Asymmetric Epistemology: Field Notes from Training in Two Disciplines

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The epistemic barriers to interdisciplinarity are understudied. To fill this gap, we ask whether a university initiative designed to reduce structural barriers to interdisciplinarity also facilitates the dissolution of epistemic ones. Through analytical autoethnography of graduate training in two disciplines, sociology and ecology, we develop the concept of asymmetric epistemology to better understand the unique epistemological position that emerges for interdisciplinarians. Building from feminist science and technology studies (STS) and scholarship on epistemic identities, our work illuminates how epistemologies are embodied by individuals, leading to tensions around identity, materiality, and spatiality during the practice of interdisciplinarity. While some epistemic barriers recede and others remain, we reveal that the navigation of these boundaries deeply impacts individuals' epistemic identities.

1. Introduction

The practice of interdisciplinarity[1] is challenging, complex, and still understudied despite the prevalence and continued growth of interdisciplinary

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1. There is much debate regarding the terms interdisciplinarity, multidisciplinarity, and transdisciplinarity. We choose to use the term interdisciplinarity because it was used in the initial university grant to gain funding for the program at the heart of this analysis.

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research institutes, departments, and scholarship. In this paper, we bring much needed reflexivity to bear on the epistemic barriers to interdisciplinary research. Through analytical autoethnography of our graduate training in two academic disciplines, we develop the concept of "asymmetric epistemology" to explain the unique epistemological position that emerges for interdisciplinarians. In so doing, this article makes an important intervention in the literature on interdisciplinarity. By taking a phenomenological approach, we show how epistemologies are embodied, creating durable obstacles for interdisciplinarians.

Previous sociological work identifies administrative barriers, disciplinary structures, and epistemic boundaries as challenges to interdisciplinary research (Mukerji 1989; Klein 1990, 1996; Turner 2000; Abbott 2001; Frodeman and Mitchum 2007; Jacobs and Frickel 2009; Downey et al. 2016; Frickel et al. 2016). Literature on the persistence of disciplines takes a largely structural approach toward the first two boundaries, focusing, for example, on how administrative and disciplinary distinctions are buttressed by job market stability (Abbott 2001), the specialized journals, conferences and departments that insulate communication (Jacobs and Frickel 2009), and organizational isomorphism (DiMaggio and Powell 1983; Frank and Gabler 2006; Sá 2008).

We, however, look at epistemic barriers—an overlooked aspect of the scholarship on interdisciplinarity—by integrating scholarship on epistemic cultures and identities (Knorr-Cetina 1999; Osbeck and Nersessian 2017) with the well-established feminist STS literature (Haraway 1991; Harding 1992; Allen 2001; Clarke 2001; Mayberry et al. 2001; Law and Singleton 2013). Epistemic boundaries, as described by Knorr-Cetina's (1999) work, include the incompatible styles of thought, research traditions, techniques, and languages that emerge through processes of knowledge and culture making. Within the literature, scholars suggest that these boundaries are made all the more apparent as interdisciplinarians attempt to cross them—either through collaboration with scholars from other disciplines or by conducting interdisciplinary work themselves.

Attempts to eliminate these three types of boundaries—administrative, disciplinary, and epistemic—are evident in new institutional efforts to promote interdisciplinary scholarship, including Brown University's Open Graduate Education Program (OGE), with which we are both affiliated. This nascent initiative provides doctoral students enrolled in one department the opportunity to earn a master's degree in a second department, "free of any disciplinary barrier."[2] Combinations include Engineering

2. Taken from the first paragraph of the introduction on the program's webpage: https://www.brown.edu/academics/gradschool/opengraduateeducation

and Archeology, Religious Studies and Anthropology, and Chemistry and Computer Science, as well as our own choice: Sociology and Ecology & Evolutionary Biology (EEB). The stated purpose of the program is for graduate students to combine fields of study and build expertise in more than one area, regardless of how related or disparate these disciplines are. With this institutional support, we simultaneously were graduate students in two departments—one social science and the other natural science. In this situation, interdisciplinarity is not simply communicating or collaborating with other disciplines, but living in-between intellectual spaces by training in both. Our case of this individual experience of being in two disciplines at the same time exposes epistemic boundaries that the literature has not yet investigated.

Sociology and EEB are distinct within the tacit science hierarchy, and at times they exhibit incompatible epistemologies (e.g., interpretivism and postivism) (Sievanen et al. 2011). However, the disciplines also have similarities, given that they both seek to make sense of interactions at multiple scales. They are at times paired in interdisciplinary environmental scholarship as both grants and research institutes acknowledge the need for increased socio-ecological research to address global problems (Sievanen et al. 2011). Our formal training in both disciplines—separately but concurrently—uniquely subjected us to two different routinizations of dialogue and methodological rigor. As individuals, we became the site for the reproduction of disciplinary norms. Though we were training and conducting research in sociology and ecology separately, we had to navigate how to practice both disciplines at once. The program thus provides an ideal opportunity to explore the following question: By lessening the administrative and disciplinary boundaries to interdisciplinarity through institutional policies, can—and normatively, should—the epistemic boundaries dissolve as well? We use 18 months of analytical autoethnography of our interdisciplinary experiences to show the details and complexities of living between two epistemic cultures.

Our analysis is predicated upon the reciprocal relationship between individuals and institutions in defining the epistemic culture of a given discipline, or what is more broadly understood as social epistemology (Goldman 2011). Individual researchers are part of discipline-based social relationships and institutions that dictate what is considered good and bad scholarship. These social conditions are thus embedded into individual epistemic identities. However, as individuals change their research agendas by, for example, conducting interdisciplinary research, they also shape the institutions and epistemic cultures of which they are a part (Goldman 2011). Individual epistemic identities are shaped by disciplinary epistemologies; such epistemologies, in turn, develop according to the identities

of those who make up the discipline. Though there are many other factors that shape the epistemologies of a given discipline, such as funding, subdisciplinary specialty organizations, historical origins of the discipline, and objects of inquiry, our investigation only focuses on how these epistemological distinctions between disciplines affect the individual and not vice versa.

More specifically, we demonstrate that through interdisciplinary training, some epistemic boundaries between disciplines dissolve or are more easily traversable while others remain persistent. We postulate that one reason for the durability of disciplinary epistemologies is because they are embodied in individual researchers. We call the interdisciplinarian's resulting interstitial affective and epistemological stance toward scholarship asymmetric epistemology. As a counterfactual, symmetric epistemology serves as the theoretical point at which scholars travel effortlessly between disciplinary cultures, practices, and spaces.

Identity, materiality, and spatiality emerged from our analysis as three themes that connect to the forming and dissolving of epistemic boundaries, as discussed in the empirical sections of the paper. In the ideal type of symmetric epistemology, these themes would remain unchallenged and perhaps largely irrelevant for the researcher in any disciplinary context. In practice, however, interdisciplinary researchers find tensions around identity, materiality, and spatiality as they toggle back and forth between disciplinary worlds. Or, put in other terms, interdisciplinarians are faced more often with three recalcitrant questions: who are they (identity), what are they studying (materiality), and where are they studying it (spatiality)? Given that epistemology is embodied, and thus travels with interdisciplinarians across disciplines, challenges emerge for scholars trying to answer these questions as they move.

2. A Brief Background of the Sociological Literature on Interdisciplinarity

In recent decades, universities have restructured to accommodate interdisciplinary research institutes and training programs (e.g., Klein 1996; Brint 2005; Brint et al. 2009; Jacobs and Frickel 2009; Frickel et al. 2016). And in some cases, departments have expanded to include a wider array of intellectual traditions. Meanwhile, the National Science Foundation (NSF) and other large funding institutions have made interdisciplinarity a research focus. Scholarship on interdisciplinarity is growing along with its real-world progress, addressing a plethora of issues including the persistence of disciplines (Turner 2000; Abbott 2001), the emergence of "interdisciplines" (Frickel 2004), the dynamics of interdisciplinary collaborations (e.g., Smith-Doerr et al. 2016; Osbeck and Nersessian 2017), and

the flow of knowledge across disciplines (van Leeuwen and Tijssen 2000; Rinia et al. 2001; Rawlings et al. 2015).

A key issue addressed by scholars of interdisciplinarity is the question of whether disciplinary boundaries can be dissolved. In his landmark piece on *The Chaos of Disciplines*, Andrew Abbott (2001) argues that the durability of disciplines is due to their structural and cultural functions in academia. The academic job market plays an important role in structurally reinforcing the institutional organization of disciplines within universities by hiring primarily within disciplines (Turner 2000; Abbott 2001). From a cultural perspective, Abbott (2001) argues that disciplines prevent intellectualism from becoming too abstract by keeping academia rooted in distinct disciplinary norms. On the other hand, Abbott holds that interdisciplinarity is not new, but in fact has persisted continually and organically since the emergence of academic disciplines.

Despite whether or not interdisciplinarity is a recent endeavor, the fact remains that scholars, especially in sociology, are increasingly publishing articles on the topic (Jacobs and Frickel 2009; Frickel et al. 2016). Because of such growth, this paper does not purport to provide a complete analysis of the current sociological literature on interdisciplinarity. We identify only the major trends in order to lay the foundation for as-of-yet unexplored intersections with STS. Interdisciplinarity is an especially important topic for sociologists given the influence of social movements on science production (Frickel 2004; Frickel and Gross 2005; Rojas 2007) and the common enrollment of sociologists in interdisciplinary research teams, programs, and institutes that address complex socio-ecological and socio-political issues, such as climate change (Shove 2010; White et al. 2015) and biotechnology (Heimeriks 2012). The nearly universal acceptance that interdisciplinary research is commercially successful is another explanation for the growth of work on the topic (Nowotny et al. 2001).

What are the implications of this institutional and intellectual expansion? Some argue that because interdisciplinary research is largely problem-driven, it will not challenge the status quo of structural and cultural academic topographies (Klein 1990; Abbott 2001; Frodeman and Mitchum 2007). On the other hand, more optimistic readings of interdisciplinarity suggest that boundary-crossing research can in fact create new epistemologies, methods, and divisions of labor (Mukerji 1989; Turner 2000; Frickel 2004; Rojas 2007).

In general, the literature on interdisciplinarity can be overly celebratory, assuming that that traditional academic disciplines constrain interdisciplinary work and that interdisciplinarity is unfettered by disciplinary hierarchies (Frickel et al. 2016). Scott Frickel et al. (2016) suggest in their recent book, *Investigating Interdisciplinarities*, that the sociological work on

interdisciplinarity has yet to thoroughly scrutinize the effects of interdisciplinarity on researchers, students, and knowledge. Of particular concern to these authors is the scarcity of work on the institutional and political support "from above" for interdisciplinary work (Frickel et al. 2016). Their edited volume makes it clear that interdisciplinarity is not as unquestionably positive as it seems, but in fact, is fraught and ambiguous. For example, research on interdisciplinarity at the Canadian Institutes of Health identifies the power struggles for scientific authority between social sciences and humanities (Albert et al. 2016).

In an attempt to reframe research on interdisciplinarity, Downey and colleagues (2016) argue that interdisciplinary work cannot be seen as purely an intellectual product, but rather an intellectual process. By taking this processual lens, the ambiguity around interdisciplinary work—how to define it, what methods to use, what theories to use—can be better understood (Smith-Doerr et al. 2016). In other words, the process of producing interdisciplinary work is an outcome in and of itself, at times a blending of disciplinary norms, and at other times dominated by one discipline.

Overall, the literature's greater focus has been with organizational scholarship on the administrative and disciplinary boundaries of interdisciplinary research, while much less has been done to study the epistemic boundaries. We contribute toward filling the gap on epistemic boundaries by drawing upon the analytical value of interdisciplinarity as a process (Downey et al. 2016), the relevance of disciplinary hierarchies, and the effects of interdisciplinarity being promoted "from above" on researchers and students (Frickel et al. 2016)—all identified as important by the sociological research. We add to this body of work by examining the consequences of disciplinary and epistemic boundary-crossing, across the natural-social science hierarchy, on individuals' sense of self and their work as researchers. To sum up, our research makes two important contributions: (1) a focus on the phenomenological experience of the interdisciplinary process; and (2) attention to epistemic boundaries for interdisciplinarians.

3. STS Literature on Epistemic Barriers and Identities

Epistemic barriers define the cultural terrain of science, maintained by "boundary work," or scientists' efforts to defend the cultural boundaries between science and other activities such as religion (Geiryn 1983). Demarcating boundaries between science and non-science serves to establish the distinct norms and values that characterize scientists as scientists and science as science. While boundary work sets up divisions between cultural fields, "boundary objects" serve to travel across them. Boundary objects are the standardized, consolidated outputs from research such as maps and graphs that can be understood by various actors across disciplines and professional fields

(Star and Griesemer 1989). Understanding how scientific boundaries are protected and crossed is important for conceptualizing how disciplinary boundaries are maintained or dissolved through interdisciplinarity.

Within the STS literature, scientific disciplines are, in part, defined by their epistemic culture, which Knorr-Cetina (1999) describes as a product of technological processes and social organization, an "amalgam of arrangements and mechanisms—bonded through affinity, necessity and historical coincidence—which in a given field make up how we know what we know" (1999, p.1). Knorr-Cetina pays attention to scientists' sensory ways of knowing and strategies for preserving embodied experience, typified through manual work and stories that enhance the laboratory experience. Recent work has shown that epistemic cultures can be redefined within small organizations, such as interdisciplinary research teams, creating unique approaches to knowledge production that defy the traditionally understood epistemic cultures of one discipline or another (Smith-Doerr et al. 2016).

In addition to material objects and social organizations, Kohler (2002) argues that the physical spaces disciplines occupy are an important factor influencing their epistemic cultures. He focuses specifically on the importance of the field and the laboratory as distinct cultural spaces within a border discipline that incorporates both, like his case of biology. Our fields—sociology and ecology—hold their own epistemic cultures. Both are also border disciplines in which research moves across distinct spatio-cultural environments where fieldwork and analysis occur.

To bridge the distinct spatial worlds that reinforce disciplinary boundaries, new interdisciplinary research spaces, like the Wisconsin Institutes of Discovery at the University of Wisconsin—Madison campus, make architectural considerations to foster disciplinary overlap and collaboration (Downey et al. 2016). These accommodations reflect the ways in which space is a factor in the formation of epistemic cultures both within a discipline and between disciplines. Interdisciplinarians do the hard work of living across epistemic cultures, constructing their asymmetric epistemologies as they explore and ask questions in these multiple cultures. The process of navigating epistemic cultures spatially therefore has a very real impact on the individual.

Recent work has emerged to examine the interconnectedness of identity and disciplinary training (Osbeck and Nersessian 2017), which provides important insight into the way that being interdisciplinary is both a social and personal act. Osbeck and Nersessian put forth the notion of epistemic identities, arguing that an "affective dimension, a relation to self-representation, and a relational tie to other possible identities…must be included in the effort to understand the intricacies of social and personal dynamics in the intergroup relations that enable interdisciplinary science" (Osbeck and Nersessian 2017, p. 228). Their analysis of interdisciplinary bio-medical

engineering research demonstrates that participants develop a "complex identity formation" incorporating the "conflicting ideologies concerning good science, the norms and standards specific to disciplinary specialties, specialized tasks, [and] theoretical framework(s)" (Osbeck and Nersessian 2017, p. 254).

However, Osbeck and Nersessian focus on how epistemic identities come to the fore through collaboration in interdisciplinary teams, for example between a sociologist and an ecologist, joining the team from their own disciplines. Building from this important work that places identity and epistemology as central to understanding interdisciplinarity, we argue instead that scholars who are themselves interdisciplinary form pluralistic identities (e.g., sociologist and ecologist) and hybrid identities (e.g., socio-ecologist). We focus on this experience for plural-hybrid individuals, especially those who traverse the power-laden social and natural science divide, itself protected through boundary work and authority claims.

4. Theoretical Intervention: Asymmetric Epistemology

We put forth a new concept called asymmetric epistemology that addresses gaps in the sociological literature on epistemic barriers to interdisciplinary research by drawing from the STS literature on epistemic culture and identity. Feminist STS theories are also central to building our concept. Asymmetric epistemology illuminates the multiple and, at times, unequal identities that interdisciplinarians hold, simultaneously, as they cross entrenched academic fields. The foundational ideas of plurality, hybridity, and standpoint from feminist critiques of onto-epistemic symmetry provide the platform for conceptualizing the embodiment of multiple epistemologies within the individual (Fujimura 1991; Haraway 1991, 2010; Star 1991; Harding 1992, 2015; Singleton 1996; Law and Singleton 2013).

For example, Actor Network Theory (ANT) is premised upon the idea of "generalized symmetry," which refers to a flattening of the social landscape to treat all humans and non-humans with epistemological and ontological equivalence (e.g., Callon 1986; Latour 1990). In critique of ANT and Latour, Fujimura (1991) writes:

> In contrast to Latour, I am still sociologically interested in understanding why and how some human perspectives win over others in the construction of technologies and truths, why and how some human actors will go along with the will of other actors, and why and how some human actors resist being enrolled … I want to take sides, to take stands. (Fujimura 1991, p. 222)

This quote foreshadows one of the outcomes of our asymmetric epistemology: we are scholars who sometimes resisted being "enrolled" in

ecology. Since we were trained first in sociology and second in ecology, we brought with us sociological perspectives on research that we could not or did not want to unlearn. In this case, a feminist approach to science means refusing to discard any selves, to "pass" or to become "pure," and acknowledging multiple membership (e.g., Fujimura 1991; Haraway 1991; Star 1991; Harding 1992). Interdisciplinarity therefore becomes a feminist act when one is both sociologist and ecologist or socio-ecologist, regardless of one's current disciplinary context.

Asymmetric epistemology bears resemblance to Sandra Harding's seminal work on "strong objectivity," which argues that researcher bias and previous life experiences can inform a deeper understanding of objective science (Harding 1992, 2015). Scholars are not value-neutral and instead use various academic and non-academic epistemologies to inform their research—a constant theme throughout feminist STS (e.g., Law and Singleton 2013). As Law and Singleton write, "there is no neutral place," and science is best understood when "located" (Law and Singleton 2013, p. 486). What these authors mean is that one's standpoint matters for science production, because it shapes the kind of questions they ask, the methods they use, and the applications of their research. While Harding and others initially used the idea of standpoint to address feminist scholarship, it has since been used as a platform to explain the tensions that arise for interdisciplinarians, especially for those traversing the social and natural science gulf where the conflict between objectivity and standpoint can be unresolvable (Allen 2001; Ginorio 2001; Mayberry et al. 2001).

Interdisciplinary researchers bring engrained values across disciplinary boundaries, and these internalized values are in constant negotiation with disciplinary cultural norms and external expectations of a "good scientist" or a "good humanist." The result of this meandering between distinct disciplinary worlds is the recurring sentiment of idiosyncrasy (Mayberry et al. 2001). An anthology of feminist STS (Mayberry et al. 2001) calls interdisciplinarians "intrepid travelers," enduring a unique and oftentimes isolating experience, and self-described as "schizophrenic" (Ginorio 2001) and holding "dual citizenship" (Allen 2001). As researchers cross epistemic cultures, they find that their own identities shift (e.g., from sociologist to ecologist, or vice versa), turn plural/multiple (e.g., ecologist and sociologist simultaneously), or become hybrid (e.g., socio-ecologist). These epistemic identities, as we show in our analysis, are shaped by internal values, social interactions in disciplines, objects of study, and places of study—all of which are implicated in the barriers that can emerge or dissolve through interdisciplinary research.

In short, the upholding and blurring of epistemic barriers are embodied processes for the interdisciplinarian. Living with multiplicity in settings

where it is not the norm is at the center of the individual experience of interdisciplinarity. Within this multiplicity are the status hierarchies of disciplines, which can further tear at the researcher's sense of themselves as a "good scientist" or "good humanist." We also demonstrate that the negotiation between interdisciplinary researchers' internal and external worlds is affected not just by the multiplicity of the researcher but of the researched, too. In the following section, we discuss our methodology—analytical autoethnography—which serves as an ideal means with which to understand the epistemic barriers to interdisciplinarity.

5. Methodology: Analytical Autoethnography

Autoethnography offers deep insight into the effects of interdisciplinarity at the level of the individual and reflexivity during interdisciplinary training and practice. According to Ellis and colleagues, "Autoethnography is an approach to research and writing that seeks to describe and systematically analyze (graphy) personal experience (auto) in order to understand cultural experience (ethno)" (Ellis et al. 2011, p. 273). Autobiography and ethnography blend, making autoethnography both a process and a product.

Furthermore, autoethnography emerged as a strategy to challenge universal narratives through revealing the entanglement of "facts" with scientists' vocabularies and ways of knowing. Typically, scientific research takes for granted a disciplinary perspective, whereas autoethnography enables a more nuanced understanding of knowledge production by merging personal experience with the analytical, thereby challenging the "canonical ways of doing research and representing others" (Ellis et al. 2011, p. 273). Autoethnographic methods are able to capture researchers' experiences as multiple selves—here, as sociologists, ecologists, and women—without fitting them to a singular disciplinary narrative. Notable scholarship employing autoethnographic methods has focused on, among other issues, gender (Keller 1995; Roy 2004; Giordano 2014), sexuality (Foster 2008; Adams and Jones 2011), race and ethnicity (Boylorn 2006; Tsalach 2013), and, most relevant to our work, interdisciplinary research (Allen 2001; Clarke 2001; Ginorio 2001; Winskel 2014).

More specifically, we adopt analytical autoethnography as our approach (Anderson 2006). This requires the researcher to be: "(1) a full member in the research group or setting, (2) visible as such a member in published texts, and (3) committed to developing theoretical understandings of broader social phenomena" (Anderson 2006, p. 375). This approach carries the same methodological rigor associated with ethnography, but the ethnographer is also a full and visible member of the group or phenomenon under study.

Through our analytical autoethnography of interdisciplinarity, we seek to shed ready-made explanations of knowledge production and instead rely upon rich description. As interdisciplinarians in a newly minted program, we are an experiment in translation across disciplines and, in a similar vein, we seek to use ethnographic methods as a means to translate across the human and non-human world (Baiocchi et al. 2013). In this sense, translation takes on a double resonance for our methodological approach.

We conducted 18 months of autoethnographic fieldwork during 2014 and 2015 while working on two separate ecology projects, with different research groups and advisors, as part of our interdisciplinary graduate training. Apollonya's research focuses on how the diets of juvenile bluefish in New England fisheries reflect their northward migration and larger processes of productivity exchange between salt marshes and the open ocean. Amy's project examines how reusing waste from large-scale chicken production as different forms of fertilizer on cornfields may affect nutrient pollution in the waterways of the Chesapeake Bay region. Apollonya spent time casting her fishing rod from boats and the public docks along the windswept salt marshes of Massachusetts, while Amy worked collecting water samples from the soils of experimental agricultural fields in the coastal plain of Delaware and the rolling hills of Pennsylvania. After fieldwork, we analyzed our fish and soil water samples in different laboratories. We aggregate our separate autoethnographic field notes from these experiences to inform the paper's arguments about interdisciplinarity.

6. Results: Tracing the Path to Asymmetric Epistemology

Our asymmetric epistemology starts from our internal worlds as scientists and works outward to include the technologies, other non-human actors, and social organizations that frame our individual experiences. We juxtapose the opening of some spaces with the closing of others, while also creating an oscillation effect between the internal and the social that broadens as our experiences as interdisciplinarians expand. We proceed in chronological order and focus our analysis on commonalities across our two cases rather than on differences. Asymmetric epistemology is characterized by the three dimensions drawn from our data and the feminist STS literature—identity, materiality, and spatiality—and the three questions that parallel those dimensions.

6.1. Identity: Who Are We?

Being trained first in sociology, the transition to being dual ecology and sociology graduate students created a struggle of identity. How do we, as interdisciplinarians, fit between social and natural science, and how are we

perceived by others? We needed to locate ourselves in relationship to our production of new knowledge through two quite different traditions. This question of who we were followed us across disciplines, and our answer formed more strongly in the moments when we encountered the epistemic boundary at the crossing from sociology to ecology. We found that identity is tied to intellectual autonomy, as well as experiential and embodied knowledge.

As interdisciplinarians, we felt the obligation to legitimize our selves, our presence, and our approaches to research in both the ecology and sociology departments. In sociology, we petitioned for the inclusion of environmental factors in sociological research in a way that avoided the oversimplification of ecological processes. And in ecology, we argued for the inclusion of social dimensions in research on environmental problems that extended beyond the dominant paradigms of economically driven human action and quantitative analysis.

However, ambiguity about how to navigate these two worlds was pervasive. Amy posits,

> How can I reconcile wanting to be a reflexive social scientist (and natural scientist) with positivist natural science? This *is* why I am in the Open Graduate Education program… to learn and understand what positivism in natural science means. This is why it feels so taxing, so much energy to mode switch… it's having to navigate ecology from my standpoint where values and subjectivity matter.

Our increasingly ambiguous and conflicted academic identities were related to the differences between the epistemic cultures of ecology and sociology. First, in joining the ecology department we noticed the uneven trade-off between individual autonomy and community. Regular lab meetings are an opportunity to update the advisor and to plan the next steps in a project, and advisors dutifully read and give feedback on research and writing to align with the lab's way of doing things. Within this apprenticeship system model, and unlike in sociology, final decisions are made by the advisor. In an early lab meeting Amy writes, "the perceived loss of autonomy is unsettling… In sociology, I always feel like I can have an opinion on my projects, others' projects, or papers I read."

During a fieldwork conversation with ecology graduate students, a colleague responded to our lack of regular meetings with advisors in sociology: "That can't be good for the development of your field. I think of grad school as an apprenticeship sort of thing." This aspect of ecology's epistemic culture maintained through lab meetings and regular contact builds a stronger base of commonality around acceptable research questions and how to answer them. We found this close attention to reproduction of the epistemic culture within the community jarring. Because, we, as sociologists already worked toward

publishing sole-author papers early in graduate school, we were concerned about giving up our academic agency in the apprenticeship epistemic culture of ecology. We bristled against the stronger weight of advisors, post-docs, and other ecologists more advanced in their careers. As we would come to find out though, ecological research relies upon collaborative teams in a way that much of the sociological research does not.

Part of our internal crises around epistemic identities had to do with field experience. Given the importance of experiential knowledge in biological disciplines (Knorr-Cetina 1999; Kohler 2002), we were tested in our development as ecologists by having to gain experiential skills for fieldwork, such as driving a boat, in addition to learning ecological research methods. Apollonya was told by an advisor to her ecology project, "it's always good to just check in with the water…see what's there, get your hours in on the water. Part of increasing your knowledge base is just the experience—being out on the boat, in the marsh, in different sorts of weather, and different times of year." The archetype of the ideal ecologist who "just goes out there" to the salt marsh like it is a comfortable second (or preferred) home was tempered by Apollonya's anxiety of starting the boat engine. At the Plum Island field station there was one shared boat, the Apeltes. The Apeltes required a pull string to get the engine going, and it took Apollonya three months of fieldwork to get the stance, timing, and strength in perfect coordination to get the engine started.

Nodes of experiential knowledge proved to be useful for our early endeavors in the field. Amy relied heavily on the broader community of fellow ecologists, notably two graduate students from another university, to learn how to construct lysimeters—the tools she used to collect soil water from under cornfields. No one in her lab had yet worked with the materials Amy needed for fieldwork. As a result, she relied upon her lab's social network to find individuals with experiential knowledge. She participated in a "paying it forward" process common among ecologists—borrowing techniques from someone with greater experiential knowledge and then leaving behind a protocol adjusted through trial-and-error for future ecologists.

In Apollonya's case, the local bait shops were regular stops on her daily fishing adventure. She consulted with the owners and fellow fishermen who passed through, finding any opportunity she could to talk about bluefish. The first time she walked into a bait shop to ask about juvenile blues in Plum Island Sound, the owner responded by pulling out a topographic map of the region, and Apollonya, accordingly, pulled out her field notebook to note the best fishing locations, or "honey pots."

The language used to speak about the marsh reflected a division of experiential knowledge and vocabulary between academics and non-academics. The ability to navigate between both the academic jargon and

non-academic vernacular showed true experience in the Plum Island field station. The Latin name for marsh grass, *Spartina alterniflora*, was shortened to TSA and used largely by fellow biologists at the field station. However, expressions such as "boiling water" to describe the effect of juvenile bluefish in a feeding frenzy were used colloquially by the owner of the marina and other avid recreational fishermen in the area.

Despite our desire to retain our sociology identities, we had to become sufficiently ecologist to develop the experiential knowledge related to language and social networks to complete our fieldwork. However, more deeply embodied forms of knowledge were another matter. The value placed on experience was not solely related to the amount of time spent in the field or to the tangential skills we needed to know; just as significant was our dress, language, and overall self-representation.

Upon arriving at the field station for her first day in early June, Apollonya realized very quickly that she was not prepared to go into the marsh. There were specific boots, sun-blocking shirts, and long water-repellent pants to wear. For both of us, our level of experience in the marsh and on the farm could be measured by how worn our hats became, the shape and severity of our sunburns, and how much mud (or chicken feces) was caked in the soles of our shoes. The embodiment of ecology was further tied to our practice of gender with fellow ecologists on our field teams, and with collaborators outside the academy (Teller and Porcelli 2016). In sum, we spent much time in the field trying to embody the singular ideal ecologist, knowing we were not, as a means to justify our intellectual contribution to the discipline.

As this section shows, interdisciplinarity reinforces disciplinary identities during the process of doing research. Transitioning between these two academic fields was difficult due, in part, to our identity as sociologists first and ecologists second. Being an ecologist meant being able to fulfill the skills we needed to conduct our fieldwork and our embodiment of those skills. We identify with some aspects of ecology's epistemic culture, like the value of collaboration. Ultimately, however, we felt that our identities as sociologists remained prominent throughout our training across epistemic cultures. We practiced ecology enough in order to enroll, but aspects of ecology's epistemic culture, including the apprenticeship system, experiential skill sets, vocabulary, affinities, and dress, clashed with our sociological affinities in a way that made full emersion in ecology difficult. In terms of identity, we were plural but sociology came first no matter where we stood in boundary crossing.

6.2. Materiality: What Are We Studying?

As we progressed through our ecological research, we found that we could not unlearn our sociological training, which influenced the ontological plurality with which we saw our field sites. This aspect of sociology's

epistemic culture—ways of thinking about materiality—travelled more smoothly with us into ecological fieldwork. Throughout our fieldwork we found that our research subjects and materials were themselves plural—what was once a wild animal became flesh, and what began as an assortment of hardware materials became a scientific tool. And as the enactments between the researcher and the researched changed throughout the data collection process, we were forced to question our own values as those, too, became slippery.

In our attempts to be successful ecologists we found ourselves relying upon certain non-human actors to give meaning to our fieldwork, whose meanings also changed given external pressures and internal values. Fishing is a classic case of this. Lures imply temptation and each person Apollonya consulted had a different approach to luring the bluefish out of the water. Tom suggested diamond jigs, while Nat thought Charlestown spooners were the best bet, with deadly dicks a close second. All three of these lures are shiny and catch the glimmer of the sun, making them resemble silversides, common prey for bluefish. The spooners and deadly dicks also appeal to our anthropomorphic, gendered, and sexualized ideas of insertion and removal; using a rattler with a skirt catches the fish's attention by making noise or small splashes on the surface. Michel Callon famously asked about Atlantic scallops in St Brieuc's Bay: "Does *Pecten maximus* anchor?" (Callon 1986, p.70). In this case, a similar question could be posed: Is *Pomatomus saltatrix* (bluefish) tempted?

In response, Apollonya notes,

> Fishing poles are ways of "talking to" the fish. Whatever the type of pole, leader, or lure, fishermen are trying to seduce the fish, trying to be attractive but also to seem "natural" to the fish. Even in the way that we cast and then jerk the pole, we try to imitate being an "injured prey fish" in order to convince the predator fish to bite us.

The pole was an extension of her arm, and the line an extension of the pole. The lure was the bait—it had to be exactly positioned in the right water column at the right depth—and all of these factors had to be in perfect synchrony to appear natural. In effect, Apollonya was learning to think like a bluefish, which reflects the "slipperiness" of fish-as-beings, or ontological equals (Law and Lein 2013). By slipping into being and thinking like a fish, this also meant that Apollonya had to incorporate being and thinking like a predator, tempted by the lure of a splash or a shimmer.

Meanwhile, Amy was practicing her own ontological enactments, transforming hardware store goods into research technology. She found that it made this work feel surprisingly amateur and accessible, building her own

tools mostly from hardware store materials and only one piece ordered from a scientific materials company. "I know I'm using an established protocol and not inventing the lysimeter, but I'm still creating them from scratch," she notes. As she installed the lysimeters that had taken months to plan and construct, she writes,

> First step, measuring out and marking the plot sizes with tape measures and flags. Next step, getting our hands dirty. We took augers (long poles with a handle on top and a sharp cylindrical piece at the bottom) and twisted them down into the soil to create holes for the lysimeters. After 20 minutes of this, a hole was ready. The silica slurry (to help draw water to the pores of the lysimeter) slopped down into the hole, then the lysimeter squished into it. After seeing them daily and being able to tend to them in the lab, it was difficult to let them go down into the ground where they were on their own—agency! After this, I refilled some of the soil around and on top of the lysimeter, so that only their tubes to carry water extended above the surface.

At first, the process of building her own tools reflected Amy's anxieties about her own capabilities in ecology. We do not work with materials in the same way in sociology, leading to feelings like, "How could I possibly build a lysimeter from a pipe, a stopper, and some tubes that will actually do good science?" In effect, the lysimeter became a kind of boundary object that embodied her anxieties and defined the epistemic culture of ecological fieldwork. Amy writes,

> Never in sociology fieldwork do you get your hands quite so dirty like this. You typically don't feel your subjects as a social scientist (and probably shouldn't), but the soil was here in my hands, and I could see and feel that it was wetter down below. It changed color depending upon where in the [soil] horizon it was. At the surface [the soil] was littered with corn residue from past seasons…I can feel my work—it's all over my hands.

Things went wrong, as they so often do in the field, and when they did we saw that the intersection between humans and non-humans was blurry, muddled with feelings of frustration, helplessness, and extreme satisfaction. Throughout the summer, Amy found that some of her lysimeters were "giving her trouble," making it difficult to "coax the water" out of the ground. She grew increasingly frustrated because she could not see the problem. Her lysimeters, being three feet underground, would have to fix themselves, aside from one aboveground check, trimming the tubes that carry water above the soil surface to eliminate any tiny holes in them that

could be the problem source. By digging up the lysimeters, she would have compromised the integrity of her experiment. She could communicate by hand pumping for longer and with more force to draw water, but a few times the lysimeters never answered, and whether or not she would get a response was usually clear from the sensation she felt in her hands from the first pump. Given the clay soil at one farm, which dried in crumbly aggregates leaving spaces of air pockets within the soil and around the lysimeter cup, the vacuum necessary for drawing up water could not form during the driest periods of the summer season. Amy hoped for rain to moisten the soil and improve the performance of the vacuum.

Apollonya found herself similarly hoping for changes in climate: warmer waters. The unseasonably cold water temperatures and mild summer stalled the migration of juvenile bluefish up the East Coast from South Carolina where they began in early spring. As a result, her early attempts to catch the bluefish were pointless since there were no juveniles in the estuary. She spent two and a half months practicing her cast and becoming an expert in lures without collecting any fish specimens.

The first time she caught a bluefish, in early September, Apollonya was so eager to collect data that her moral compass disappeared. It became less about whether or not she was ethically killing the fish, but rather how many she could catch. She justified this mental transition "in the name of science." Over ten days of catching the "snappers," or juvenile bluefish, in early September, Apollonya heard the fish flopping around in the worn Home Depot bucket.

> It's interesting to think about the noises creatures make when facing certain death and the look on their faces. Some die with their mouths open as if gasping for breath (which fish don't do with their mouths). For some, their gills are so flared out you can see the crimson red tissue inside, standing in stark comparison to the silvery blue of their scales. I never knew how red their gills were.

What had been for many months mere flashes of silver in the murky, brackish water had now become red flesh. Apollonya was no longer thinking like a bluefish but like an ecologist, and the bluefish, once alive and tempted, was now something different: a research specimen.

Our interactions with research subjects and materials breached our morals at times—a vegetarian killing fish for science and an environmentalist using countless plastic bags to protect her tools from contamination. "How do you keep foregrounded the ironic and iffy things you're doing and still do them seriously?" Donna Haraway asked in a 1991 interview with Penley and Ross (1991, p. 4). This tension between academic research

and personal values spans the epistemic cultures of ecology and sociology. Both cultures are concerned with whether the knowledge produced through empirical research is worth the possible harms of the practice in the world. It was a point of commonality for our ecology colleagues and us—as we all struggled with our own grey areas of morality. Both sociology and ecology data collection come with their own inherent compromises—for example, the greenhouse gas emissions generated from hundreds of hours of driving to research sites in exchange for understanding how humans can be less disruptive to nutrient cycling. On the question of what we study, we were able to hybridize into socio-ecologists. However, coming from the social sciences into a natural science epistemic culture, we felt a special need to make compromises with our own values and do whatever necessary to produce research in line with ecology's scientific standards.

6.3. Spatiality: Where Do We Do Research?

Once our fieldwork produced research specimens—be it fish flesh or soil water—we moved to the laboratory where distinct spatial barriers affected our epistemological approach to scientific research. We noticed a rift between the laboratory and field absent from ecologists' epistemology. In our asymmetric epistemology, sociological considerations like context, continuity, and organizational patterns are still prominent. The lab and field are separate spaces and going between them marks a cultural shift.

We noticed how time was measured and experienced differently in the field and the lab. For Amy, time in the field was influenced by the experimental design:

> All the samples had to be collected the same day, and that was the measure of completion, not how long in hours it took. And the design dictated that I'd see the farm again in two weeks. It's kind of an interesting imposition of experimental time on top of more "natural" cycles. The weather and the corn's growing season dictate when the research starts and ends, but for the rest of the research, time is imposed by design.

However, at Apollonya's site, the tides told time:

> …when I can go out, set up [fishing] lines, when I can retrieve the lines. Every six hours there is a 9 foot fluctuation of the tide, flushing out all the water and refilling it. There is a board in the office that shows the height and time of every high and low tide in a day. I plan my research accordingly. Sometimes I would start my day at 5am, sometimes 9am.

Moving into the lab then created a temporal disconnect. For Amy, what took an entire agricultural growing season of field time, eight months, was

processed in the lab in two weeks. Time was measured not by the passing of the sun overhead or the experimental design, but by the whirring of the nutrient analysis machine and the number of samples processed. Hours spent in the lab with only a sliver of daylight eliminated all ways of telling time that were present in the field. Amy writes,

> There is incredible routine to all of it. Take samples out of the freezer the night before, pour them out into the analysis cups in the morning, ID them, get the nutrient analysis started, check in to replace my cleaning solution, save the data, throw out the cups and samples (devastation – all those hours in the field going down the drain), put the reagents in the fridge, and grab the next day's samples from the freezer and set them out. Repeat. Repeat. Repeat.

In addition to the differing measures of time between the lab and the field, a disjuncture arose between levels of sterility and predictability. In the field, tasks were planned for as well as they could be. However, something always went wrong due to travel, environmental exposure, and overuse. Ecologists make do the best they can with duct tape, extra knots, or one tired hand pump. The room for improvisation was not as justifiable in the lab where precision and sterility were paramount. Amy explained the sensory changes between lab and field as follows:

> In the field, dirt was everywhere. I was caked in it at the end of every field day. But the lab is about sterility. I wear gloves to pick out the cups that the samples go into and try to touch them as minimally as possible. Everything is cleaned with [hydrochloric acid].

Apollonya had a similar experience preparing her fish muscle tissue samples for isotope analysis, a process that requires drying the tissue in an oven for several days and then grinding the sample into a fine powder to be analyzed in a mass spectrometer. The mass spectrometer traces nutrients in the sample, revealing a pattern that suggests what the fish ate and where. Throughout the process it was important to be wary of dust, and bits of cleaning material could dramatically skew the data by getting into the powder. Ethanol, cleaning wipes, and latex gloves—all used to promote sterility—could potentially influence the results. This embodied predictability and sterility was a marked transition from the ad hoc and mud-ridden experiences in the field.

The product of the soil, tides, and weather in the field became partial and isolated in the lab, as Knorr-Cetina (1999) highlighted in her analysis of molecular biology labs. Yet, for those with an asymmetric epistemology, embedded in these partial products are remnants of the context from that moment when the sample was collected. We strained to see one continuous

project across these two spatio-cultural environments, yet we also wanted to include more narrative than was there. Less water in a sample tube was a reminder of a dry spell in Pennsylvania during July, a specific time and place when the corn was waist high and Amy was working with the hand pump until she was dizzy, sweaty and calloused to draw that half-inch of water. In the lab, that tube with little water translated into only one chance to analyze that sample's chemistry in the machine. And if that round of analysis was insufficient, the entire moment would be eliminated from the data. Amy explains,

> Plants, soil, landscape, and the visible variation in the fertilizer treatments are reduced to a test tube with water in it, which is then reduced to three numbers on a spreadsheet. The amount of water in the tube varies from 10mL to 50mL, but this means nothing for the science, just a vague memory of how easy or difficult the lysimeter was that day.

We found ourselves searching for the memories and stories accompanying that sample, yet all that matters for research purposes is the label on the test tube marking which fish or farm plot it originated from. For both of us, the sample eventually became a measurement of nutrient concentrations—all the rest erased.

Throughout our ecology research, spatiality played a significant role—shaping measures of time, altering the physical dimensions of research, and restructuring our own behaviors. In this sense, space is defined not just through social organization and technological processes. Instead, space is shaped by behaviors and enactments that characterize lab work versus field work. For ecologists, the oscillation between lab and field reflects a natural rhythm that is all a part of the same narrative and the same iterative epistemological process. However, for us, trained primarily in sociology—where continuity across data collection sites and moments of analysis are important, even in quantitative work—they were distinct empirical realities that made translation across them difficult. Here again, in terms of spatiality, we found ourselves holding pluralities, with our sociological imagination forefront and trying to overcome epistemic holes.

7. Final Notes and Practical Suggestions

As our results show, epistemic barriers to interdisciplinarity remained even as administrative and disciplinary structural boundaries receded. We posit that the reason for this durability is because epistemic barriers are embodied. This embodiment creates an unevenness in research design, process, and analysis that regularly challenges the identities of researchers. Through our autoethnographic account of straddling two academic fields, we

demonstrate that the lenses through which academics conduct primary research are mediated by their exposure to disciplinary training scripts, epistemic cultures, and social organization. In our case, we developed an asymmetric epistemology that largely remained informed by our sociological training but also hybridized with ecology's epistemic culture at points. This brings additional empirical evidence to the existing argument that complex epistemic identities can be cultivated through embedded interdisciplinary experiences (Osbeck and Nersessian 2017).

Our data demonstrate that some boundaries do dissolve following new institutional interdisciplinary opportunities. One, around materiality, is the slippery boundary between the researcher and the researched and the parallel slipperiness of our values. Moreover, the role of non-human actors in our work to tempt, lure, coax, and come up empty-handed allows us, as interdisciplinary researchers, to deconstruct conventional norms of ecological data collection. The ability to gather data is not a given, it is contingent upon forces beyond the capacity of the researcher, such as the strength of the tide and the prevalence of precipitation. In short, ecology is a continual negotiation between technology, the physical environment, the researcher, and the organisms themselves. This aspect of our asymmetric epistemology is also found in ecology's epistemic culture.

Yet, more barriers persist through interdisciplinarity. First, we saw the lab and field as tangibly separate spaces with distinct rituals and measures of time, which breaks from the traditional view within ecology that sees these two spaces as connected and iterative (Kohler 2002). Second, the distinct epistemic identities of sociologist and ecologist can be difficult to bridge or make hybrid. The trade-off between autonomy and apprenticeship characterized our training in ecology, but not sociology. This was a noticeable place of tension for us that also reflected the hierarchical divide between the two disciplines (Sievanen et al. 2011). The reliance on technical experiential knowledge in ecological research also set an initial barrier between our internal worlds and the "social" world of ecology—and once we began to join the social world of ecology through accumulating this knowledge, our embodiment of the sociological epistemic identity continued to prevent the development of a symmetric epistemology.

Similar to Osbeck and Nersessian's (2017) work, we show that the self is in constant tension with broad expectations of rationality in research and epistemic cultures. As sociologists needing to establish legitimacy as natural scientists, we felt particularly strained by the clash between our internal worlds and ecology's epistemic culture. Such examples include: (1) Apollonya, a vegetarian for ethical reasons, spent the summer and fall killing fish, listening to them die in a bucket while continuing to hunt for more; and (2) Amy and her colleagues drove hundreds of miles each month

to collect ecological samples for a project designed around studying ways to reduce our nutrient pollution to the environment. We had to rationalize this behavior because it fits within the expectations of a "good" fish biologist or biogeochemist, and more importantly within our personal expectations for successful projects and the social expectations of our research teams.

Importantly, the asymmetric epistemologies developed through interdisciplinarity have inherent tensions that invite reflexivity, which is good for thinking critically about science, yet taxing for interdisciplinary individuals. We spent a great amount of energy on the invisible work of proving ourselves as trained ecologists, despite our internal multiplicity and the unanswered questions that persisted—who we are, what we are studying, and where we are studying it. We "stayed with the trouble," as Haraway says, by choosing to disrupt the political norms of disciplinary graduate training as a way to achieve deeper understanding of the world around us (Haraway 2010, p. 1). However, this process exposed stubborn obstacles to achieving true interdisciplinarity. Whether this type or depth of tension develops through combinations of disciplines that are more or less similar than ecology and sociology remains an open empirical question.

Given these conclusions, the trend toward increased interdisciplinarity would benefit from improved reflexivity. We must continue to ask ourselves, what do we gain and what do we compromise by being part of two epistemic cultures or only part of our own interstitial one? As Star (1991) suggests, "Part of the public stability of a standardized network involves the private suffering of those who are not standard—who must use the standardized network, but who are also nonmembers of the community of practice." Though she is referring to social inequalities, this could also describe the high-tension experience of multiple membership across the disciplinary hierarchies of academia, which we captured through the novel methodological approach of analytical autoethnography.

Despite more support for interdisciplinary research and training, the social pressures to normalize and commit to one discipline remain as strong as ever, perhaps even stronger in these new interdisciplinary settings. We found that researchers are still expected to have a primary epistemic identity, and we were often put in the position of defending the epistemic culture of the discipline we most identify or are identified with. The pressure was further amplified for us as graduate students, having to prove our positions as experts in two disciplines with different—and sometimes incompatible—epistemic cultures while still training in both and navigating our forming epistemic identities.

Despite these challenges, we continue to believe that interdisciplinarity is positive for academia, though it will require an embrace of the unique

perspective of each asymmetric epistemology. We offer three additional discussion points: First, the organization and timing of interdisciplinary training matters. We do not prescribe any particular approach, but being trained first in sociology and then simultaneously in both fields influenced the asymmetric outcome of our epistemologies. In effect, we could not unlearn sociology when doing ecology, and thus our analysis focuses on the way that our ecology research and training was informed by our sociological perspective. Second, having spaces for interdisciplinarians to come together is necessary for exploring the dissolution and formation of disciplinary boundaries, promoting the practice of reflexivity and providing mutual support within emerging interstitial epistemic cultures. Moreover, this kind of shared space for interdisciplinarians would shed light on the extent to which asymmetric epistemologies form across other interdisciplinary combinations, which are more or less epistemically similar. Does asymmetric epistemology still emerge if one cross-trains in an area that is already interdisciplinary, e.g., American Studies, or stays within the same branch of knowledge production (e.g., two humanities disciplines)? Third, the assumption that broadening necessarily means shallower fonts of knowledge is false. Asymmetric epistemology, similar to Harding's "strong objectivity," may actually be a deeper epistemology, as it incorporates the tensions of multiplicity and requires constant reflexivity on the part of the individual.

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