Published in final edited form as:

Biosocieties. 2018 December ; 13(4): 698–714. doi:10.1057/s41292-017-0090-z.

The paradox of care in behavioral epigenetics: Constructing early-life adversity in the lab

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Abstract

Many epigenetic studies focus on how stress, trauma, and care become molecularly embodied, affect gene expression without changing DNA sequence, and produce changes that influence the health and behavior of individuals, their offspring, and future generations. This article describes how care has become central in research on the epigenetic effects of early-life adversity. My analysis draws on two years of ethnographic research in a behavioral epigenetics laboratory in the United States. Building on traditions in feminist theory and the sociology of science, I document how care is enacted with research samples, experimental protocols, and behavioral endpoints in experiments with model organisms. My findings point to tensions between researchers' care for the data and their measurement of adversity as a discrete variable in the form of maternal interaction, neglect, and abuse. I argue that these tensions suggest a "paradox of care" that is actively shaping how epigenetic knowledge is produced and its impacts in society. My analysis shows how decisions in the lab are shaping new understandings of how early-life experiences influence health, with significant impacts on our expectations of mothers and pregnant women. This study suggests that the more complex explanations of health and development promised by epigenetics are simultaneously constructed and constrained by caring practices in the laboratory.

Keywords

behavioral epigenetics; care; early-life adversity; knowledge production; feminist science studies; laboratory ethnography

Introduction: The Paradox of Care

We can hear a soft cacophony of chirping birds in the laboratory next door as the Principal Investigator and I pull light blue elastic booties over our shoes, gauze caps over our hair, and tie yellow gowns around our midsections. This ritual is just one of many that structure work in the lab. Today, that work will take us into a dark room that houses seventy-two female and twenty-four male C57BL/6 mice. Under the soft glow of a red lamp, the Principal Investigator will breed these mice with a steady and quiet cadence, gently picking up each male to confirm his sex and setting him into a cage of females before transferring the cages,

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one-by-one, back to their places on the shelves. The breeding is being done in preparation for a series of experiments that aim to identify how early-life experiences of care and adversity influence the epigenome.

While the experiments I follow in this article focus exclusively on mother mice (dams) and their pups, I begin with this scene because it has become clear over the course of my observations that even the handling of the mice during this initial stage of the research process and the environments where they are housed can be critical for the outcomes of the study. This is because epigenetic research focuses on how experience gets “under the skin,” influencing gene-expression in ways that may affect health and behavior (Landecker and Panofsky, 2013). If the males are handled inconsistently or too tightly, it can stress them and the females when they mate. If the cages are overcrowded or the bedding wet from leaking water bottles, it may influence the females during pregnancy and early rearing. These conditions can lead to significant challenges in epigenetic research when care and adversity are the specific variables under investigation. Carefully cultivating consistent experiences for the mice is therefore central to measuring whether and how care matters.

Both within and beyond the lab, matters of care have become a growing area of science studies scholarship in recent years (Puig de la Bellacasa, 2013), with feminist scholars drawing particular attention to how often-neglected forms of care shape science – from the questions that are asked to the ways that knowledge is produced (Star, 1989; Friese, 2013; Kerr and Garforth, 2015; Martin, Myers and Viseu, 2015). For example, Martin, Myers and Viseu point out that “care is both necessary to the fabric of biological and social existence and notorious for the problems it raises when it is defined, legislated, measured, and evaluated” (2015: 625). This article builds on this observation and the larger traditions on which it draws by emphasizing care as a potentializing practice that operates in multiple modalities during epigenetics research with model organisms (cf. Friese 2013; Lee, 2017).

Based on more than two years as a participant-observer in a behavioral epigenetics laboratory, I highlight two fundamental but paradoxical ways that *care* emerged as central in the experiments I followed. First, I show how scientists actively produced, measured, and attended to care, and its absence and inverse in the form of abuse and neglect, as *central variables* that stood in for experiences of “early-life adversity” in their study. Doing so allowed them to effectively connect offspring experiences during early life to behavioral outcomes and epigenetic modifications that may be passed on to future generations.

Second – and paradoxically – researchers’ conduct throughout the study reflected a deep appreciation for how *their own forms of care* helped stabilize the specific variables under investigation as meaningful and consequential. This was accomplished through their careful and consistent interactions with the animals, protocols, tissues, and analyses. These actions reflect the critical role that care plays in stabilizing early life adversity as a meaningful measure. In this way, researchers’ own modes of caring for the mice and for their science buoyed the validity of their findings, which *nevertheless* highlighted maternal-offspring interactions over-and-beyond the influence that researchers themselves had on the mice. The primary focus on dams and pups in the experimental work that I describe therefore

reinforced the centrality of the mother-offspring dyad for offspring health, highlighting the gendered dimensions of epigenetic knowledge production.

These forms of care reflect what I see as a “paradox of care” that is central to the process of epigenetic knowledge production in the lab. By illustrating the practices involved in this paradox – the simultaneous *centrality of care to the study* and the *intended invisibility of many forms of care work* that make the science possible – I show how researchers working with model organisms acknowledge the impacts of experience on the body, but limit what experiences are made to matter in the production of epigenetic knowledge.

Through their careful and consistent conduct during the study, the establishment of clearly defined and bounded measures of adversity and behavior, and analyses of mouse brains and bodies, researchers therefore construct two key variables – *adversity and care* – as legible and influential experiences that have lasting effects for behavioral health. These practices matter because they allow behavioral epigenetics to trace the molecular effects of particular experiences, elevating some forms of care as primary for health, while largely eclipsing others. My observations of how mouse models are used to produce knowledge about the molecular and behavioral effects of early-life experiences therefore suggest that care is central to how adversity is produced as a coherent and interpretable concept in epigenetics research.

While these claims about the centrality of care to science are consistent with existing feminist literature, my findings here are unique from existing studies in three important ways. First, my argument focuses on epigenetic research – an area of molecular and behavioral science that explicitly focuses on the *biological* effects that experience has on the body. Studying epigenetics therefore requires not only paying attention to how practices of care shape *knowledge production*, but accounting for the *material effects* that these practices have on bodies and lives (cf. Lamoreaux, 2016). As Jorg Niewohner and Margaret Lock (this issue) point out,

“[while] epigenetic findings open a door to situate biology within a more complex understanding of human activity... it is also clear that social science inquiries need to pay attention to the actual knowledge practices and epistemic cultures that are involved in these processes of situating.”

This article therefore focuses on the context in which epigenetic knowledge is produced by tracing the various meanings of care in the lab and the epistemic culture that elevates some of these as central to study outcomes, often over and beyond others.

Second, the focus of my study on *research practice* contributes insights to larger conversations about the politics of postgenomic knowledge production. In many of these discussions, epigenetics has been characterized as an antidote to the deterministic ‘gene-for’ narratives that accompanied the genetics era because of its emphasis on how experience influences gene expression (Lock, 2013; Mukerjee, 2016). However, while some see this science as a revolutionary end to nature/nurture debates and a way of accounting for what has been called the “non-linear entanglement of environment, material body, and social practice” (Niewohner and Lock, this issue), others caution that epigenetics may reinforce

causal narratives that privilege the molecular over the social, despite the stated importance of each (cf. Dupras and Ravitsky, 2015cf. Dupras and Ravitsky, 2016; Meloni and Testa, 2014; Landecker and Panofsky, 2013; Lappé and Landecker, 2015; Lappé, 2016; Lock, 2013, 2014; Pickersgill, forthcoming; Waggoner, 2013, 2015).

Paying attention to care in research practice provides a distinct lens through which to analyze these debates. Rather than *either* emancipatory or constraining, molecular *or* social, observing how care operates in and through epigenetic research suggests that some scientists mobilize these potential dichotomies productively throughout the research process. Toggling between them strategically and *with care* allowed the researchers I followed to acknowledge the impacts of experience on the body, elevating particular kinds of care and their absence as meaningful experiences that can shape both gene expression and behavior, depending in part on when during life they occur. By tracing the explicit connections between scientific work and the impacts that epigenetic findings have in the world, I suggest that care matters not only as a central *variable* in the studies I followed, but as a way of *actively shaping* the reliability and credibility of postgenomic knowledge itself (cf. Latour and Woolgar, 1986; Knorr Cetina, 1981). This commitment is clear in the awareness that scientists bring to each phase of the research process, as I illustrate in this article.

Finally, as I alluded to above, my analysis explicitly traces the gendered dimensions of care in the lab, reflecting how epigenetic knowledge is often produced in and through some bodies more than others. In the experiments I followed, these included female researchers, whose labor was central to the experiments, and female mice, whose bodies and behaviors were the material through which this knowledge was produced (Almeling and Waggoner, 2013; Daniels, 1997, 2006; Kenney and Muller, 2016; Lappé and Landecker, 2015; Lappé, 2016; Richardson 2015, forthcoming; Richardson et al, 2014; Warin et al., 2012; Warin, 2015; Waggoner, 2013, 2015).¹ This observation reflects the centrality of gender in the production of epigenetic knowledge – a topic that deserves ongoing attention as this science becomes a basis for increasing social and biological claims related to health, behavior, and disease. The following sections describe my methods and then trace the paradoxical tensions between care and control that facilitate epigenetic research.

Methods: Scale and Care, In and Beyond the Lab

This article draws on two years of observations of lab meetings and experiments conducted by scientists in a group focused on a range of behavioral epigenetic projects. The experiments that I observed trace the relationships between experiences of maternal care, neglect and abuse, epigenetic change, and later health with the goal of understanding how

¹Despite an increasing number of studies on the epigenetic impacts of men's experiences and exposures, science studies scholars have pointed to the disproportionate attention paid to women as primary objects of epigenetics research and the potential of epigenetic science to reinforce the social and medical focus on women's bodies and behaviors as sites for others (cf. Richardson, 2015; Richardson et al. 2014; Almeling and Waggoner 2013; Daniels 1997; Daniels 2006; Kenney and Muller, 2016). This scholarship illustrates how post-genomic research has shifted the temporal politics of maternal care (Waggoner, 2013, 2015; Lappé and Landecker, 2015; Lappé, 2016) and depicted women's bodies and choices as centrally responsible for – or doing 'double damage' to – their children via epigenetic modifications initiated before birth and during early development (Warin et al., 2012; Richardson et al, 2015; Kenney and Muller, 2016)). As 'environments of exposure' (Landecker, 2011) and 'embedded bodies' (Niewohner, 2011) female bodies have therefore become unique sites through which epigenetic claims are made, even in the context of ongoing research into the myriad factors that influence gene expression.

variations in early-life experience influence anxiety-like, depression-like, and impulsivity/aggression-related behaviors in pups. These phenotypes were selected because anxiety, aggression, and depression are associated with heightened risk of suicide in humans (Brent, Melhem, Donohoe, and Walker, 2009; Loman and Gunnar, 2010; Tureki, Ernst, Jolland, Lanbonté, and Mechawar, 2014; Turecki, Ota, Belangero, Jackowski, Kaufman, 2014).

Though suicide is an exclusively human outcome, mice provide a model system in which early-life experiences can be actively manipulated and epigenetic changes observed in key regions of the brain (Millstein and Homes, 2007). Observing the relationship between epigenetic modifications and these phenotypes in mice was therefore seen by the researchers I followed as a meaningful way of tracing the connections between early life experiences and behaviors associated with suicide, even though mice are not suicidal.

Further, the researchers were astutely aware that human lives are much more complex than those of laboratory mice, involving myriad factors that can influence mental wellbeing over time. Most study designs of human suicide require retrospective rather than prospective data analysis, and – together with the difficulty of accessing human brain tissue – these issues often limit scientists' ability to make causal claims about the relationships between early life experiences and suicidality. Mice allowed researchers to actively manipulate and trace the effects of the early care environment on the brain and behavior, providing a model experimental system that has become widely utilized in the study of early-life adversity and its effects (Blewitt and Whitelad, 2013).

The lab where I observed was located in a private research university in a large metropolitan city on the east coast of the United States. The Principal Investigator was tenured and held numerous competitive public and private grants that helped support her research and that of her postdoctoral fellow, graduate student, and undergraduate researchers. Their projects focused primarily on mouse models of behavioral conditions, including anxiety, aggression, and depression, as well as analyses of human samples done in collaboration with other investigators within and beyond the university. Over the time that I participated in lab activities, members of the group hailed from various fields including psychology, epidemiology, developmental biology, and genetics. All but two of the researchers were women, a point that was at once mundane and meaningful given the lab's emphasis on the epigenetic effects of care, a topic long associated with women's labor (Rose, 1983).

My observations of wet lab experiments and dry lab activities were accompanied by attendance at conferences and events related to epigenetics, extensive review of life and social science literature, and participation in university classes on developmental biology, genetics, ethics, and heredity. All of these activities were part of a larger multi-sited study examining the production and circulation of epigenetic knowledge, which helped me contextualize the research that I followed in the lab (Marcus, 1998). During our weekly meetings, I listened to work in progress, presented my own research, and engaged in conversations about behavioral epigenetics. Occupying the dual position of participant/observer in these ways informed my understanding of the practices and paradoxes embedded in the epigenetic experiments I observed.

While we all focused on behavioral epigenetics, the scale on which the researchers and I thought about this topic was often distinct. Their presentations oriented around methodological and practical issues in the field, while mine focused on the social and ethical dimensions of the science and impacts of epigenetics in society. These topics drew interest and inquiry. For example, while discussing media representations of epigenetic findings, members of the lab expressed frustration with the way that animal studies were depicted. While the researchers were acutely aware of the critical distinctions between animal models and human lives, they felt popular depictions and social critiques often collapsed such dimensions when describing the implications of epigenetic findings.

This mattered to them because many viewed their work as contributing to a field that was still grappling with the best analytic approach, the most reliable tissues and time points to base their research on, and challenges establishing standardized measures and definitions that could be applied across distinct research areas. Behavioral epigenetics therefore provided a useful resource and an important set of tools, but one that required significant care in how exactly studies were conducted and communicated. The care researchers took in experiment design, conduct, and analysis was therefore not only important for their own studies, but for the field as a whole. An appreciation for the complexity of experience and its effects on the body was ever present in the lab and a central motivation for researchers' careful interactions with the mice, protocols, samples and analyses. They saw these actions as allowing them to produce "good science" and reliable results that would contribute to epigenetic findings as a legitimate resource for understanding health (cf. Thompson, 2014).

In what follows I describe three phases of the research process, beginning with my entrée to the lab, then the uniquely gendered qualities of the maternal separation model, and the measures involved in assessing the effects of maternal separation in the behaviors and bodies of mice. These sections show how "care organizes, classifies, and disciplines," illustrating the paradox of care that was central in this site of epigenetic knowledge production (Martin et al., 2015: 627).

Care and Control in the Lab

When I began my observations, access to the laboratory was restricted and required a university issued badge that had been granted privileges by the lab manager. After meeting with the Principle Investigator and attending several lab meetings, I gained access to the lab itself. The tour provided clues about the flows of knowledge in and through the laboratory, the importance of control and consistency in the conduct of experiments, and the role of key equipment in establishing conditions that allowed researchers to test the effects of particular experiences and not others – from BPA-free cages and organic feed to the carefully calibrated centrifuge and thoughtfully organized small white boxes that store samples in the –80 freezer (cf. Latour and Woolgar, 1986; Fortun and Fortun, 2005; Nelson, 2016).

My first tour began at the industrial freezers where samples of brains, placentas, and gonads were stored. These frozen tissues provided the connections between experiences of early-life adversity, epigenetic change, and behavior – a way of materially tracing the effects of maternal care, abuse, and neglect on the body (cf. Lee, 2017). These tiny tissues were

remnants of researchers' carefully cultivated experiments. Each sample embodied the protocols designed to better understand the biological mechanisms that might lead to anxiety-like, depression-like, and impulsivity/aggression-related behaviors. For the study I would observe, researchers were specifically interested in the brains of sacrificed offspring. I learned that knowing which brains came from which litters and having clear records of their experiences of maternal separation and each animals' subsequent behavior, was pivotal to establishing claims about the epigenetic modifications that might be associated with human suicidality.

The proper organization and classification of these samples therefore mattered considerably for the findings that would result from the experiment. The samples – each one frozen, labeled, wrapped in envelopes of folded tinfoil, and stored with carefully organized identification numbers into small white boxes – provided the molecular evidence of how experience gets under the skin and affects gene expression in key brain regions associated with behavior. Fortun and Fortun (2005) have written about how this “care of the data” produces the conditions of possibility for the research itself, shaping articulations of “good science” with careful practices that occur throughout the research process (cf. Lappé, 2014). The notion that tissues taken from mouse bodies and brains might tell us something about the risk of suicide in humans relied on this careful cultivation.

However, as I toured the lab I couldn't help but feel that the sterile laboratory environment and the experimental protocols taking place within it were a world away from the complex spaces where experiences of adversity play out in the daily lives of humans. I thought of caregivers affected by deep histories of social and economic disadvantage and structural inequalities that influence some communities more than others. These conditions point to the intersectional and situated nature of experience, yet such intersections were purposefully disentangled in the lab.

In experiments with mice, some forms of experience were silenced and others elevated to show clear relationships between early-life experiences and their epigenetic effects. I illustrate in the next section how this constructed a specific idea of *adversity* that was intimately connected to maternal care, a notion that would later be traced back through the epigenetic modifications embodied in these tiny tissue samples. In the lab, care was therefore “a selective mode of attention... [that] circumscribes and cherishes some things, lives, or phenomena as its objects. In the process, it excludes others” (Martin et al, 2015: 627).

Of Mice and Mothers: Producing Early-Life Adversity

In 2011, Jorg Niewohner observed that epigenetic modification is a process “highly sensitive to change over time and at different levels of context: cellular, organismic and environmental. Therefore... experimental designs are potentially open to any kind of contextual change” (p. 288). The destabilization of the genome and its opening up to experience and time, has since provided many examples of how environments influence whether genes are turned on or off, and the relationship between these changes and health outcomes (Lappé and Landecker, 2015). The dynamic nature of these changes including

their variability over time and the potential instability of their effects, requires experimental protocols that can effectively stabilize some aspects of experience while preventing others from influencing study results (Nelson, 2016; Dupras and Ravitsky, 2016).

In his ethnographic work, Niewohner observed a central concept used in this stabilization project. He states, “in the process of stabilization of an experimental system, the notion of *early-life adversity* is beginning to emerge as an epistemic object” (Rheinberger, 1997 in Niewohner, 2011: 288, emphasis added). Similar to the site that I studied, in the group that Niewohner observed, early-life adversity helped “organize the messiness of environmental context and social change...” and was thus stabilized “in daily practice through standardized animal behavioral models” (Latour and Woolgar, 1986 in Niewohner 2011: 289). Niewohner argues that this was in part because the concept provides,

“a coherent interpretive frame that is able to harness at least part of its heterogeneity. It is at the same time an established concept anchoring ongoing research in relevant pasts and setting out a research strategy for the future that goes significantly beyond the current epistemic horizon by bringing the social and material environment into molecular research” (Niewohner, 2011: 288).

He argues that research into the effects of early-life adversity therefore provides a resource that draws uniquely on several fields where it has increasingly been mobilized as a concept in human and animal studies, despite ongoing concerns about what exactly it measures (Tractenberg et al., 2016). He observes that early-life adversity,

“anchors ongoing environmental epigenetics research by providing important links to behavioral psychology and the work with standardized animal behavioral models... [and to] the idea that the body goes through phases of increased sensitivity towards internal and external change” (Niewohner 2011: 289).

This interdisciplinary lineage and its use in hundreds of research studies has produced early-life adversity as a central object in claims about the unique sensitivity of the developing brain during pre- and post-natal development (Turecki et al., 2014). Due to the idea that the brain is more plastic during these periods, research focusing on early post-natal experiences has been used to study the effects that adversity may have on later behavior, with research increasing suggesting that such effects may be influenced by epigenetic modifications that can be passed on intergenerationally (Champagne, 2008, 2011).

However, as I spent time with the scientists that I followed, it became clear that their own forms of care were central in not only stabilizing the experimental system, but in producing *early-life adversity* as a meaningful measure of experience. This matters because early-life adversity is a term that has been used to capture everything from chronic stress to poverty, nutrition to neglect, abandonment, and abuse (Niewohner and Lock, this issue). During my observations, I came to see the coherence of this construct and its utility as a meaningful measure of *human* experiences as possible specifically because of the concerted efforts of the researchers.

From handling the dams and their mates during breeding to controlling variables such as fragrance and the timing of experiments, members of the lab recognized their actions as

influential not only for the outcome of the experiment, but for the epigenomes of the mice as well. Measuring the effects of early experiences of adversity therefore required great care, including efforts to produce conditions that effectively silenced many other experiences as influential for the behavioral outcomes and epigenetic changes they wished to trace, all so they could connect their findings explicitly to experiences of maternal care, neglect, or abuse in early life.

Of course, rodent models have long been central in laboratory experiments. In her research on animal behavior genetics, Nelson (2013) details the value and role of animal models in understanding human disorders, developing the concept of ‘epistemic scaffolds’ to describe “the use of a particular test for producing particular types of knowledge about the human” (Nelson, 2013: 5). While Nelson’s argument focuses on the production of epistemic scaffolds, here I illustrate what happens as a result of a particular test being implemented, and the forms of experience it attends to and helps silence (Nelson, 2013: 5). In the study I followed, the maternal separation model is central to such practices.

Maternal separation provides an experimental paradigm used in animal experiments with mice, rats, and primates to study the effects that disruption in the quality of early parent-infant interactions have on offspring psychopathology, mental health, and behavior (Tata, 2012). While the timing of the specific intervention varies by experiment, maternal separation refers to the separation of pups from their mothers for either short or prolonged (1-24 hour) periods of time every day for the first 1-3 weeks following birth. Because rodent pups are dependent on mothers during this time, the separation is particularly stressful for dam and pups alike (Nishi et. al, 2014). The effects of separation include increased abuse (dams stepping on, aggressively grooming, or dragging pups), decreased nurturing including nursing, licking and grooming, and effects on offspring including increases in anxiety-like and depressive-like behaviors and impaired learning and memory (Tata, 2012). This model has a long history in animal science (Levine, 1967), where it has become a key tool in animal models of human depression and anxiety disorders (Millstein and Holmes, 2007; Andersen, 2015).

Numerous human epidemiological and observational studies also show associations between childhood trauma, abuse, or neglect and heightened risk of mental health diagnoses. For example, children who experienced emotional, physical, or sexual abuse are at increased risk of anxiety disorders (cf. Tata, 2012) and studies document that the loss of a parent in early-life increases a child’s later risk of depression and substance abuse (Brent et al, 2009), while others point to multiple impacts of parental neglect (Loman and Gunnar, 2010). Mouse models have been used over the past several decades in attempts to observe the biological effects that separation has in the controlled context of the laboratory.

Gudsnuk and Champagne (2012: 279) have pointed out that, “animal models of early-life stress and variation in social experience across the lifespan have contributed significantly to our understanding of the environmental regulation of the developing brain” with researchers increasingly investigated the role that epigenetic mechanisms may play in mediating the effects of these early-life experiences. Epigenetic modifications have thus been positioned as biological clues about the effects that environmental conditions have on gene expression and

their potential reversibility through social or therapeutic interventions (Yam et al, 2015; Dupras and Ravitsky, 2016).

As noted above, in the experiment I observed, the maternal separation model was used to generate phenotypes in mice deemed appropriate for the study of suicidality. The manipulation of early care environments was therefore a purposeful mode of stabilizing differences in early care environments shown to affect human behavior, with maternal separation allowing the bodies and brains of pups to become useful tools for understanding the relationships between early childhood experiences, epigenetic modifications, and – ultimately, but association – suicide.

The use of the maternal-separation model therefore did two kinds of work in the studies I followed. First, it allowed researchers to manipulate experiences of care and adversity during the first weeks of pups' lives, producing variations that would be connected to later behaviors and with epigenetic changes observed after death. Second – and importantly for the effects that study results may have in the world – it positioned maternal care and mothers themselves as central to epigenetic findings related to early-life adversity and mental health.

Such traffic between human experiences and animal models required deliberate and ongoing efforts on the part of researchers to clearly articulate what is and is not being measured cf. Frieze and Clarke, 2011; Nelson, 2013). Researchers emphasized that this was even more necessary in epigenetic research because of the sensitivity of the epigenome to environmental stimuli and change over time. Nelson (2013: 6) has pointed out that descriptions of “animal models as ‘exemplars’ or modeling as a process of ‘extrapolation’ creates the impression that findings are first worked out in model systems and then translated to other cases, thereby obscuring the ongoing interactions between the model and the modeled that take place during all stages of animal modeling work.” Such interactions were central to the researchers' that I followed, which were reflected in the great care they took to stabilize maternal separation and its effects as the variables of interest, even while they actively acknowledged the myriad other conditions in the lab that could also influence the experiment.

Sociologists have long observed that behavior and mental health are situated experiences, influenced not only by social classification, but by inequality, toxic exposures, nutrition, access to resources, quality of social and community engagement, violence, fear, and discrimination, as well as economic, social, and personal stability. It became clear to me during my observations that the maternal separation model was not meant to reflect such structural or sustained experiences; using it instead allowed researchers to intentionally isolate maternal-infant interaction from this host of others experiences. In this way, the model produced the absence of maternal care and experiences of abuse as central for understanding how early-life experiences affect gene expression (cf. Curley and Champagne, 2016), providing a potential biological mechanism between early-life adversity and suicidality that could be interpreted in relationship to human experiences, as well. Such efforts intentionally controlled the environments that might complicate study findings and, in doing so, effectively embedded myriad social and structural conditions into the single variable of *early-life adversity*. This had the effect of producing mothers' actions as central

to offspring health and development across the life course, even as researchers acknowledged the many other experiences – from handling to the temperature in the lab – that could shape their outcomes of interest. Tracing the behavioral effects that maternal care had on the pups, however, had to be carefully attended to as well.

From Early-Life to Behavioral Endpoints

After the dams and pups had been separated and their behaviors recorded through a system of protocols intended to document each pup's proclivity for the phenotypes of interest, the lab manager and I sat in front of a computer in the dry area of the laboratory. Two boxes appeared on the computer screen, one dark and one light. A small tail was visible in the box on the left, an indication that this mouse had traveled from the dark portion of the light/dark box experiment to the light portion. This, the lab manager told me, suggested anxiety-like behavior, a trait that the researchers were testing in all of the maturing pups to assess the effects of maternal separation before they were sacrificed and their tissues analyzed. The light/dark box was just one in a litany of tests administered to the mice to assess their behavior in response to experiences of adversity.

The lab manager and I were blind to the groups being tested, one of which had not been separated from their mothers and experienced normal variations in care during early life, and the other who had experienced less licking and grooming and more abuse and neglect as a result of the separation protocol. The effects of these early-life experiences were being analyzed in the test on the screen. After watching more than 100 hours of video, the lab manager had observed differences in pup behaviors that she hoped would map onto their early-life experiences and be reflected in epigenetic modifications in key regions of their brains. If found, these connections would provide evidence of how offspring respond differently to early-life adversity both behaviorally *and* biologically, reinforcing the lab's experimental system and the central importance of care within it. Researchers hoped that this evidence would provide a missing link in understandings of human mental health: the epigenetic modifications associated with suicidality and, potentially, ways to reverse them.

As we sat together, the lab manager pulled up a new video, this one showed a test assessing aggression-like behavior in pups. The test on the screen showed a mouse in a plastic, BPA free, cage. The cage was clear with no bedding, food or water source. The black 6 mouse moved spastically from one side of the cage to the other until another mouse of the same sex and age was placed in the cage. The gloved fingers of a researcher's hand appeared at the top of the video, suspending the additional mouse for a moment before lowering it gently into the cage.

The behavior between the two mice was the object of interest, but like the quiet and steady cadence involved in breeding this pup's parents, the handling of each pup during these behavioral protocols was just as influential for the study. Though her behavior was not coded or videotaped, the researcher conducting the experiment was also a key factor in the experiment. I came to understand her near absence from the video as symbolic of what was expected of researcher interactions with the mice throughout the study: all were trained to be careful and controlled so as not to introduce variability into the experiment and influence the

results. To assess the impacts of care, their own actions had to be standardized and consistent too.

It was important for the test in that video and others to be administered by the same individual at the same time of day and without the potential disruption of fragrance or makeup. The lab coat, gloves, booties and hairnet I mentioned at the beginning of the article were therefore not only routine safety measures, but key elements in stabilizing early-life adversity as the explicit variable under investigation. Though unclear from the simple black and white videos, the care provided to the mice during and between tests was also strictly enforced. Given the sensitivity of the epigenome to numerous stimuli, the consistency of researcher actions and controlled environment of the lab helped isolate pups' experiences of maternal care as the main variable shaping the behavior we saw on the screen. Nelson (2016: 59) has also described how the neuroscience researchers she observed were acutely aware of how changes in the experimental environment might introduce gene-environment interactions and "change the science" in ways that had to be "approached with consideration and caution." Researchers in the lab I observed were deeply aware of such effects and their potential to influence not only the mice, but the promise of epigenetic research, too.

In the cage on the screen, the two mice scurried and sniffed each other, then transitioned quickly into a blur, wrestling with one another before they separated abruptly and moved to separate corners of the cage. This was the aggression-related behavior the lab manager was tracking. The routinized coding of the videos would provide an analog account of these behaviors: numbered one for interactions such as the wrestling we saw on the screen and zero for normal or no interaction. Such clear distinctions would organize these seemingly erratic variations in behavior into clean data points, providing a way of tracing the relationships between early-life adversity, maternal care, and clearly delineated behavioral outcomes. As I watched the videos, I took in the frantic and curious movements of the mice, but couldn't help thinking about the context that lay beyond the frame.

Discussion: Care as Knowledge Production

Through the sections above, I have illustrated how practices of care and control figure as important features in the production of epigenetic knowledge. These processes are at work across multiple scales and throughout the practice of epigenetic research: from the hypotheses that guide experiments, to the protocols used to measure behavior, to the technologies that enable these to be aligned with epigenetic modifications, tissue samples, and time points across the life course and into the next generation. Tracing these material practices and the logics that guide them is therefore central to assessments of epigenetic knowledge production and its consequences. Attention to the multiple modes that care takes in epigenetic research thus reveals the importance of following knowledge production from the very beginnings of the research process.

This article has focused on how care operates as a central research object and form of practice throughout this process, shedding light on the tensions involved in its enactments. These tensions – between measuring care as a discrete variable and caring for the data in ways that suggest quite the opposite – suggest an acute awareness on the part of the

researchers that care matters, not only for health but in the production of epigenetic knowledge itself. Their carefully cultivated experiments reflect what I have characterized as a “paradox of care” that is at the heart of this research effort.

In her research on translational science in animal models, Carrie Friese has suggested that while care has always been central in experimental science, it has long been repressed. She (2013: S129) describes what she deems the “uncanny emergence of care as science” in the preclinical laboratory studies she observed. Similar to the site I studied, Friese (2013) observed that scientists insisted on the care of their animals as a potentializing practice: care was critical to accurate, reliable, and translational findings. This translational appeal is central in epigenetic research too, where non-human animal studies are largely performed in an effort to document mechanisms that may also be at play in humans.

As the sections above make clear, in the lab I followed, the importance of caring for the animals also extended to the protocols, conditions in the laboratory, and the maintenance and storage of biological samples, as well. This reflects what Fortun and Fortun (2005) have called “the care of the data” and what Jieun Lee has traced in her analysis of how care is produced and deemed valuable in placenta economies (2017). What is distinct here, however, is that in epigenetic research these practices and their effects reach beyond the establishment of ‘good science.’ Because of the sensitivity of epigenomes to contextual change, researchers’ care for the data has direct effects on the very bodies and behaviors they are studying.

To illustrate the molecular effects of experience on the body, researchers must therefore attend to the larger context in which research is conducted while actively limiting the effects that context has on the bodies of their research subjects. To document the molecular materiality of experience, the complexities of social life are therefore purposefully constrained. These choices produce some forms of care as primary, while black-boxing others (Latour, 1983), positioning maternal care as central to offspring health. By connecting early-life adversity to maternal care in the lab, researchers also make it possible for narratives of maternal responsibility to become linked to their results beyond the lab, leading to the simplified notion that care is determinative of outcomes as complex as anxiety, depression, aggression, or even suicide (Tureki, Ernst, Jolland, Lanbonté, and Mechawar, 2012; Turecki, Ota, Belangero, Jackowski, Kaufman, 2014). This is a suggestion that is at once performed by the controlled experiment and explicitly complicated by the researchers’ awareness of the myriad interactions that shape their science, both biologically and socially. It is this paradox of care that I have drawn attention to in this article.

Conclusion

I have shown that the tensions between care and control reflect researchers’ deep appreciation for the multiple ways that care matters. It matters for the quality of their research, the legitimacy of their claims, and for the field. Importantly, it also matters for the mice and the effect that their experiences have on the epigenetic changes that the researchers wish to document. Through their curated efforts to both produce those experiences and ensure their stability, researchers’ actions reflect a deep awareness of just how much

experience matters. These actions have effects not only for the mice, their tissues, and the researchers' data, but beyond the lab as well.

The forms of care I have documented make it possible for data from animal models to speak molecular truth to human lives, including such deep traumas as childhood neglect, abuse, and abandonment – even while researchers remain intimately aware of how distinct these realities are from the controlled space of the lab. The researchers I followed were acutely aware that experiences of childhood neglect and abuse are not isolated variables in human lives. They recognized these experiences have unique effects on the body and behavior, that they are situated in social and structural conditions that shape their probability, and that these same environments can exacerbate or ameliorate the effects of early-life experience on individuals over time. Adversity has deep histories that are disproportionately distributed and differently embodied.

Yet, in the lab, these complex realities were purposely disentangled from their structural and historical contexts in order to document how care might matter on a molecular level. Experiments with model organisms provided a unique opportunity to control social conditions and their extended timescapes, to access tissues that are difficult to ascertain from humans, and to inform the state of knowledge about how experiences materially affect the body. To do so, researchers relied on not only specific research tools, but a culture in the lab that saw each phase of the study as essential for the success of the experiment.

Fortun and Fortun (2005: 47) argue that,

“articulations of ‘good science’ must be rooted in a tradition of thought and practice, even when intended to establish new agendas and open up new lines of work... Science then, is bound both to the known and the unknown, the past and the future... one must work within their constraints and contours, continually making decisions about how best to uphold competing values.”

I have pointed to three phases of the research process when researchers display such competing values. These observations suggest the importance of care not only as an object of scientific inquiry – a variable being assessed for its effect on mouse bodies and behaviors – but as a mode of practice that buoys epigenetic claims. Care in the lab is simultaneously stabilizing and potentializing, active and passive, restricting and promissory. These paradoxes are central to the larger project of behavioral epigenetics, revealing how “the very concept of care is not only multifaceted and contextual, but also suggests different political commitments, inspiring a range of different ethics and forms of intervention” (Martin et al. 2015: 634).

My observations suggest that in research on early-life adversity, researchers simultaneously construct, attend to, and perform care as a measurable variable influencing behavior *and* enact care in order to stabilize the experimental systems they rely upon. Thus, in this site, researchers insisted on care as central to the success of their science. In their efforts to create humane and consistent conditions, they acknowledged the deep and embodied impacts of care on bodies and brains, while also illustrating why not having such conditions matters so significantly for health. Here, I have shown how efforts to illustrate the epigenetic effects of

experience on the body produce some forms of care as specific and measurable, while others remain, nearly invisible.

Biography

Martine Lappé is Principle Investigator of an NHGRI-funded Career Development Award and Postdoctoral Fellow in Columbia University's *Center for Research on Ethical, Legal, and Social Implications of Psychiatric, Neurologic, and Behavioral Genetics*. She studies lived experiences and expert knowledge related to health, science, and biomedicine. Her projects focus on autism spectrum disorders and environmental epigenetics.

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