on individual cases of BAC were not lengthy but included comparisons to standards, and the notes on the report contained identification and dates of standards, as well as instrument information. The analysis was instrumental and standardized, and the parties in the legal system were very familiar with the structure of the report.

Values: Well-organized, error-free analysis. Toxicologists' technique included careful attention to detail in analyzing many similar samples simultaneously, which instilled values of error-free, obsessively organized processing. In toxicology it was vital that the hundreds of samples they received each week for analyses were not mishandled in any way. My first day in the toxicology lab, the analysts joked with me that they were the "OCD unit": the most important aspect of their job was making sure that they were matching the correct samples to the individuals on their analysis list. Every step taken in the analysis process was checked off on this list as the toxicologist looked at the labels on the vials and made new matching labels as samples were moved from place to place and the original vials were finally replaced in their boxes.

Thorough, error-free documentation and sample tracking were vital in every unit of the laboratory but a particular fixation in the toxicology unit, where samples for BAC had to be analyzed within several days. For instance, as Jason and Neha were pulling samples out of the refrigerators one morning, Neha complained that a third toxicologist, Jorge, had not yet shifted the samples from the temporary property boxes to the neatly ordered and labeled toxicology boxes. Jason replied, "No, that's my fault, Jorge got tasked to do something else and I have been doing it the last couple of days. I'm a bit behind, I ran out of time last night." To me, they noted the importance of having compulsive organizational skills to work in toxicology, and Neha said, "Occasionally you get a normal person in toxicology and they annoy the rest of us by not putting things back in the right place or forgetting to label something."

Vigilance in attending to every step of the analysis was both important and difficult given the repetitiveness of the process. When Jason was pipetting the internal standard and a urine sample into a vial, he pointed to the air gap in the pipette tip that indicated the pipette was ready to pull up rather than dispense and said, "If it isn't there, the pipette will dispense the internal standard into the sample and it is ruined. Not only do you have to write a long report, but the lab gets to make fun of you for a few weeks.'' A good toxicologist was someone who was quick and careful, obsessive about record keeping, and unwaveringly attentive while performing multiple repetitive tasks.

Response to evaluative spillover. Prior to the release of the NAS report, MCCL had been adjusting its practices to conform to ISO 17025, a set of general laboratory standards recommended by ASCLD for future lab accreditation. The toxicology unit was revising its protocols in accordance with ISO requirements, one of which was the creation of a three-year plan to ''apply procedures for estimating uncertainty of measurement.'' Therefore the toxicologists already had a plan for estimating measurement error when they heard about the potential challenge to their testimony on this basis. They decided to implement their plan immediately and put together the statistical analysis to prepare for testifying in this case.

As this shows, the evaluative spillover encouraging toxicologists to change to ''be more like DNA'' did not come from public scrutiny, media attention, or criticism of toxicological technique. Instead, the institutional pathway by which toxicologists encountered an evaluative comparison was a defense attorney's immediate challenge to their presentation of specific case results in court in which he would draw a parallel to error measurement techniques used in DNA profiling. It was a direct threat to their ability to successfully testify rather than a broader legitimacy challenge such as that to the firearms examiners' technique.

Moreover, toxicologists interpreted this challenge as consistent with their values and technique; it did not perturb their occupational culture. They were able to interpret the pressure to ''be more like DNA'' narrowly—in terms of meeting one particular standard related to measurement error, which ASCLD, the lab's accrediting association, was already asking them to meet. While the reports in use by toxicology did not yet include this standard, the lab was already concerned about tracking uncertainty of measurement. The BAC protocol already required that they trace the instruments, reagents, and standards used in a laboratory log. The state law required that BAC measurements had a confidence interval of +/– 5 percent, and that was also the ASCLD requirement, so the lab had been reporting results at the 95-percent confidence level. With the move to meet ISO requirements, they were preparing to accurately report the uncertainty of measurement based on the protocols they had already been using.

Jason called attention to these compatibilities in a toxicology outreach session for the criminal justice community:

> I've heard lots of defense attorneys say that labs are scrambling to put in uncertainty due to the NAS report. This is not true, we were already doing it . . . uncertainty of measurement is not just spurred by NAS, it is called out in many documents in scientific fields; it is scientifically known.

He presented several slides of citations from these documents, adding, ''It is being addressed in other places [related to forensic science] such as ISO 17205 and NIST 1297 sec 2.1.'' He also explained that uncertainty measurement was based on historical data that the lab had already been collecting since they updated their protocol over five years prior:

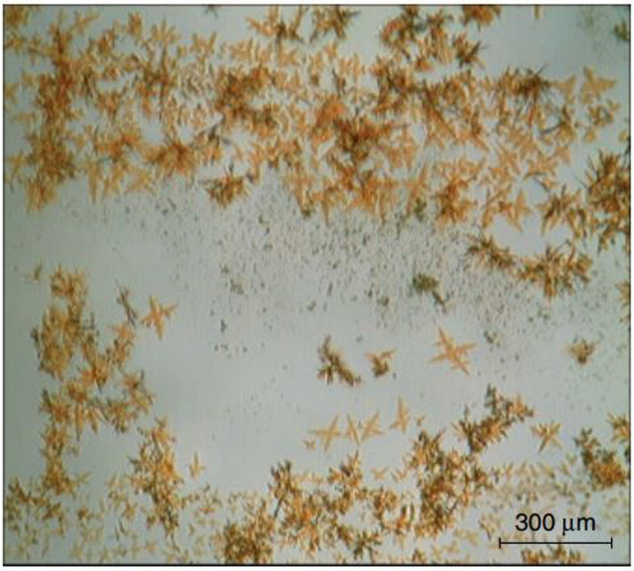
> So the instrument is the same instrument we've been using for five years, and our method hasn't changed. . . . We average out our quality control data, and we not only use that historical data but go through every step of the procedure and assess it for uncertainty. If you use glassware, or pipettes, every piece of equipment, the reagents, all are assessed for uncertainty. We quantify them, normalize them, and then combine and express them together.

In their presentation, the toxicologists were visibly proud of their new practice of reporting measurement error. They were now able to report a measure of BAC (the maximum allowable BAC is .08) with a range of +/– .003 and a confidence interval of 99 percent. Quantification of their results was already standard, the ''OCD'' unit had always been concerned that they made no errors, and thus the new practices were consistent with their values as well as their techniques. Finally, the institutional pathway through which evaluation of their practices was encountered was a very direct and immediate one—an analyst from MCCL would be challenged personally in court on the scientific validity of their lab's techniques.

Narcotics. Narcotics analysis was seen as legitimate by the scientific community, the public, and the courts and, like toxicology, narcotics analysis escaped negative mention in the NAS report. Evaluative spillover from attention to DNA profiling instead followed an institutional pathway through the narcotics professional association and listserv discussions. The release of the report triggered renewed attention to an internal professional debate among narcotics analysts nationwide over technique. In the narcotics subfield, laboratories in the Eastern and Western U.S. favored different analytic techniques: in the Eastern U.S., gas chromatography/mass spectrometry (GC/MS) was the method of first choice for identifying controlled substances, while in the West, microcrystallography was used more frequently. Although the narcotics community agreed that both methods were scientifically valid, GC/MS had the advantage of instrumentation logs and graphical outputs that were seen as compatible with the standards of DNA profiling. This internal debate over the comparative legitimacy of their own analytic techniques concerned the narcotics analysts at MCCL, as they were worried their laboratory practices might be outlawed by the professional association.

Technique: Wet chemistry. Every morning, narcotics analysts at MCCL picked up large boxes of Kapaks—sealed plastic packages of potential controlled substances dropped off by law enforcement officers—from the property room in the basement and returned to their lab to analyze them. Analysts primarily used wet chemistry techniques to identify the different samples of controlled substances analyzed in their unit, assessing and recording their crystalline structures. Microcrystallography, or crystal testing, is a long-standing method of identification in which a chemical reagent is added to a drug, causing crystalline precipitate to form. The size and shape of the crystals, as seen under a microscope, are characteristic of particular drugs (see figure 4). In the lab, analysts performed these tests in minutes: the preparation of the slide was straightforward, and the crystals precipitated rapidly. They examined the slide under the microscope as the crystals formed; then, when the slide became overcrowded, they disposed of it. They noted the crystals' distinct shapes in their reports by both naming the shapes (as ''feathery Ks,'' ''rabbit

Figure 4. Image of crystalline structure of cocaine—called "daggers."*



* Image from *Microcrystalline Tests in Forensic Drug Analysis* (2009), reprinted with permission from Wiley. https://onlinelibrary.wiley.com/doi/abs/10.1002/9780470027318.a9102, downloaded May 16, 2019.

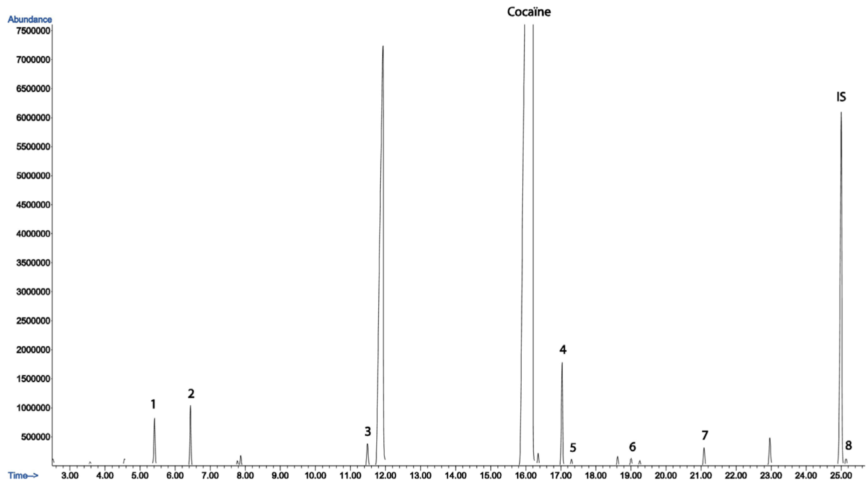
ears," "clothespins," "hockey sticks," "daggers," "3-D jacks") and drawing a picture of what they saw.

GC/MS was a newer method of analyzing controlled substances using an instrument called a gas chromatograph/mass spectrometer; a drug was put into a solvent and processed through the instrument. The gas chromatograph separated the mixture's components, and then the mass spectrometer hit the material with a beam of high-energy electrons, which created positively charged ions that decomposed into fragments. Under these conditions, no two substances created the same fragmentation pattern. Both the retention time from the GC and the ion spectrum from the MS were recorded as output graphs from the instrument (see figure 5). The instrument included a library of retention times and ion spectra of known substances, and the sample was then matched against the drug library and a sample of the known substance.

At MCCL, narcotics analysts used crystal tests for many of their cases and resorted to GC/MS analysis for "unknowns" they could not recognize by sight or smell, or other drugs that could not be confirmed through crystal testing. In their jurisdiction, the law required a short turnaround time for narcotics cases, because the specific charges for suspects depended on identifying what controlled substance they were carrying and how much of it they had. This placed pressure on narcotics analysts to finish the analyses on their samples rapidly and accurately. The most common substance analyzed in the unit was methamphetamine, which could often be confirmed in 10–15 minutes with crystal testing.

With crystal testing, analysts recorded what they saw under the microscope by drawing it, and as one narcotics analyst noted, "In the report, we describe what we see, we don't just say 'this is meth.'" These reports were technically

Figure 5. Chromatogram obtained for a typical cocaine sample.*



* Image from *Forensic Science International* (2015), reprinted with permission from Elsevier. https://reader.elsevier.com/reader/sd/pii/S0379073815001413?token=FB0331D019C734CFA99296CA8672EB047ECE2DFA92A8D3D996BB49ED5D9C9A0631A312D87A7B8B26B1C08B5BBDE5B85B, downloaded April 7, 2019.

reviewed by the unit supervisor. But because there could be unknown compounds that produced similar crystals, crystal tests provided ''less certainty,'' and the guidelines of the narcotics scientific working group (SWG-DRUG) required that two crystal tests be performed on each sample, using different solvents. MCCL's practice, therefore, was to provide verification of the results of the first crystal test with a second, different crystal test.

Values: Accurate and quick identification; curiosity, autonomy, and variety in the work. While narcotics analysts used some chemistry techniques and instruments similar to those used in toxicology, their work was more autonomous and much less standardized. And while their turnaround times required them to be efficient, as a group they were curious and thorough about hunting down the identities of the different substances they analyzed, and they held fast to ideals about scientific investigation.

Although methamphetamine was the most common substance encountered in narcotics, the daily box of Kapaks typically included marijuana, cocaine, ecstasy, prescription sedatives, hashish, psilocybin, and more. Analysts excitedly related their identifications of unusual substances to one another (and to me): ''Check out these mushrooms!'' They contrasted their craft-based chemical identification work with the analysis done in toxicology, which they felt was routine and boring: ''it's mind-numbing, you press buttons and open tubes all day.'' Several of them had worked in toxicology and had been eager to move to another unit. In Taylor's words, ''I took a job in tox because it was what was open in the lab at the time, and it took a long time to get out. . . . Too much paperwork and not enough benchwork! So I convinced management to train me in other areas.''

In the narcotics unit, analysts valued careful science and were very prickly about their science being represented appropriately. These values came through clearly the day that an undercover police officer, a district attorney, and two defense attorneys visited the lab to go through a huge amount of evidence from a drug bust. After Jodi removed about 20 baggies from a Kapak and laid them out on the table, one defense attorney pointed to them and asked, "That's the alleged coke?" Tim, the supervisor, replied, "*Not* alleged. Jodi tested it, it is cocaine." The defense attorney continued, "How pure is it?" and Tim answered, "We don't quantify it. If [the suspects] processed it again, it might be chemically slightly purer. I wouldn't attest to that though." The defense attorney sighed and said, "I know. It is like when I talk to my own experts. I should know better than to talk to a scientist, it is maddening." Tim pointed out, "It is kind of like your 'alleged' versus our scientific certainty."

During the meeting, one of the defense attorneys asked a lot of questions about the chain of custody, and afterward I asked the analysts about this. Their answers reflected another value of the unit, one held in common across all the units in the lab: careful documentation. Tim replied, "Yeah, if the best argument he's got is chain of custody, he's screwed. That's what we do day in and day out, we dot our i's and cross our t's." Taylor added, "Redundancy up the yin yang."

Their care in documentation sometimes warred with their need to be efficient. Because of their turnaround requirements, narcotics analysts strongly valued efficiency in processing cases, to the extent that one or two analysts timed themselves on "typical" cases and were teased about their race with the clock. For instance, when the information system for filing case reports was changed, the new data-entry process was slow and complicated, which caused a major slowdown in case-processing times. The unhappy analysts met with the information technology representative to discuss the specific problems with the new system. At the end of the meeting, one analyst, Billie, said, "We have efficiency concerns, will we talk about those?" Taylor added, "These are not small things." They discussed several problems with the wait times for particular data-entry screens to open. Taylor ended with, "If we could fix all these, I could cut it down to 7 minutes, which is just one minute longer than [the old system]." Billie joked, "We don't want to set our bar quite as low as that!" Good narcotics analysts had to balance this efficiency with thorough scientific analysis of many different types of drugs.

Response to evaluative spillover. MCCL analysts were concerned that the outcome of the debate over the legitimacy of their wet chemistry techniques might lean toward the prohibition of crystal tests, because East Coast analysts preferred instrumentation, and they were believed to have over-representation on the board of their scientific working group. In the words of Jodi, a veteran narcotics analyst:

> One of the things we are worried about in our state is that we won't be allowed to use the crystal test anymore. It is not a test that can be physically checked—the analyst sees the slide, but there is no written output from it. So it can't be reviewed by others later on. And with the NAS and other attacks on forensic science, we worry that crystal tests may be phased out. It is the oldest identification method for drugs; it has been around since the 1800s. And it is very definitive, and quick and easy to do. But on the East Coast they don't do it. And we'll probably have to move to the GC/MS tests, that's mostly what they do back east. But that takes a lot longer to analyze, and we wouldn't get our results back immediately. Now, we do the crystal tests and it is much quicker.

Robin elaborated on this problem as she described a workshop she attended about a recent Daubert hearing that challenged the use of crystal testing: ''It depends on the kinds of cases you have. Here in Metropolitan County, we couldn't keep up with the caseload if we didn't do crystals. We only have two instruments, and the runs take a long time, so we couldn't keep up.''

In a round of discussions online, the SWG-DRUG community debated requiring that a second analyst visually review the crystals. This would be time consuming, according to MCCL analysts, because crystals form too rapidly for a second analyst to view, so the reviewer would have to perform a duplicate set of crystal tests from scratch, doubling the time the analysis took. The MCCL analysts also discussed the possibility that the lab could purchase digital cameras for their microscopes. This was not an inexpensive option, although as one of the analysts pointed out, it would be a lot cheaper than purchasing additional GC/MS instruments.

Most troubling to the analysts was the loss in autonomy, variety, and control over the work implied by a move to instrumentation. They saw the work of analyzing controlled substances through GC/MS as simple and requiring less judgment. Taylor explained, ''On the East Coast, the instruments are there and ready to go, just dilute and shoot. Any schmo from the street can do it, just let them on the instrument. With crystal tests, we have to validate [the procedure] and train people to do crystals.'' Such training entailed coursework in which novices worked side by side with experienced analysts on specially equipped microscopes to identify the crystalline forms properly. Potential changes to their current practice threatened the analysts' sense of craft training and judgment. As Billie noted:

> I like crystal tests partly because I'm a chemist. I like chemistry, and I can get behind the chemical part of the crystal tests. The other part is . . . I don't want to do the same thing 12 billion times in a day. I like to do different things. So if I have different tools in my arsenal I'm happier. I know other people would prefer just to take all their drugs, put it in methanol, throw it on the GC, and be done with it. But I'm not one of those people, because it would bore me to death. I would hate that.

Narcotics analysts at MCCL resisted turning their work into the standardized, ''boring'' practices they felt comparisons with DNA profiling implied.

Because narcotics analysts strongly valued autonomy and variety in their work, they resisted adopting instrumented techniques even though doing so would produce output more congruent with that of DNA profiling. And because they encountered the evaluative spillover through the pathway of an internal professional debate, there was no direct or immediate need to make a change; therefore they held onto the practices they valued.

DISCUSSION

This study demonstrates how technology adoption influences occupational groups' work practices through evaluative spillover effects in which comparisons to new standards of practice are made. In doing so, it links institutional pressures, organizational structures, and occupational actors with the actions and interpretations of workers on the ground. The results of the analytic comparison of the responses to the rise of DNA profiling give us a detailed picture

Table 2. Responses of Forensic Science Occupations at MCCL to Evaluative Spillovers from Comparison with DNA Profiling

	Firearms	Toxicology	Controlled substances (narcotics)
Institutional pathways of spillover	*Multiple paths of critical evaluation*	*Local, direct court challenge*	*Internal professional debate*
Scientific	Yes—NAS report	No	No
Public	Yes—Media criticism	No	No
Courts	Yes—Broad admissibility challenges in outside jurisdictions	Yes—Direct challenges of their own testimony by defense attorneys	No
Professional association	No	Yes—ASCLD standards for accreditation	Yes—SWG-DRUG group debate
Technique	*Incompatible* Comparative microscopy technique had no analogue to instrumental and statistical analyses in DNA profiling	*Compatible* GC instrumentation and error measurement practices were made compatible with instrumental analyses and error measurement practices in DNA profiling	*Compatible* One form of infrequently used instrumented analysis (GC/MS) could be made compatible with instrumental analyses in DNA profiling
Values	*Incompatible* Perception of DNA profiling's objectivity strongly challenged values of subjective, trained judgment "We can't be like DNA, it is just impossible"	*Compatible* DNA profiling's error measurement techniques matched values of error-free accuracy "Metropolitan County is kind of leading the state" in error measurement	*Incompatible* Idea of moving to instrumentation more like DNA profiling challenged values of variety and autonomy in the work Do not want to be "any schmo from the street" doing instrumented analyses
Response of group at MCCL	Rejected evaluation and resisted changing local practices	Adapted local practices	Resisted changing local practices

of how technological change is interpreted through the lens of occupational values and technique as workers apprehend and respond to pressures coming through particular institutional pathways.

As table 2 summarizes, when members of each occupational group evaluated their own forms of evidence production with respect to DNA analysis, they considered different aspects of the technology in making comparisons with their own techniques. They also interpreted DNA profiling in light of the values they held about their work. Because each occupation had distinctive techniques and values, their interpretation of the possibilities of adapting the work to "be more like DNA" varied. Moreover, the findings show how evaluative spillover followed different institutional paths in influencing the three forensic science occupational groups. Each group perceived challenges to its legitimacy, but these challenges traveled through different pathways of the institutional field—public scrutiny led to broad challenges from outsiders, attorney networks raised local courtroom challenges, and insiders highlighted the comparison to bolster their internal professional arguments. These pathways affected the sense of urgency and the character of the changes made to forensic science work at MCCL.

Evaluative Spillovers in Fields of Occupations

The findings in this study demonstrate that introducing technology into a field not only influences the workers who directly interact with the technology but also has evaluative spillover effects on the surrounding occupations. As we know from significant past study of adoption of technologies in the workplace, direct contact with new technology alters work relations and can shift occupations' status (Barley, 1986, 1990; Zetka, 2003). In this case, however, the attention the NAS report paid to DNA profiling, identifying it as the only objective forensic science, was an impetus for evaluation of the entire field, many members of which did not use the technology highlighted by the comparisons. My findings demonstrate that evaluative spillovers that spring from the introduction of new technologies represent a mechanism of potential change for occupations. Because this is an ethnography of one laboratory in the field of forensic science, rather than make claims about how spillovers would take place in other occupational fields, it demonstrates the possibilities of evaluative spillover for triggering change.

Because evaluative spillovers stem from comparisons of legitimacy with related occupations, they can affect occupational groups that do not use or interact with the new technology. In the case of forensic science, because these occupational groups worked in the same field, they were susceptible to evaluation with respect to DNA technology. DNA profiling had developed meaning in the field as an objective, compelling scientific form of evidence that was accepted by the courts, the broader scientific community, and the public; it epitomized modern, efficient progress (Smith, 1994) in forensic science. Yet this meaning manifested differently for each of the neighboring occupations—for firearms, DNA profiling was an overarching objective statistical practice; in toxicology, comparisons were made specifically to error measurement practices; and for narcotics, the certainty of the instrumental output of DNA profiles motivated comparisons with instrumented chemistry. For these occupations, DNA profiling was not an abstract science but a set of techniques and practices open to their interpretation. Thus evaluative spillovers manifested in different ways depending on the institutional paths through which comparisons were encountered in the field and on each community's construction of how DNA profiling was related to its own values and techniques.

Institutional Pathways of Evaluative Spillovers in a Field

Examining occupational responses to the NAS report's comparisons with DNA profiling reveals the influence of the institutional pathways that evaluation and judgments of legitimacy take through the field. In all three cases, we see a variety of activity in professional associations, scientific communities, courtrooms, and the media in relaying the meanings of evaluative spillover to members of the occupation. In the case of firearms, comparisons were primarily taking place in the broader academic science community (the NAS report), the media, and distant courts. And although some members of their professional association were worried, the firearms examiners at MCCL rebuffed the evaluative pressure in their daily work. In contrast, toxicologists faced an immediate and direct challenge in their local courtroom that was consistent with changes requested by the laboratory's accreditation association. Their toxicological techniques were not under attack by the media, courts, or the scientific community. Rather, they were motivated to change their work practices by their anticipation of being attacked on the stand if their practices failed to meet a scientific standard associated with DNA profiling. Also, the changes they were already making in response to the institutional pressures from the ASCLD's accreditation policy made it easier for them to respond. Finally, narcotics analysts faced neither an immediate work challenge nor a broad legitimacy comparison. Their techniques were acceptable to the public and scientific community, and they did not encounter court challenges of any kind. Yet debates in their occupational association raised evaluative concerns that influenced their internal professional discussions about techniques.

Earlier studies of the role of institutions in occupational fields have typically conceptualized such institutions as actors, pointing to changes in law or the lobbying actions of professional associations as mechanisms for closure during jurisdictional battles (Kronus, 1976; Halpern, 1992). Although the actions taken by legislatures to create monopolies over tasks or the implications of professional associations acting to create educational standards and codes of ethics are obviously important, this focus on institutions as actors overlooks the ways in which daily activity in and around such institutions affects occupational members' work practices and beliefs.

By tracing the institutional pathways of evaluative spillovers, these findings contribute to our understanding of technological change in occupational fields by exploring how meso-level institutions like professional associations and courts have a mediating role in change (Misa, 1994). Specifically, I show how these institutions influence the context of occupations' social negotiations (Strauss, 1978)—they structure how occupational members interpret technological change. In this case, forensic scientists' working interpretations of what might happen in a court case, or what direction an online professional debate was taking, created the conditions that organized their responses to evaluation and to potential challenges to the legitimacy of their work.

Thus the institutional pathways along which evaluative spillovers travel create opportunities for interactions and meaning making that may lead to change. The different meaning-making opportunities afforded by courtroom challenges provide an interesting comparison. Toxicologists interpreted the immediacy of a potential court challenge in Metropolitan County as an opportunity to change their practices, whereas firearms examiners at MCCL did not have direct encounters with challenges to their practices in court. Moreover, the MCCL firearms examiners did not interpret colleagues' reports of challenges in other jurisdictions as a potential problem; one senior examiner was proud that his own practices "had never been challenged." The examiners from other jurisdictions who had testified in pre-trial admissibility hearings, in contrast, seemed motivated to change practices in the field.[5] At MCCL, the immediate challenge

[5] While I heard these firearms examiners give presentations at a professional meeting, I do not have data on their local actions as they were not members of MCCL.

faced by toxicologists spurred interaction and action around change, while that pathway—and as a result, that opportunity for interaction and meaning making—did not exist for the firearms examiners.

Exploring the institutional pathways in a field extends our understanding of the dynamic ways that people inhabit institutions. Similar to the studies of Binder (2007) and McPherson and Sauder (2013), the case of evaluative spillovers in forensic science demonstrates the enactment of occupational logics in interaction. In addition, the findings suggest a concrete means of linking institutional pressures to local enactments: institutional pathways. The literature on inhabited institutions carefully documents how local interactions serve as the mechanism by which institutional meanings and local interests intersect to create variation, but these studies do not often delve deeply into the characteristics of the institutional environment (see Hallett, 2010, for an exception). Both Binder's (2007) and McPherson and Sauder's (2013) studies included descriptions of institutional logics, but the characteristics of the institutional environment are not linked in a grounded way to the outcomes they find. By explicating the pathways through which forensic scientists encountered the influence of spillovers, this study models how dynamically tracing how institutional change is confronted in specific locales can help us understand responses to that change. Exploring such pathways would be a potentially fruitful way for scholars to start concretely analyzing the institutional environment in future studies.

When further exploring evaluative spillover in occupational fields, we should consider how to define and bound neighboring occupations. In other words, how far can we expect evaluative spillovers to extend? Strauss's (1978) notion of social worlds could be a helpful starting point here. We might define neighboring occupations as those occupations that "share commitments to action in an arena of social concern" (Clarke, 1991: 138). This encompasses both related activities and overlapping interests; without these, we would probably see less evaluative spillover. The study suggests that having overlapping audiences is an indicator of neighboring occupations—in some ways the NAS report defined the field in which evaluative spillover occurred. But because this was an ethnographic study set in a field of closely related occupations with the same evaluating audiences, it cannot provide a definitive answer to defining neighboring occupations; instead I raise this as a question for future studies to explore.

The Entwinement of Occupational Values and Technique in Responses to Technological Change

This study shows that the relationship of occupational values and technique is critical in shaping responses to technological change in a field. We know that workers resist deskilling in a variety of creative ways (Braverman, 1974; Wilkinson, 1983). Moreover, in some cases of technological adoption, high-status occupations can use their power to mandate change that may be detrimental to the work of lower-status groups (Barrett et al., 2012; Pine and Mazmanian, 2017). And as other studies in the inhabited institutions tradition have noted, knowledge workers may try to repel the erosion of their expertise (Hallett, 2010; Huising, 2015). Yet resistance to technological change is a complex dynamic influenced by more than just status and power.

By charting occupational values and technique with respect to evaluative spillovers from technology, we develop a more fine-grained image of how workers respond to change. For firearms examiners, the idea of becoming more like DNA profiling was an affront to their values of holistic, subjective judgment, and they found analogies to their technique inexplicable; they thus robustly resisted changing their practices. In narcotics, although the analysts knew that one of their analytic methods fit closely with the standards of DNA profiling, their values of craft judgment and variety were also strongly challenged by the comparison with DNA. In contrast, the toxicologists embraced the change suggested by evaluative spillovers from DNA profiling: not only was it relatively straightforward to incorporate into their technique, but also they valued the error-reduction aspects of the change.

The analytic tactic of disentangling technique and values while considering them simultaneously therefore provides some insight into what motivates occupational groups to resist change. Considering technique without values would suggest that if their technique was consonant with the new technology, occupational groups might be more sympathetic to changing their practices. But the case of narcotics analysts, trained to perform a compatible analytic technique, demonstrates that they interpreted the use of these techniques with respect to their occupational values of variety and craft judgment and thus resisted changing their practices. Moreover, this analysis shows that values and technique are inseparable in practice. The values that occupation members share are rooted in the work itself and thus are intertwined with their techniques: good toxicologists value obsessive avoidance of error as a consequence of seeing what happens using their techniques if those values are not enacted. It thus should not be terribly surprising that they also interpret new technologies within the framework of the values and techniques they use in their work.

This study demonstrates that technological change through occupational spillover unfolds within intertwined occupational interpretations of technique, expertise, and values. In this case, the initial impetus for change in forensic science was the evaluative spillover from a high-status legitimate technique, DNA profiling. Yet the status and power of toxicologists, narcotics analysts, and firearms examiners were much less important to the outcomes than the nature of the work: the specific occupational values each group held and how these were instantiated in the practices they used. To truly understand how technologies affect expert work requires developing detailed, deep understandings of occupational cultures and examining how these influence meaning making and action.

Evaluative Spillovers and Occupational Change

This study explored one field in which neighboring occupations responded to evaluative spillover, but we can see similar evaluative dynamics unfolding in other complex domains of knowledge work. Close to home in the academic social sciences, the recent replication debates bear a striking resemblance to DNA envy. As psychologists became worried about the reproducibility of experimental results (Open Science Collaboration, 2015; Gilbert et al., 2016), the professional and public discussions about their replicability crisis spilled over to other social sciences. Notably, ethnographers in sociology responded in a blog in the American Sociological Association's public magazine, *Contexts*. Murphy and Jerolmack (2016), the authors, commented that "demands for data transparency are sweeping the social sciences.'' Ethnographers do not typically use experimental technologies, nor is ''replicability'' a culturally shared value for ethnographers, who primarily analyze qualitative data to build, not test, theories. Yet these scholars interpreted this pressure as suggesting ethnographers rethink ''the long-held convention of masking—the practice of hiding or distorting identifying information about places, organizations, and people.'' In academia, where evaluative pressure is keen, it is not surprising that evaluative spillover complicates occupational dynamics. On the basis of my findings here, I would expect a lot of resistance to change on the part of ethnographers: anonymity of sources is a strongly held occupational value that is instantiated in practices as well as established in universities' Institutional Review Board (IRB) norms, and the particular institutional path taken by the comparison (a public blog of the ASA) is not a very immediate one for sociologists.

Finally, given the broad impact that digital technologies are expected to have on the workplace, evaluative spillovers from such technologies are likely to spread more widely within and across industries. As mentioned, doctors are now being evaluated in terms of a standard of care that includes technological savvy (Samydurai, 2016). Similarly, professionals across fields from media and advertising to banking and insurance are feeling pressure to develop perspectives on the implications of AI, big data, and blockchain to present to their clients, even if they are not planning to use such digital technologies for their work (ATKearney, 2017; Michaelis, Lenhard, and Hunke, 2017). To understand how these new technologies affect work and expertise, it is crucial to examine how workers themselves interpret them within the framework of their occupational cultures, organizational structures, and institutional influences. This study demonstrates that technology not only changes work directly but can prompt evaluations that may change occupational practices in a field.

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