

Diffractional Entanglements and Readings with/of Data

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Abstract

In this inquiry, I outline Barad's objectivity and argue that its value lies in how it demands that researchers attend response-ably to the specific material arrangements of knowledge production. Though a complete accounting of the complexities of knowledge production in educational research is not possible, the practice of accounting and attending to specific material arrangements has value. Creating lines of inventive connection, I explore the disturbances, patterns, and omissions that diffractive analysis makes visible and how those differences might matter, knowing that I can never get it right. ([Click here for video of Cannons Diffraction - Spacetimematteringswith Data](#))

Keywords: diffractive analysis, objectivity, indeterminacy

Reconfiguring the World

In discussing diffractive methodology, Barad (2007) asserted, "the point is not merely that knowledge practices have material consequences but that practices of knowing are *specific material arrangements that participate in reconfiguring the world*. (p. 91). Research reconfigures the world. These reconfigurations have ethical and material consequences. Questions of which truth matters, what data can be used to support particular claims, how knowledge gets made, and who decides what counts as knowledge have become increasingly important in today's political and educational climate. Yet, in the midst of doing qualitative research it is sometimes hard to tell how the ways that we are producing knowledge might matter. Barad's assertion that we participate in the world's reconfiguration through our knowledge making practices both affirms how our research practices matter and places a profound responsibility on the researcher.

Qualitative researchers have been questioning the ethics of knowledge production for years (e.g.

Bridges-Rhoads & Van Cleave, 2013; Jackson & Mazzei, 2012; Lather, 1991; MacLure, 2013b; St. Pierre & Pillow, 1999). The ethics of our actions in the field (Kofoed & Staunæs, 2015) and in analysis (Lenz Taguchi & Palmer, 2013) are up for debate. This inquiry comes into conversation with the persistent questioning of these feminist qualitative researchers and considers what value objectivity might have within diffractive methodology.

In order to do science, to know something of the world, scientists and researchers come into configuration with the objects of study. In humanist conceptions of science, there is an assumption that objects and subjects have fixed and inherent properties that can be described and measured. The measurement or observation exists outside the referenced object, as an objective marker of truth. The effect of the measurement, what the measuring does, is either assumed to be negligible or is subtracted out of the equation through concepts such as objectivity, reflexivity, and positionality. Qualitative researchers have taken up these terms and other vestiges of science to varying degrees, and they have debated what should or should not count as scientific research (Denzin, 2009; Fielding, 2010). Objectivity has, at times, fallen out of favor in educational research. Yet, Barad has argued that objectivity has value and is possible within diffractive methodology. The persistent question in this inquiry is as follows: What is the value of Barad's objectivity within diffractive methodology and qualitative research writ large?

In order to consider this question, I first lay out Barad's objectivity drawing from her work with Bohr's writing about knowledge making practices. Then, I consider how Barad's theoretical framing troubles and shapes 'data' and how data participates in knowledge making practices, particularly in the field of educational research. Next, I describe the knowledge making apparatus I laid out in this inquiry and the resulting material productions. Then, I describe a version of diffractive methodology—an embodied engagement reading across and through the productions of theory, data, and apparatuses—that drew attention and attended to the differences produced through various configurations. Finally, I return to Barad's objectivity and its value.

Coming to Know

The study from which this inquiry is drawn took place in a small urban middle school in the Southeastern United States. Two teachers at the school were teaching a mathematics course focused on mathematics in the news. The research was complex. I had taught with and was close with one of the teachers. I knew students and parents at the school. I knew the classrooms and the building. Signs that I had made still hung in the halls, greeting me as I entered the site. The ethics in this research endeavor were even more complicated than I thought when I wrote the first version of the study.

I began this research with humanist notions that I would come to know something important *about* the teachers and students and curriculum that were the *object* of my study. I designed a

comparative case study of two middle grades classrooms in which the teachers were engaging in social justice mathematics. I began by “doing science” using conventional methods that would be legible to a broader research community. The knowledge making apparatus consisted of field observations, semi-structured interviews with the two teachers and document analysis of the students’ work.

However, shortly after entering the field, I engaged with Barad’s (2007) theories and texts. In her agential realist conception of science, neither subject nor object are fixed and boundaries are co-constituted and questioned. Knowledge is produced through specific material arrangements, of which the researcher is part. Though Barad accounted for the complexity of social science research, she remained attached to the idea of doing science. She pursued objectivity as a possibility. Barad (2007)’s objectivity is produced through relationality and responsibility to material configurations and draws on Heisenberg’s and Bohr’s arguments.

Uncertainty and Indeterminacy

Heisenberg proposed the *uncertainty* principle, an epistemic concern that relies on the limitation of what one *can know* at the same time. The key to his argument was that the object of measurement, in his case an electron, was disturbed by the measuring tool, a photon. A person cannot know the value of the electron’s momentum and position at the same time because the particulars of the measuring apparatus does not allow them to. Heisenberg’s uncertainty principle, or not knowing a particular attribute at a particular time, implies that there is a determinate value to be known. In his account, the value of the property is knowable, however one does not have the proper perspective to be able to access the value. The value is determinate, but it is unknown.

In contrast, Bohr argued for the *indeterminacy* principle. In this view of objectivity, Bohr argued that objects do not have determinate values *to be known*. Bohr proposed that the properties of objects are indeterminate. Any measurements are a result of the configuration of the measuring apparatus. The measuring tool is included in the measuring apparatus; therefore, the measurement is not inherent to only one particular part of the apparatus but to the overall phenomena that includes the object to be measured and the measuring device. Therefore, a change in the measuring apparatus would change the phenomenon. This view radically undermined the traditional subject/object divide upon which conventional science depends.

Barad’s Objectivity

Barad built on Bohr’s indeterminacy principle in her agential realist perspective. Barad proposed an agential realist objectivity that is determined through ongoing cuts together and apart. Phenomena are the “ontological inseparability/entanglement of intra-acting ‘agencies’” (Barad, 2007, p. 139). The properties and boundaries of phenomena become determinate through intra-action. Intra-action refers to the on-going, co-constitutive, and iterative reconfigurations of matter. It is intra-actions therefore that “enact agential separability” (Barad, 2007, p. 140). This

enacted separability is the cut together-apart. The cut is an ongoing enacted making and remaking and is not in any way a permanent cut. A phenomenon, then, is an ongoing construction that reconfigures the world. In Barad's framework there is no inherent subject/object distinction or separation.

The ongoing enactment of the subject/object distinction complicates objectivity. Yet, Barad (2007) asserted that objectivity is possible. Cuts are made in the enactment of research that create subject/object distinctions. Any measurement is a part of the cut together/apart phenomenon and produced along with it. In Barad's take on objectivity the specific material arrangements and the cuts that are made in the creation of the apparatus must be accounted for. Not only are the boundaries between what counts as data, researcher, texts, materials and so on troubled, but the whole idea of how they are constructed is questioned. In other words, what counts as data is in ongoing and iterative co-constitution in relation to the apparatus, the measuring device, the researcher, the texts, and vice versa.

All measurements involve a particular choice of apparatus that provide the "conditions necessary to give meaning to a particular set of variables, thereby placing a particular embodied cut between the object and the agencies of observation" (Barad, 2007, p. 115). In other words, in the case of this research project, when I entered the school where I used to teach with a consent form, a cut was enacted that moved me from mathematics and science teacher to researcher, and my colleague from friend to participant. And yet, with Barad, these cuts are not stable – they are together/apart. I was still mathematics and science teacher; my colleague was still my colleague. However, in coming to the school to do research, I was entangled in an apparatus that gave meaning to my presence in the room that was different from the hundreds of times I had been in that room before. And, as I have discovered through this process, I can never undo that cut, the researcher mark is on my body and puts me in relation differently with my colleague. In the course of the research, I participated in evolving and shifting intra-actions within the larger apparatus of research that produced me alternately as friend, researcher, visitor, insider and outsider. None of these subjectivity productions was final, still the configurations that produced them all left marks on bodies and determined the knowledge(s) that could be produced and the relations that could be enacted.

Knowing and being are entangled and co-constituted. Further, ethical matters are inextricably tied to knowledge production. How we¹ come to know matters for what we know and therefore each moment of knowing/being is an ethical relation. The particular entanglements of

¹ Here I use we not to signal a collective of qualitative researchers, but to signal the plurality of the knowledge making apparatus. "There is no 'I' that exists outside of the diffraction pattern, observing it, telling its story. In an important sense, this story in its ongoing (re)patterning is (re)(con)figuring me. 'I' am neither outside nor inside; 'I' am of the diffraction pattern" (Barad, 2014, p. 181-182)

researcher/theory/data/participant/materials/texts and how these terms are troubled and co-constituted matter for knowledge and subject productions. In other words, the ways in which data is arranged and rearranged in entanglement with theory, texts, and disciplines constrains but does not determine the knowledge that is able to be produced. Barad's objectivity demands that we account for these arrangements. I begin this accounting with a consideration of the specific material arrangements of data production.

Specific Material Arrangements: Data in Intra-action

As Koro-Ljungberg, MacLure, and Ulmer (2018) have argued, there is an opening in the field of qualitative inquiry to take up and think data differently: to think connections among data and field and researcher, to think data out of time, to think data and place differently, and to think data and anti-data, or what is silent in the data. Data are mobile, co-constituted, material, immanent and situated, though not bound. Data are not neutral. Data have power in knowledge making apparatuses, both qualitative and quantitative. How much do you have? Where and how did you get it? Where do you keep it? How do you protect it?

Data has been accused of being cooked (Scheurich, 1996, p. 54) or plucked. It is spectral (Nordstrom, 2013); and as St. Pierre (1997) asserted, transgressive in the form of dream data, sensual data, emotional data and responsive data. It glows (MacLure, 2013a) and torments (Bridges-Rhoads & Van Cleave, 2013) and does not sit still, it wants, it desires (Koro-Ljungberg, 2015). Data have often been characterized within a binary of being utterly static or almost independently agential.

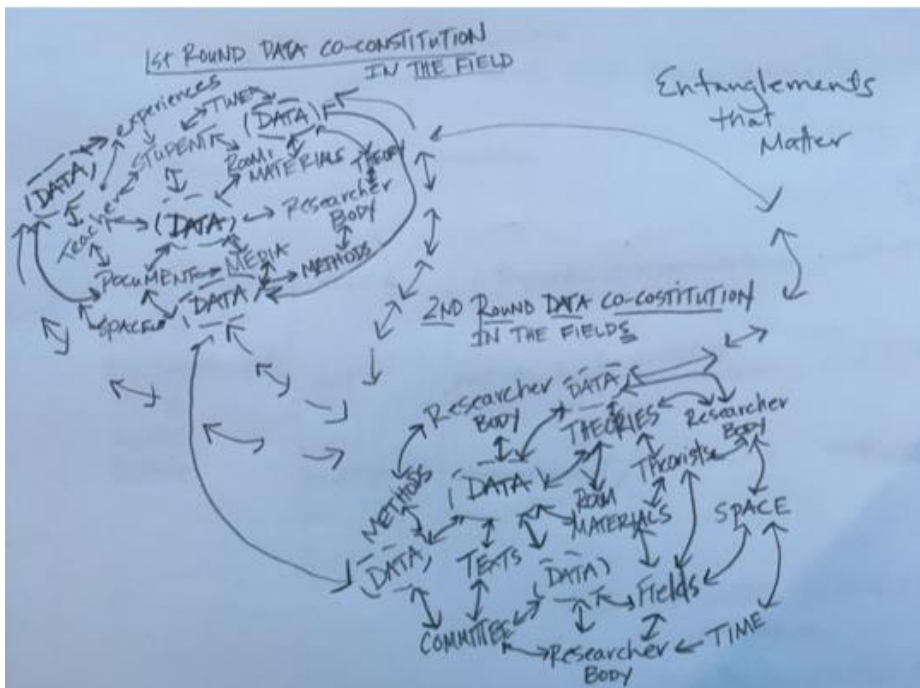


Figure 1 Figure 1. Accounting of First and Second Round Data Co-Constitution in the Field(s).

Thinking with Barad, I conceptualize data as somewhere in between—as produced in intra-action with researcher, participant, students, room, memories, documents, methods, technology. In Figure 1, I gesture toward this intra-action. Like all models and representations, the figure can never capture completely the ongoing co-constitutions of data. At the same time, this figure produces some things as mattering that are not always considered as part of data production. For example, data from student work is constrained but not determined by the ways that the documents that teachers create structure particular kinds of responses from students through the types and order of questions and the amount of space for responses. Data thought with Barad's ethico-onto-epistemological frame cannot be considered outside of the specific material arrangements within which they are produced. The data are never data on their own as separate and cleanly bounded objects with determinate properties.

The phenomena that I name first round data co-constitution in Figure 1 aligns with what educational researchers conventionally name data. These data are the evidence of research in the field: field notes, transcripts, documents, audio recordings, student work. In this first round, I also account for the material and embodied intra-actions within in the field. How does my body in the room (as a part of the research apparatus) reconfigure and reconstitute the “data” that is collected/produced? In addition to the first round of data co-constitution in the research site, I attempt to account for another round of data co-constitution as the data comes into intra-action with bodies of literature, disciplines, fields, methodologies, and methods. The theories, methods, materials, citations, and prevalent journals of a field intra-act in specific material arrangements to produce knowledge.

Although I lean toward an understanding of data as agential in this study (Koro-Ljungberg et al., 2018), I align with Barad's views of agency as distributed in the phenomenon. Therefore, the data only glow in a specific material arrangement, to use MacLure's (2013b) often cited example of child-vomit-researcher-teacher-carpet-expectations. None of those phenomena glow in isolation, rather, the glow is produced in intra-action. Moreover, glow is produced within the *particular apparatus* of that material arrangement for MacLure as she is co-constituted with it.

Data as indeterminate and in relation requires response-ability to the arrangement and an accounting of the specific material arrangements of the knowledge making practices. This relates to my ongoing question of how to be responsible to and with data and to and with participants (Cannon, 2018). As I will discuss more later, the always already incomplete accounting of specific material arrangements prompts more responsive and response-able research. There is an ethics in acknowledging the uncertainties in the arrangements and an appropriate hesitation in drawing conclusions or acting on the knowledge produced as a result (Kofoed & Staunæs, 2015). Though Kofoed and Staunæs discussed ethical hesitancy within fieldwork, their tenants can be a guideline for data analysis as well.

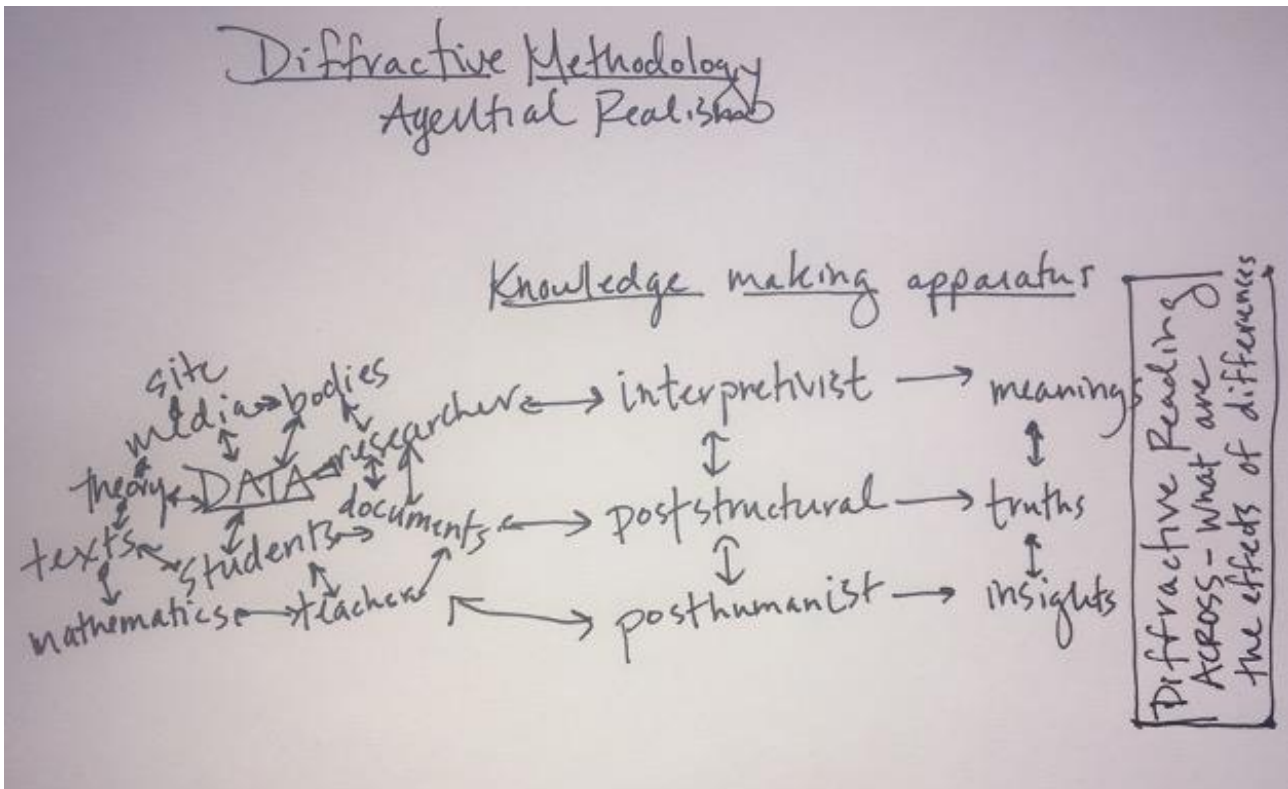


Figure 2. Diagram of Knowledge Making Apparatus for Diffractional Reading.

Methodology on the Move

Barad (2007) described knowledge making apparatus as “perpetually open to rearrangements, rearticulations, and other reworkings” (p. 203). She noted that the openness, the uncertainty, is “part of the creativity and difficulty of doing science: getting the instrumentation to work in a particular way for a particular purpose (which is always open to being changed during the experiment as different insights are gained)” (p. 203). Importantly here, Barad draws a line of kinship (Haraway, 2016) between science and creativity and acknowledges the continual reworking of instrumentation. The apparatus is created and creative, continually reworked. The openness of this way of doing science demands creativity. It also demands ethics on the move. This way of doing science is not prescribed, rule bound, a science of morals. This is a science of aporia, of hesitation and consideration of the specific material arrangements before and as we are moving—knowing. Knowing that cuts cannot be undone, and marks are made on bodies.

The diffractional apparatus constructed in this project was configured with attention to particular arrangements—of data, theory, researcher body, materials, fields—and the meanings, truths, insights, questions, material consequences these arrangements might produce. In Figure 2 above, I sketched out a diffractional methodology to read one set of co-constituted data across and through multiple specific material arrangements (attuned to different theories and fields).

In the first line I imagined an interpretivist knowledge making apparatus. Here, data is coded into neat categories to create meanings and knowledge legible to the field of statistics education research. In the second line I imagined a post structural knowledge making apparatus for the field of mathematics education research. In this line, and the taken for granted structures and discourses are actively questioned and the stable subject is put under erasure. In the third line, I imagined a posthumanist knowledge making apparatus, where materials, bodies, and more than human entities and affects produced insights. In sketching out this diffractive methodology, I enacted cuts between interpretivist, and poststructuralist, and posthuman entanglements with the data—knowing as outlined above that the data is constantly on the move and being co-constituted in arrangements. The cuts, I thought at the time were necessary to make this data legible to particular fields. I imagined that I could produce objective versions of the study to compare.

I conceptualized the apparatus with Barad (2007) and her reading of Bohr's two slit experiment, and the diffractive patterns created by the slits. The two slit experiment described by Barad (2007) created a diffraction pattern with "an indeterminate outline around each of the edges: along both the inside and outside edges there are alternating lines of dark and light that make the determination of a 'real' boundary quite tricky" (p. 75). The apparatus of my thought experiment also left an indeterminate outline between inputs and their reflections.

The boundaries enacted in each performance of the methodology were indeterminate and tricky. And the boundaries are difficult to trace, so often more *counts* in knowledge production than is convenient or reasonable to account for in educational research. For example, the specific material arrangements include the ways that the places and spaces in which the knowledge was produced enacted cuts together-apart. For example, I wrote parts of this text on the floor of a hotel bathroom. Sitting on two pillows with my laptop cold on my bare legs. My two children were asleep in the beds less than seven feet from me. My fingers pressed the keys a little more softly than usual in hopes of not waking them. It was 5:30 in the morning, and we were halfway to my mother's house in Florida. I decided to stop at a hotel given that I did not think I could drive 10 hours by myself. The material reality of the places where I have written matter in what gets said and how it is said. Again, I cannot note all of the places my writings have come from, but I provide this example to illustrate both that it matters, and it is impossible to account for in full. A performative methodology, a methodology on the move, asks that we account for *where we know from* (McKitterick, 2021).

Since each entanglement is a dynamic reconfiguration of the world, the *first* reading was not first. I had already been thinking with Barad and this clean arrangement of data and theory that I drew in Figure 2 was never possible. There are no clean lines between readings, nor could I disentangle data from the previous code that clings to it in its new arrangement. Objectivity seemed

impossible.

However, the complexity of doing science this way, does not preclude its value. The hope is to produce something beyond or to expose another way of being in relation not to mirror or reflect reality. The knowledge making apparatuses come together to make a diffraction pattern to be read/created/invented. Apparatuses are “are not static laboratory setups but a dynamic set of open-ended practices, iteratively refined and reconfigured” (Barad, 2007, p. 167). The apparatus of the thought experiment cannot contain all of the specific material arrangements that produce this knowledge, the practices of knowledge production shifted and morphed as they were co-constituted.

Performative methodology is creative and considered. It is not happenstance or casual. And, the instrumentation requires reworking as new insights are gained. The sketch that I drew in Figure 2 gave insight into the ways that I was thinking about doing this science. Barad’s objectivity requires the accounting of the specific material arrangements in knowledge production. The figure is a gesture to that accounting. And, the marks on my researcher body did not allow this linear way of doing science.

The ethical implications of this type of accounting are both humbling and harrowing. I am doing research knowing I can never get it right (Pillow, 2003) and knowing that it matters. My response-ability to the research process is an ongoing responsibility² to the world’s intra-active, lively, and burgeoning becoming. Though I believe neither of the initial entanglements to be elegant or sufficient, the overall entanglement allowed me to attend to the data in more responsive and response-able ways. The diffractive reading across the data productions allowed new insights into what counts (or not) in various arrangements.

² I use response-ability (Barad, 2012) when considering my ability and attention in response to a part of the research phenomena. I use responsibility as a gesture toward what I owe to others in relation to them, which is premised on a moral view of relations where there are particular agreed upon rules to follow in how we should behave. If I were to write this sentence again, I would use response-ability in both places for theoretical reasons; however, I think that I still often operate in my life and research in a space of “shoulds.” I should have asked her another question. I should have said thank you. I should have waited longer for her response. I should be sitting down taking notes. I should not take up so much space.

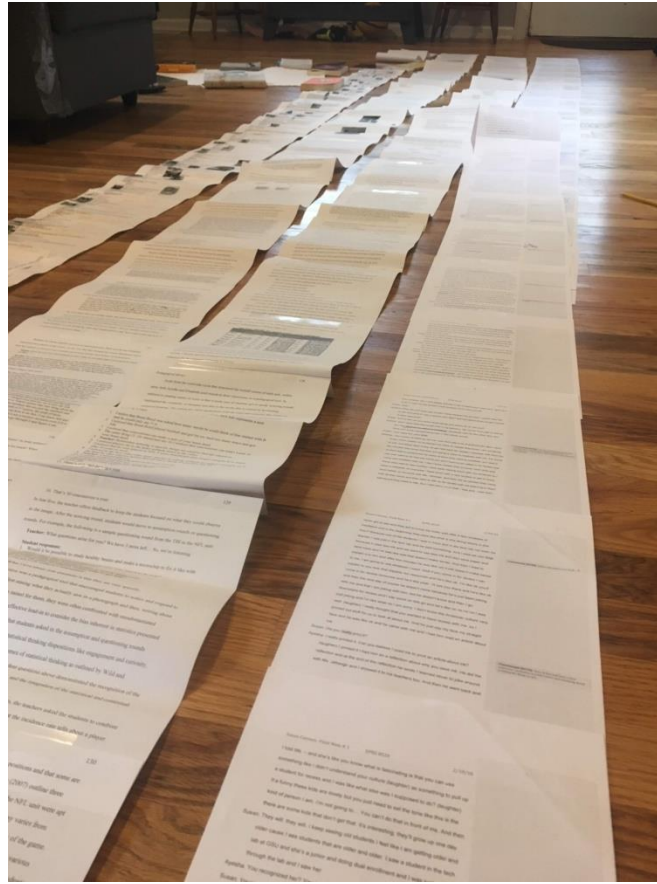


Figure 3. Image of Transcripts and Interpretivist and Poststructuralist Readings Scrolled out on the Floor.

Diffractive Reading

I have established the complexity of Barad's objectivity, the accounting for specific material arrangements of knowledge making practices and the ways in which the research apparatus can be tuned and reworked. The implications of these reworkings and different ways of doing science in educational settings matter. Diffraction is one way to think affirmatively about how the differences in research/living arrangements come to matter. Diffraction is attuned to "differences that our knowledge-making practices make and the effects they have on the world" (Barad, 2007, p. 72). The goal of the diffractive methodology was not to compare what (method/theory) is the same or different or which (method/theory) was better, but to "carve out what is new through the interference" (Smythe et al., 2017, p. 29). Diffraction prompts a different engagement with difference that moves beyond the binary of old/new, good/bad, humanist/posthumanist to attend carefully to the differences these practices make and how they come to matter in educational research. Diffraction is meant to disrupt linear and fixed causalities and to work toward "'more promising interference patterns' (Haraway, 1997, p. 16), both between words and things" (as cited in van der Tuin, 2011, p. 26). The hope is to provoke new thoughts and theories toward inclusion and responsible action. The question then is how might one *read* those interference patterns or see the difference difference makes.

Barad (2014) described diffractive reading as “affirmative engagement” that seeks to make “new patterns of understanding-becoming” (p. 187). I follow Hepler and colleagues (2019) to think of diffractive reading as “intra-action between texts that brings new texts into being” (p. x). Further, in response to Hein (2016), Murriss and Bozalek (2019) describe diffractive reading as, “different from critique in that text/oeuvres/approaches are respectfully read through each other in a relational way, looking for creative and unexpected provocations, strengthening these, rather than using an atomistic binary logic to compare one with the other” (p. 873). The *reading* of the interference patterns is affirmative critique, “to be interested in creating new connections and concepts” (Andersen, 2018, p. 59-60) and to “ask what are the possibilities for its further reinvention” (p. 59)?

After I wrote the interpretivist and poststructuralist readings of the data, my intent was to study the versions and consider the differences and how they might matter, to be provoked. I was not sure how I was going to do this. The computer screen was not big enough to contain all the versions I wanted to read together—or rather it contained them too much. The materials needed to be touched and moved. I had scrolls of paper with various versions of the transcription, one was collaged years earlier with images from google searches and handwritten notes (See Cannon, 2018). I laid out that collaged transcript, the transcripts from the photo elicitation interview with Ayesha and Elisabeth (pseudonyms for the teachers in the study) and the two writings that were produced through my entanglement with the data. At the time, I was renting a house with a connected living and dining area. The papers stretched from the front door to the entry to the kitchen, 20- 25 pages each taped end to end. A 25 foot by 5 foot rug of words, images, notes, and comments on comments.

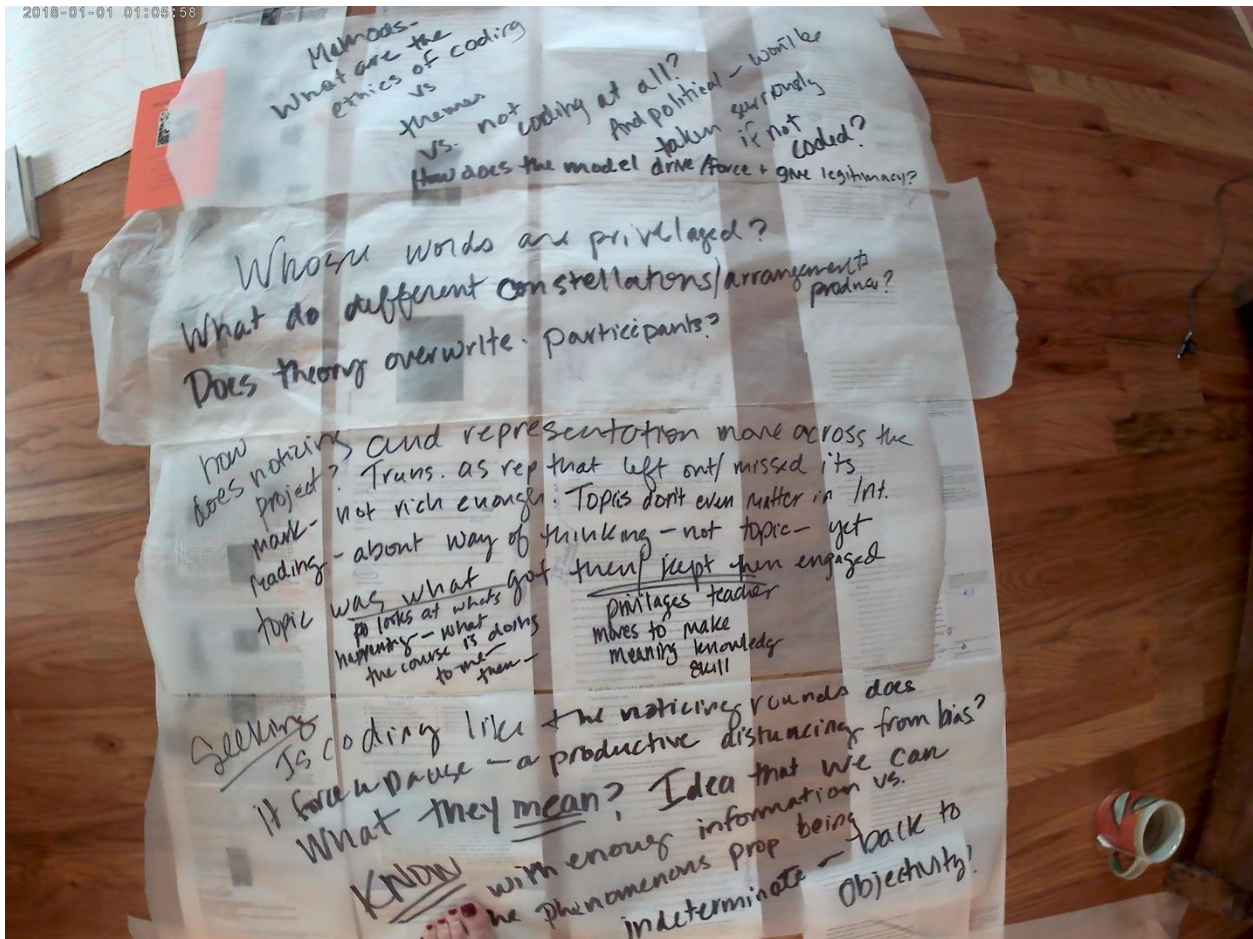


Figure 4. Images of Four Knowledge Productions Laid out on Floor with Trace Paper Overlay, Questions, Coffee Cup, and Foot.

Listening and Silence

In addition to the text that filled the floor, I set up my laptop on the small white table in the dining area. I turned on the audio of the first interview, when it ended, I played the next one and so on, until I had listened to all the audio recordings of our conversations. By the time all the interviews had played through I was still reading, my knees cracked, my back was tired from balancing over the papers. I reread all four documents one at a time as they laid beside each other on my floor – the coded versions and the collaged versions of both interviews—taking notes on them as I went, my voice and the participants’ voices in the air in the room along with my dog’s bark (who had died) and my daughter’s voice from when she interrupted one of the interviews to bring us a small plastic toy (her voice from 3 years ago, a toy that no longer matters to her). These were spectral data (Nordstrom, 2013) interruptions or materializations entering into the analysis bringing and making different spacetime matters, carrying me away and back again into different versions of myself and the data³.

³ I had written this sentence yesterday (a yesterday now two years ago), something I added in the re-reading and thinking, then this morning I re-read Lenz-Taguchi (2012) and was struck by her words in intra-action with the

I had read all of these things before, over and over again; and it mattered that I read the versions against/with/across each other and that the audio was playing. There were things that I heard in the audio that I did not realize had gotten left out, that had not counted as important enough or did not fit into any of the categories, and they mattered in my becoming with this data with this research. Hearing my dead dog's bark pulled me in some way into the spacetime-mattering of that interview upstairs on the couch— *Frank, the best dog in the world enters the room*, I heard myself narrating in an upbeat voice on the audio of the interview projecting from my laptop, that voice had become unfamiliar. I was taken back to sitting upstairs on the couch with Elisabeth while other guests (why were there guests there) laughed on the back porch.

Sometimes as one interview ended, I did not notice for a while. The silence would creep up on me and tap me on the shoulder, suddenly there lurking, making me self-conscious of how long I had been in my (our) own world. Other times, I was attuned to the disappearance of the voices, and they would disrupt me, prompt me to stand and start a new interview before bowing down again to the papers on the floor.

Spectral Accounting: Moving Toward What Looks Like Nothing

Then entanglements bring us face to face with the fact that what seems far off in space and time may be as close or closer than the pulse of the here and now that appears to beat from a center that lies beneath the skin. The past is never finished once and for all and out of sight might be out of reach but not necessarily out of touch. (Barad, 2007, p. 394)

Though I did not yet know exactly what I was going to do or how long I would be doing it before I began the diffractive reading, I felt compelled to document the event. I set up a camera on the bar by my kitchen and recorded the process. The camera was witness and participant (Nordstrom, 2015) in the intra-action and at the same time a kind of testament to the vestiges of validity —me making sure there was proof that I had done what I said. Here is the [video of Cannons Diffraction - Spacetime-matterings with Data](#).

The video was ten hours long, so I time lapsed it down to a few minutes. Rewatching it years later, there is a ghostliness to the movements through the frame, my (her) body jumping from location to location, the paper pushing across the floor as I (she) read, the cats entering and exiting and sunlight through the windows moving across the pages. I bow down to the data, with the data. I read each version through again and then read horizontally across— the expanse of the floor allowing the texts to mingle. One cat gets onto my back pressing his weight and warmth into me. I stay at that spot in the transcript, not wanting to displace him. I leave to pick up my kids from school and the video captures the intimacy of our afterschool routine, a milk carton enters the

sentence I had written—“a diffractive reading involves me as a researcher in disclosure of a reality that causes me to differentiate in relation to myself—as in a *difference in itself* as understood by Deleuze (1994:28)” (p. 277).

frame in the foreground. We sit in front of our respective screens, each body bent and curled to the device. I change clothes from long pants to shorts. The data is sacred and is also trampled and underfoot. In a moment the scrolls disappear, and the floor is revealed again. The chair in which I nursed both of my children, returned from a cousin comes into this home, into view, carrying memories. I see myself placing felt pads underneath it to protect the rented floor. The room is rearranged to accommodate the new chair. The video ends with the materials regulated back to the two white tables pushed together. It is almost as though nothing happened.

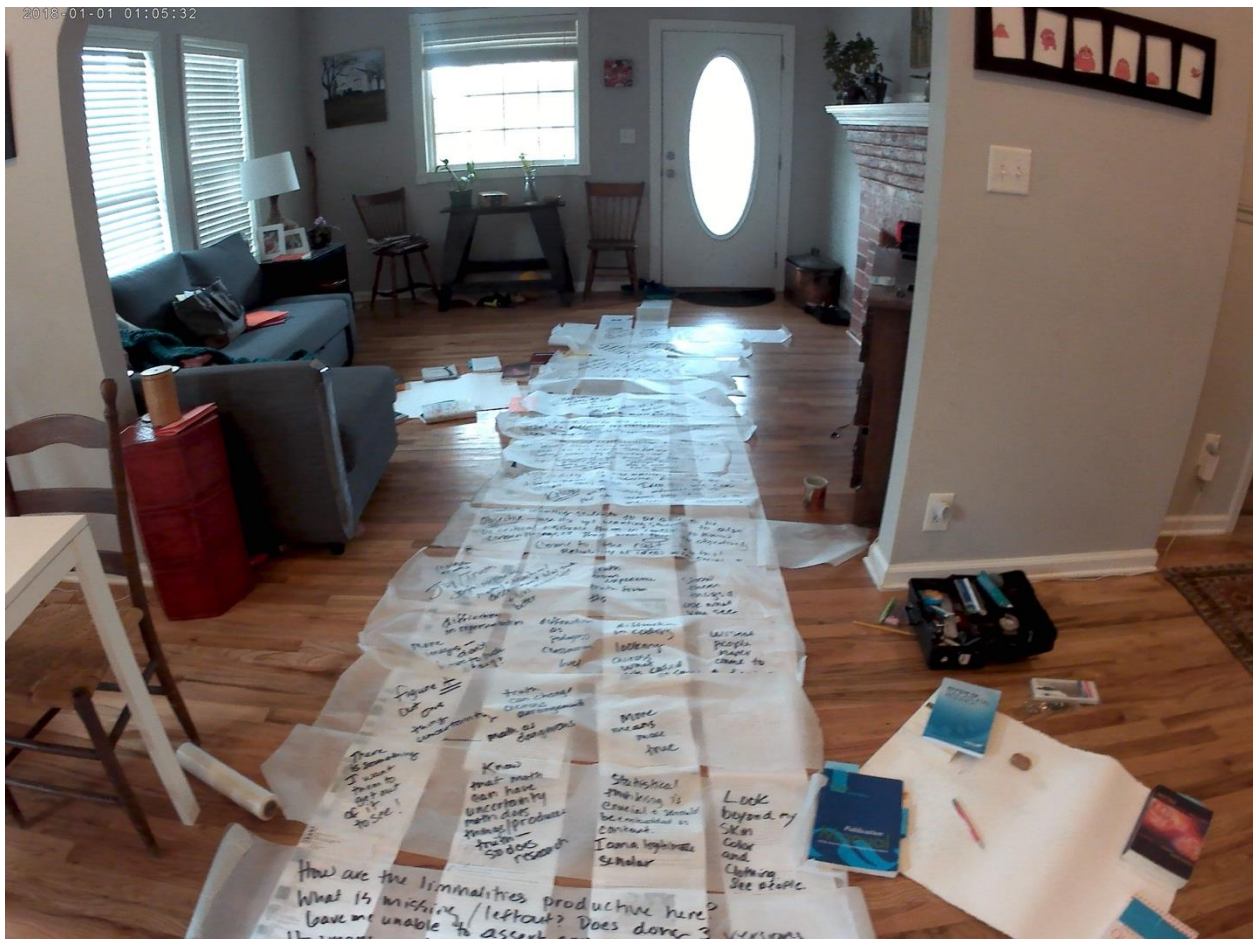


Figure 5. Specific Material Arrangements of Diffraction Reading, Image of Living Room with Scrolls, Trace Paper, Maps, and Writings Utensils

Why Might Diffraction Readings Matter?

Barad attests that diffraction “makes manifest the extraordinary liveliness of the world” (2007, p. 91). The diffractive reading, listening, moving across the papers, put me in a responsive material arrangement with the data, texts, voices, and images. This material arrangement produces a different liveliness in the data, in the text. Inventive lines of connection crept across the versions and kin was made between readings (Haraway, 2016). The versions became one larger string figure of connections and accounting of *where we know from* (McKittrick, 2021). I know from all of the places in this configuration at once, not one and then the other.

In reading across the versions, I considered diffraction as a process that “makes inquiries into how differences are made and remade, stabilized and destabilized, as well as their materializing effects and constitutive exclusions” (Kleinman, 2012, p. 77). The diffractive reading makes connections and allows affirmative critique of difference.

Reading across the versions, begged the questions: *Whose words are privileged?* (What is being stabilized?) *What do different constellations, arrangements produce?* (What is being remade?) *Does theory overwrite participants? How do they matter?* (What is destabilized?) I drew arrows between, I laid trace paper across the versions and asked questions of the research, of the apparatus, of the phenomenon. “Permanent marks ...[are] left on bodies” (Barad, 2007, p. 119), not just my researcher body. *What are the ethics of coding, or of emerging themes, or not coding at all? Can coding force a distance or objectivity or an amount of time with the data that is productive?* The coding made data matter differently in the phenomenon. Each time I worked with and through the data they were arranged within a new phenomenon of which I am a part, and it carried the marks of previous arrangements. String figures are knotted together. A death comes sweeping back to me. Knot. A smile in the collage gestures to the original photograph and the moment it attempted to capture. Knot. Diffractive reading made manifest, as my body bows to the data, the glows, the heartache, the joy— the liveliness, the disturbances, and the obstructions.

Obstructions/Disturbances/Interference : Making Things Small

Diffraction patterns created by overlapping waves in water can create disturbances that signal an obstruction, a rock jutting out into the water or an object falling from above. The wave that results from this overlap can be larger or smaller than either of the original component waves depending on the arrangement. In the case of this diffractive analysis, reading across the versions prompted me to notice disturbances and obstructions that did not fit in a linear research apparatus. What was left out or did not fit in any recognizable scholarly knowledge production? I could see how certain bodies and stories did not matter within these apparatuses, and that a different apparatus would be needed to make them matter—to produce them as scholarly knowledge.

Forgetting, covering up

I was struck in engaging with the four scrolls of paper, as the paper cutout of Michael Brown⁴'s face repeated over the length of the collaged transcript faced me. Though the students in the middle school classrooms had studied Michael Brown's murder in Ferguson, MO in 2014, he was erased (or rather regulated to a table of topics for the class) in the final versions of the research

⁴ Michael Brown was an African-American man killed by a White police officer on August 9th, 2014. It was the year that this study began, so the teachers discussed Michael Brown's killing and the larger pattern of systemic racism and disproportionality in police stops and arrests in the United States in the *Current Events Math* course. Just as Michael Brown was erased in final versions of my dissertation, his life has in many ways been overwritten by his tragic death. I offer a limited list of references here that can be read diffractively for readers who are not familiar with this event. [His sisters on StoryCorps](#). [On CNN](#). [In U.S. Department of Justice Report](#). [In New York Times](#). [In The New Yorker](#). [On Fox News](#). [In The Atlantic](#). [On BBC](#). See also: <https://blacklivesmatter.com/> and <https://www.aapf.org/sayhername>.

(Cannon, 2019). The focus of the mathematics courses that I researched was to help students to see beyond the data presented in the news to better understand social issues. The students researched police stops in Ferguson and the disproportionality in the data on stops, searches, and arrests by race. I had transcribed the audio of the interview with the teacher as she spoke about this work and listened and relistened to that audio as I collaged the transcript. I printed out images of Michael Brown at that time, gluing them in the white spaces on the transcript. I recognized then that these scraps of paper with images of Brown in his graduation cap failed to capture him. Yet, it felt important at the time to try to look at him. Until I unrolled that transcript and bent on the floor to study it, I had not realized how present his life and death and been to me in those moments years ago. And, in the final drafts, there was just one line in a table accounting for how his story mattered in this research. His erasure in the research was an unethical worlding.

In another example, reading across the audio, transcripts, and interpretivist and poststructural readings prompted me to notice a cut and how that relates to response-ability. In an intra-action with, Ayesha, one of the participants in the study, she stated, “if only they knew me,” after sharing an interaction with some students. In listening to the interview later, I reflected that I should have probed that statement instead of turning the conversation back to mathematics—what my research study was *about*. It was not until I listened to the audio again while reading across the versions, that I realized that when I did follow up on her comment in the next interview, her story still did not make it into any of the versions. It did not count as knowledge with these apparatuses. The story was an obstruction that changed the pattern of the movement in the interview, that took us off topic, and it mattered, and even so, the knowledge making apparatus that produced it, continued moving, its direction only slightly altered.

On that day, Ayesha brought a map of the Mediterranean Sea to the photo elicitation interview. The map was marked with red circles representing the deaths of refugees. She explained that they had used the map in their unit on the European refugee crisis. They had asked the students to imagine what the red circles represented. She explained that many of the students did not know what part of the world the map was, and then went on to describe how this was surprising to her. Then she told the story of her family’s history with immigration.

In Pakistan I’m a third generation non refugee because my grandfather walked all the way to Pakistan from India. He found refuge in Pakistan in 1947 in the largest human migration every recorded. He walked from India to Pakistan with his family and with my father in his hands. My father was born in India. I was born in Pakistan. I was the first person born in Pakistan. It meant a lot to me, I guess to say that, yeah my family found refuge in Pakistan. Refugees were middle class people just like my family. My grandfather had graduated from University in India. He was an engineer; my father was an engineer here. And they are just regular middle class people and so I think when I told.... I didn’t tell them exactly all of this.

I just told my kids, “I need to tell you where I am coming from because I feel like this could be a bias, and I want you to know it. Which is that I am—I didn’t think of myself this way until I read the story—was that I am a refugee in Pakistan. And, I just happen to be an American because my father got an American citizenship here in the 70s. My grandparents had to fight to come to Pakistan in 1947, so that way I didn’t do any of the fighting. People before me did, but I am first generation non-refugee in Pakistan and from a refugee family.”

This story was not made to matter in my first two configurations of the research. I think that does not show response-ability to Ayesha and the stories that she chose to tell. Barad stated, “Cuts are enacted not by willful individuals but by the larger material arrangements of which ‘we’ are a ‘part’” (p. 178). I can excuse my exclusion of this story because it did not tie to statistical literacy or mathematics education research, yet I now see and feel an ethical responsibility to tell it. It mattered that Ayesha choose to tell this story to her students, she was accounting with and to them, *where she knows from*. As they studied the European Refugee Crisis, they knew that their teacher had connections to the stories presented in the newspaper. Therefore, the specific material arrangements of their knowledge making practices, their coming to know *about* the European Refugee Crisis shifted, was different, in relation, and hopefully more response-able.

Haraway (2016) wrote about making kin with inventive lines of connection. As I think about the difficulty and creativity of doing science, I wonder how teachers and educational researchers draw lines of connection to build relations, between content and ideas, between people and things. To draw us together, and I am hopeful that thinking in these ways matters for how we are becoming in ongoing relation and response-ability to each other human and more than human. The versions of this research that are legible to the fields of mathematics and statistics education largely obscured the liveliness of the research. The glow was dampened to conform.

Superpositions

There were places in the readings and writings and workings that the movement came into phase and aligned and picked up speed, and places, like above where it seemed to snag and stick. As Barad (2014) stated, “we re-turn to thicker ‘moment[s]’ of spacetimemattering” (p. 168). There were tangles and catches and bulky places in this research. In one of these thicker moments, I am hitting my hand against my other hand resisting a subject that I do not think I want to become, buying a version of difference that Trinh Minh-ha worked against and Barad (2014) described as a “colonizing logic whereby the ‘self’ maintains and stabilizes itself by eliminating or dominating what it takes to be the other, the non-I” (p. 168). There were other moments where I felt resonances, moments where I was pushed or pulled. And there are liminal spaces that cannot so easily be named. Barad (1996) stated, “knowledge comes from the ‘between’ of nature-culture, object-subject, matter-meaning” (p. 188). In this betweenness, in the liminal, in the crossings

there is sensation, sometimes sensation that is joyful, and sometimes sensation that tugs the stitch of a wound.

In another thick moment, the accounting of specific material arrangements prompted me to attend to the distributed agency of intra-actions. A belt became central to the ethics of a moment. I was in the classroom taking field notes. I was feeling the tension between ways of being “good” researcher following a prescribed method and Barad’s theories. I was leaning toward a traditional idea of objectivity on this particular day. I sat behind the teacher’s desk, notebook poised in front of me, listening with my head turned down, so as to not look too much like I was looking. A student approached the desk and picked up the stapler. She was holding a broken belt in her hands. I imagined how the staples might interact with the pleather. I asked if I could help her. She told me it was her mother’s belt. I came out from behind the desk to search for duct tape or string, something to repair the damage done. I knew this classroom well. I fixed the belt with the girl and then did not return to the desk. I wandered the classroom participating in conversations about the number of calories in particular foods for a unit on sugar. The intra-action pulled me into a different relation and made me a part of a different knowledge making apparatus. Being in the research space differently reconfigured the world. The belt could have been seen as a distraction to learning, something that took us away from what we were supposed to be doing—made me a more biased observer, yet, she could not focus while it was broken. She felt a response-ability to the material, perhaps, to her mother. The belt became data and it exceeds data, it in intra-action with the student pulled us together and me into movement into a different spacetime-mattering. One that I argue was more ethical engagement in doing research.

Carol Taylor (2016) described Barad’s diffraction as “the materialization and force of differences that matter in a ‘worlding’ of entangled relationality, that is, an ethic of being with/in the world” (p. 202). Diffractive analysis is ongoing ethical and political practice and production. And, I do it knowing that I will never get it right (Pillow, 2003). Barad (2014) reminded us that diffraction is “not a singular event that happens in space time; rather it is a dynamism that is integral to spacetime-mattering. Diffractions are untimely” (p. 169). Research processes emerge in their enactments within the co-constituted phenomenon of the particular spacetime-matterings of which they are apart—methodology is not performed, it performs. These representations cannot capture the unwieldy dynamism, and I cannot begin to think that I can recognize much less tell or represent all the cuts that have been made in this research/living.

Performative Objectivity

As I entangled with data and theory in various spacetime-matterings and considered the flows and pulses and snags that are produced in and out of time in this project. Data “transform[ed] themselves” (Koro-Ljungberg et al., 2018, p. 471) with me and theory as we become together. We flowed and paused and snagged in diffractive patterns of amplification and resonance. As I took up

the initial set of data—documents, and audio recordings, and field notes, and images—again and again with other materials and another body—surgically altered, materially different, and with different theories and readings, data were created again through my intra-actions with them. Data production became both flattened in terms of hierarchies and entangled in terms of agency. Data production occurred in the field, the site of research, and then again in the fields of qualitative inquiry, mathematics education, and statistics education. I gesture at the complexity of data production to point to the entangled nature of our becomings and the indeterminate futures still to be made.

Although I imagined I might be able to consider the data with each theory neatly (resting in my humanist notions), I found that I zigzagged between theory—or that theory pulled or pushed me as the data/theory/materials acted on/with me. As Barad (2014) attests, there is “no absolute boundary between here–now and there–then” (p. 168). Diffraction is not a set process or pattern. It is iterative. In becoming researcher with this data and these theoretical texts, I was radically reconfigured and became unable to see data in fixed ways. The assumptions and taken for granted ontological commitments of the theories wound around the data and me and reconfigured us into another body, and none of this entanglement can be undone.

The apparatus is “tuned to the particularities of the entanglements at hand” (Barad, 2007, p. 74) and those particularities were noted as much as possible. As Smythe and colleagues (2017) explained, “our research apparatuses create the phenomena... and we are responsible and accountable to these” (p. 180). The goal of this entanglement is insight into other possible arrangements, not to repeat or duplicate arrangements. Data are constituted differently in various specific material arrangements, and “quantum entanglements require/inspire a different sense of a-count-ability, a different arithmetic, a different calculus of response-ability” (Barad, 2010, p. 251) to all of these conditions. And, I wonder in this different calculus, what is my responsibility to continue to find other ways to make data count? When is it enough?

The question of whether we can do science, especially, social science objectively arises again. Barad leans on the power of the discipline of physics to argue for the possibility of objectivity through the accounting of the specific material arrangements of the knowledge making apparatus. I return to her description, “Hence objectivity requires an accounting of the constitutive practices in the fullness of their materialities, including the enactment of boundaries and exclusions, the production of phenomena in their sedimenting historicity and the ongoing reconfiguring of the space of possibilities for future enactments” (Barad, 2007, p. 391). I have found this accounting to be both productive and impossible. I have in this inquiry accounted for things and texts and more than human interactions that might not have counted in other arrangements. Barad’s objectivity is a tall order. The idea of a complete accounting could cause research to stall. Perhaps, it asks too much. Or the too-muchness is an opportunity, we make kin with these lines of inventive

connection, reaching out, looking, feeling to whom and how our research matters, considering where we know from to be more response-able. We do this not to get it right but to be in ongoing and complicated relation with the liveliness of the world in its worlding. We do this attending to our material and ethical response-ability to our research participants, research texts, disciplines, academic foremothers, and more than human conspirators.

Diffraction, puts forward as its underlying principle, indeterminacy. Indeterminate boundaries between things taken for granted to be separate. Properties and characteristics that are ongoing and co-constituting in each moment in response-able relation. Then the goal is not to create a true representation “but productive evocations, provocations, and generative material articulations or reconfiguring of what is and what is possible” (Barad, 2007, p. 389).

The project of thinking with Barad’s objectivity functions to draw my attention to all of the myriad creatures and material and aural insertions into the knowledge making apparatus. The cigar smoke that prompts a discovery. Lenz Taguchi (2012) cautioned/informed us that diffractive analysis “relies on researcher’s ability to make matter intelligible in new ways and to imagine other possible realities presented in the data: a real beyond those produced by processes of recognition and identification in reflexive interpretations or discursive perspectives or positionings” (p. 267), so I pause here with an acknowledgement of the limitations of my imagination as to the iterations produced already and confess that data/researcher/material/theory/spacetime continues to produce beyond what I can know/become/write/tell—and it is not enough. What have I made intelligible?

And we can never get it right. It is not about getting it right. I practice Barad’s objectivity to attend to specific material arrangements to be response-able and in relation with more than human and human partners in knowledge creation. I attend and intend to notice when in the phenomena there is a glow and to acknowledge both its complexity and its mystery. We cannot know, despite our desire, why we are drawn to particular moments, objects, bits of text as glowing. That is part of the beauty and creativity of doing science.

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