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Getting Experimental: Performing Cognition in the EEG Lab

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Getting Experimental: Performing Cognition in the EEG Lab

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Philosophy

in

Communication (Science Studies)

by

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2017

The Dissertation of Sarah Ann Klein is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

Chair

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2017

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ABSTRACT OF THE DISSERTATION

Getting Experimental: Performing Cognition in the EEG Lab

by

Sarah Ann Klein

Doctor of Philosophy in Communication (Science Studies)

University of California, San Diego, 2017

Morana Alač, Chair

This dissertation examines and intervenes in cognitive scientific experimental practice as performance. It is structured around an ethnographic study of a cognitive neuroscience lab that uses electroencephalography (EEG) to study processes of language and meaning in the brain. Working from participant-observation, multimodal analysis of interaction, and performance-collaboration, I describe how experiments are designed, performed, and understood by their subjects and researchers, how unruly experimental subjects become competent data sources, and how experiments move through time and space as empirical structures. I describe experiments as complex performances of enfolded interdependency between scientists, human subjects, technologies, and cognitive phenomena. My account of how cognition is performed in the EEG lab bumps up against the descriptive limits of generalized and universalized accounts of performative entanglement. I argue that materializing cognition as a scientific object depends on a reflexive capacity to enact, inhabit and layer relations of inside and outside, subjectivity and objectivity. This dissertation makes an intervention into theories of material-semiotic performativity prevalent in Science and Technology Studies (STS) by developing a local specification of cognitive scientific entanglement as "folding". I trace this folded form of performative entanglement through different loci of experimental practice. Chapter 1 describes how the central research object of the laboratory, the Event-Related-Potential component, folds together the world and brain. Chapter 2 considers the embodied and intersubjective work of producing "clean" brainwave objects from unruly human subjects. Chapter 3 considers how scientists inhabit one another's experimental designs through a social practice of reading. Chapter 4 documents a methodological shift from participant observer to collaborator through an iterative experiment-performance that intervenes in the activity of experiment itself.

Introduction

A cognition experiment

In the testing room it is dark and warm. As an experimental subject, my task is to listen to the sentences played through the speakers, then to attend to the word that appears on the screen without moving my eyes or blinking. I sit as still as possible so as not to interfere with sensitive electrode cap that is recording my brain waves. I try not to blink. I try not to move my eyes or my face or body. I hope I am being a good subject. I try to keep my body out of the way so that my brain's signals can make their marks. I wonder whether the voice I am hearing in the recording is the voice of the undergraduate RA who I've met a few times in the lab. The voice says:

"A housefly was buzzing merrily along until it found itself stuck in place. Soon, its body was drained of vital fluids."

A pause. The monitor flashes the word

spider

I've been told it is especially important that I try not to blink around the appearance of the visual word, so I wait till after the screen goes blank and there is a pause in the audio to blink, take a deeper breath, and shift my weight slightly. The voice says:
"Since then, the walls of the canyon have worn smooth with time."

The word

eagle

appears. This kind of thing continues for some time. It is boring, but also oddly challenging to suppress my blinks and focus my gaze. I become hyper-aware of my body and the impulses I normally follow without thinking. Any little thing - a blink, a swallow, a clench of the jaw - may threaten the integrity of the data. When the sentences end and the visual word is presented, I try to be perfectly still. I feel like an open aperture, letting the word in, and at the same time, like a conduit, sending something back out again through the wires to squiggle its way onto the electroencephalogram.

(*blink blink blink blink — Don't blink — — — ——— - - - Don't blink*)

"But recently, the company said it no longer needed assembly-line workers"

(*Really don't blink*)

robots

(— — blink blink blink)

I know I'm not really supposed to try to figure the experiment out, but I get the sense it has to do with the different relationships between the words and sentences. It's hard to think much about that when I'm supposed to be attending to these sentences, fixating my eyes on the screen, and concentrating on not-blinking. When the block of trials ends I am relieved. I roll my head in a circle, blink freely, extra even, to wet my eyes. During this break between blocks, a graduate student researcher pokes his head into the room and speaks to me - just keep doing what you're doing. He reiterates the instructions. I do two more blocks of audio sentences paired with visually presented words*:* I breathe. I quiet my body. I listen to sentences. I understand that something of interest must be happening in my brain when I am supposed to be not-blinking. The instrument by which my brain's potentials are being recorded is the electroencephalograph, which uses a cap to pick up my brain's electrical activity from the scalp's surface via gel-filled electrodes. The cognition experiment aims to turn what goes on inside my head into something publicly observable, measurable, and ultimately knowable. This dissertation asks what makes that possible.

I participated in this experiment as a part of my ethnographic study of experimental practice at the Brain and Language Lab[1] (hereafter BLL). The BLL is a laboratory at a large public university in California that investigates the human brain's processing of meaning. I found out some time later that this particular experiment investigated differences in the cognitive processing of words that were causally or

[1] A pseudonym. I will give a detailed description of the BLL's research object in Chapter 1, and a detailed account of the lab site in Chapter 2.

lexically related to their preceding context[2]. These psycholinguistic and cognitive neuroscientific researchers, I learned, were studying meaning by looking at its effects on the ebbs and flows of the brain's electrical potentials. I myself was there to understand how experiments enact cognitive objects for scientific research. It turns out we shared an interest in *how meaning is materialized* - but we focused on different scales of activity, drawing our boundaries differently, holding different parts of the world still. The kind of holding-still that is done in a cognition experiment requires a high degree of complicity and collaboration from its experimental subjects (as does a laboratory ethnography from its scientific actors). The perspective of the experimental subject offers a unique view of how this holding-still works - a perspective from the inside of methods, from the perspective of the entity being studied, that is not available to ethnographers of most scientific practices. Experiencing the inside of cognition experiments as a research subject opened up a set of questions that would structure this project: How is cognition materialized as a scientific object, and what is the experimental subject's role in that materialization? To answer these questions, this dissertation approaches the cognitive neuroscience experiment as a collaborative performance, an entwining of worlds of research subjects, technologies, and researchers.

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[2] In the preceding example, the first visual stimulus, "spider", has a causal relationship to the preceding auditory context: "A housefly was buzzing merrily along until it found itself stuck in place. Soon, its body was drained of vital fluids". The second visual stimulus, "eagle", has a lexical but not a causal relationship to the preceding sentence: "Since then, the walls of the canyon have worn smooth with time". These were stimuli from an experiment in which I volunteered as a research subject in May 2011.

Why Performance?

Approaching experiments as performances allows me to illuminate cognition experiments as material-semiotic compositions that move through time and space, requiring and configuring particular actions and relations between its actors. In structuring this dissertation around the unit of activity of the experiment, I combine theories of performativity with an analytic frame of performance. This is because experiment already blends together the quotidian and the staged, emergence and structure, citation and repetition. In other words, experiments live in the overlap between the performative and the performance.

A simplified account of this distinction is that performativity is associated with everyday reality, while performance is associated with artifice. While performativity pervades enactment and repetition of everyday social life, it is spontaneous but constrained, whereas performances are associated with composition, staging, and fictiveness. The famous example from J.L. Austin (1955/1975) exempts theatrical utterances from his theory of performativity - "I do" as part of a wedding ceremony is a performative, but when a character in a play says "I do", it is parasitic (Austin 22)[3]. Performativity, most influentially described by Judith Butler (1988, 1993) is characterized by its pervasive everydayness - gender and sex, the performative systems which Butler is best known for elaborating, are constituted through their repeated and "citational" enactments in everyday life. Butler and Austin both make a point of distinguishing

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[3] Yelena Gluzman, building on Shannon Jackson's account of the banishment of theater from performativity, expertly argues for theater as is its own kind of world-making, phenomena-enacting apparatus. (Gluzman 2017, forthcoming book chapter)

everyday performatives from theatrical performances, which, because of their artificiality, they do not see as inhabiting or operating in/on the world in the same way. From the inverse perspective of performances as extraordinary, Richard Schechner (1985) distinguishes performance from everyday life by marking "restored behavior"as the defining feature of performance. While acknowledging, per Goffman, that everyday life is also made up of performances or at least is performance-like, true performances are additionally distinguished by intentional and artful manipulations of these "strips of behavior" (Schechner 115).

Experiments are activities which have both qualities of the everyday (spontaneity, mundaneness, routine) and the staged (repeated, controlled, and composed of "restored" components). Studying experiments as performances can complicate the distinction I outline above, by illuminating how performances and performativity work together in moving a method through time and space.

Ethnomethodology and ethnomethodological treatments of scientific practice[4] have provided an orientation and set of tools which have become useful in this project for considering performativity and performance together. The ethnomethodological processes of transcription and analysis make it possible to encounter and articulate tacit and embodied features of mundane interactions that would otherwise go unnoticed, but are nonetheless intricately coordinated achievements. Examples of precise moments of scientific performativity revealed by this approach include the coordinated discovery of the optical pulsar (Garfinkel, Lynch, and Livingston 1981), and the situated "handling" of

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[4] See especially Garfinkel 1967, 2002; Goodwin 1994, Lynch 1985, 1997; Ochs 1996, Alač 2011, Vertesi 2015

fMRI images (Alač 2011). The middle chapters of this dissertation (Chapters 2 and 3) use multimodal transcription to look closely at how researchers interact with subjects to ensure legible experimental data, and at how they understand and imaginatively occupy one another's experimental designs. As such, these transcripts invite readers into different facets of experimental practices, from the novel embodied choreography of the experimental subject, to the more conceptual (but no less embodied) experimental architecture scientists enact when discussing experimental designs. Transcription of these experimental practices in cognitive science not only illuminates generalized performativity as tacit and embodied features of experimental practice that undergird and ensure its continuity. It can also reveal when and how, in these mundane interactions, the experiment becomes relevant *as a performance* for its members - as a particular desired bodily choreography, as a recombinable composition of human, material, technical, and conceptual components, and as a staged experience into which naive subjects will enter.

Ethnomethodology also helps bridge performativity and performance, because it is itself, in my view, a performance method. The process of transcription and analysis turns everyday interactions into inscriptions that can be re-encountered and imaginatively rehearsed by the analyst and her audience. In other words, in order to reveal performativity, I suggest that transcription provides an occasion to enter into a theatrical relationship to an interaction. Analysts (I here include readers) are not just passive audiences to the transcribed interaction, but are invited to inhabit a transcript in a way that is more analogous to the way an actor might inhabit a script. The attentiveness that an interaction transcript helps to activate is not directed at uncovering hidden motives or inner lives of its characters[5], but is nonetheless premised on the capacity of the analyst to share a world - to orient themselves as intersubjective partners and co-performers - with the actors in a transcript. In order to reveal the tacit, enacted, orderly, and performative, ethnomethodologists re-mediate the everyday into a kind of empirical theater.

This approach enables me to bring reflexive specificity[6] into two conversations. First, into anthropological orientations to the neurosciences, and second, into theories of performative entanglement that circulate in Science and Technology studies (STS). Some anthropological scholars of the neurosciences warn against the dangers of reductiveness of neuro- approaches. Two influential anthropologists of science who make such warnings are Joe Dumit and Emily Martin. Joe Dumit (2004) writes about the stakes of brain imaging in his study of PET scans and how they travel. Dumit describes how, as PET scan images travel outside the lab, they can become stabilized as brain-types and thus with kinds of people (ie,"NORMAL", "DEPRESSED", "SCHIZO" (capitalization in original, 8)). A major concern for Dumit is that when these images travel and accumulate meanings, they easily conflate "kinds" of people with particular kinds of brain scans, reducing the complexity and uncertainty in the actual research, particularly when these images leach into settings (like the courtroom) where scientific imaging is rendered as authoritative evidence with consequences for individuals and the legal system as a whole. In this case, the reduction is enabled by PET's circulation, and what makes this possible in Dumit's analysis is the PET scan's visuality.

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[5] Ethnomethodologists' aversion to mentalism makes them odd cousins of behaviorists.

[6] Here I mean reflexive in the ethnomethodological sense, referring to the semiotic resources and embodied practices by which "account-able" situations are enacted (Garfinkel 1967, Lynch 2000).

Emily Martin (2000) warns of the enveloping imperial logic of "brain-based pictures of human action" (575). Her concern is at least partly territorial, worrying that "the neuroreductive cognitive sciences [are] the most dangerous kind of vortex— one close by and one whose power has the potential to suck in disciplines like anthropology, severely weakening them in the process" (574). Martin positions ethnography as an alternative "technology of sociality" (584) that is under threat. Martin's warning about "reductionistic and brain-based picture(s) of human action displac[ing] our current everyday mental concepts" (575) seems to be both a general warning and an explicit call-out of Paul and Patricia Churchland, "neurophilosophers" and eliminative materialists who aim to replace "irrational" folk concepts with brain-based accounts.

The research that I present here may temper the concern that neuroscientific accounts of cognition are unified or totalizing enough to displace current everyday mental concepts for philosophers, anthropologists, or lay people. Looking at cognitive neuroscientific work in its ongoing, situated enactment reveals that in the local achievement of stabilizing cognitive objects, everyday mental concepts and subject positions are continually invoked and deployed by scientists. The work of grounding mental phenomena in the brain involves all kinds of intersubjective maneuvering and collaborative object-making, that exceeds the brain-based explanations that are under construction. I share real concerns about the dangers of reducing individuals and subjective experiences to brain-based accounts, particularly as scientific claims and evidence are abstracted beyond their productive contexts. However, with this dissertation, I hope to demonstrate that engaging closely with neuroscientific research practice can reveal local opportunities for intervening in and resisting neuro-reductionism that are unavailable from purely oppositional or defensive boundary-policing positions.

The same embedded, enacted complexity that provides opportunities for re-imagining or re-staging cognitive science also grounds my theoretical intervention into material-semiotic STS. I developed this work within performative frameworks in STS that trouble the boundaries between nature and culture, materiality and language, and objectivity and subjectivity[7]. However, I found that cognitive phenomena and the practices by which they are enacted pushed against the descriptive limits of the prominent metaphor for scientific performativity - the metaphor of entanglement. Scientific entanglement, broadly, proposes a state of affairs where "nature" is not a whole and separate realm to be discovered by science, nor is science wholly responsible for nature's "construction". In entangled and material semiotic "onto-epistemologies" (Barad 2007), the world and the way it comes to be known are mutually implicated. Entanglement, like performativity, pervades everything, but provides the additional symbolic affordances of knots and tangles through which to think the co-implication of subjects and objects. This dissertation does not contest the utility or the validity of a generalized theory of performative entanglement. However, knots and tangles were not sufficient for

[7] In its uptake in STS and elsewhere, performativity has roosted in the spaces left when "social construction" fell out of favor. Andrew Pickering (1995), John Law and Vicki Singleton (2000), and Karen Barad (2007) are a few STS scholars who explicitly develop material-discursive theories of performative ontology (or onto-epistemology), extending performativity, at its widest reach, as the mode by which the universe becomes intelligible to itself (Barad 2007). There are others, like Donna Haraway, Annemarie Mol, and Bruno Latour, who have similar material-semiotic, situated, or enacted ontologies without explicitly or consistently claiming the term of performativity, but who nonetheless describe a state of affairs in which the world and knowledge of the world are co-constituted.

articulating the particularities of making cognition into a scientific object. From my performance oriented accounts, I develop a local specification of cognitive scientific entanglement as *folding*[8].

While it might be tempting to propose folding as an alternative to entanglement, I resist this universalizing tendency and suggest instead that looking closely at different scientific practices may allow different species of entanglement to emerge. This is a different approach than Karen Barad takes in her elaboration of agential realism in Meeting the Universe Halfway. Barad's agential realism is grounded in the ontological intedeterminacy of quantum phenomena, which are known for being "entangled" in the famous two-slit experiments with the presence of an observer. In contrast to "agential cuts", which, imply that agential indeterminacy is resolved through (complete if contingent) division, in making cognitive objects, it turns out to be characteristic and productive that agential distinctions don't fully resolve. Instead of a "cut" enabling an apparatus to flip between two ontological resolutions (ie, particle/wave), we have interactions where subjectivities and objectivities are simultaneously nested inside of one another.

Barad's agential realism is consistent in many ways with the core tenets of material-semiotic and onto-epistemic performativities characterized above, but she controversially grounds her theory in the claim that quantum indeterminacy operates at

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[8] Folding does have its own phenomenological genealogy, where for Merleau-Ponty (1968) and Deleuze (1993) respectively, folding functions as another kind of pervasive, generalized account of how phenomena come into being. Arguably here, folding is an alternative or companion to entanglement. My deployment of folding does not have universalizing ambitions of this kind, but describes the local and enacted structure of cognitive scientific objects.

all scales. While I am not capable of evaluating the science of that claim[9], I would suggest that like folding, the analogy of the agential cut emerged from considering a particular scientific practice (in this case, quantum physics experiments), and that it isn't necessary to make either the fold or the cut universal.

Methods

Between 2011 and 2015, I carried out ethnographic fieldwork at the Brain and Language Lab, a lab which studies language and meaning in the brain. The BLL primarily uses EEG to record and analyze the brain's electrophysiological responses in an approach called the Event-Related-Potentials (ERP) technique. I began by participating as a subject in their experiments, and soon after started observing and filming daily research practice, focusing on interactions between subjects and researchers. In 2014 I attended weekly lab meetings, which I also eventually began videotaping. Much of the empirical content of this dissertation is centered around interactions that were recorded on digital video, transcribed, and analyzed using conventions from conversation and interaction analysis. These conventions are aimed at representing non-verbal and multimodal features of speech and interaction, including gesture, gaze, and co-ordination. I also reviewed foundational cognitive scientific literature on Event-Related-Potentials, the central research object of the lab, and analyzed their semiotic strategies[10].

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[9] While I am not qualified to evaluate the legitimacy of Barad's move from a physics standpoint, in a 2016 lecture given at UCSD's science studies program, Kerry McKenzie outlined efforts to effect convergence (or scaling up) between classical and quantum mechanics and the implications for the hope of achieving a fundamental theory, which I believe she argued was "forlorn".

I had attempted to begin a review of the scientific literature on ERPs early on in my ethnographic research but failed to get very far with it until after I completed fieldwork. Undoubtedly, being there longer helped me achieve the tacit knowledge or "unique adequacy" (Garfinkel 1967) needed to understand it. Ultimately, I read the ERP literature through the ethnographic analyses I developed. In other words, my scientific literature review was integrally mediated by my ethnography. This review, alongside data from the taped lab meetings, forms the basis of Chapter 1.

I occupied different empirical positions with respect to the practices I was studying throughout the project. Aside from taking on the role of an EEG subject myself, in the role of ethnographer that I adopted, I first attempted to make myself as unobtrusive as possible. Focusing my taping sessions on interactions between subjects and experimenters was a good device to this end, because it gave my interest and presence a bounded character. I would come to the lab when a subject was scheduled to be there, and if the subject cancelled, I would often leave. Lab members came to expect that I would be there during data collection. While I was occasionally present for other kinds of work during these early stages, such as the processing of EEG data or training new members to apply the EEG cap, most of the time I found myself sitting at the meeting table, chatting, taking notes, waiting for something to happen, or awkwardly finding positions in the narrow testing spaces that would allow me to capture as much as possible of the interaction I was recording with my narrow angle Flip Video camera. Data from this part of my ethnography form the basis of Chapter 2.

When I later began attending and taping lab meetings, my participation deepened. While earlier on I had found myself following the bounded interactions of running subjects in experiments, in the lab meetings, I was welcomed as someone with general interest in the subject. The weekly lab meetings I attended regularly in 2014 were "journal club"-style meetings where undergraduates, graduate students, and some professor and postdoc visitors and the lab PI would read and discuss journal articles together. Because I also did these readings, and because the meetings were a mixed crew of relative novices and experts, these meetings were very useful for familiarizing me with basic assumptions and concerns of the lab and of scientists carrying out related research. I asked questions and participated in these discussions without worrying much about interfering, and because I was sitting at the table and recording from a corner tripod rather than following people around with a handheld camera, I think that members were more easily able to ignore that they were being taped. Data from this part of my ethnography form the basis of Chapter 3.

In the last part of my research, I developed and explored an alternative empirical relationship to scientific practice premised on intervention that I call performance-collaboration. This involved developing a collaborative research design with a cognitive scientist that tinkered with the mechanisms by which cognitive phenomena become articulable and legitimate - in other words, experiments with (and about) experiment. In 2015, I made a performance with cognitive scientist Tyler Marghetis, called EXPF for Experiment-Performance. Together we studied experimental performativity by collaboratively intervening in its performance structure. This performance is documented and analyzed in Chapter 4.

Map

In Chapter 1, "Writing with Brains", I introduce the technology of EEG and a central research technique and object of the lab, the Event-Related-Potential (ERP). This chapter entwines technical description with analysis of the instruments and objects that help organize the experimental practices that will be explored in chapters 2 and 3. In addition to setting up these later chapters, my account in Chapter 1 looks closely at how Event-Related-Potentials function to objectify cognition by holding together activity occurring simultaneously at two different scales - laboratory and brain. This chapter develops a specification of cognitive scientific entanglement as enfolded by analyzing how inside and outside, subjectivity and objectivity are negotiated in cognitive scientists' accounts of the ERP. I close with a discussion of the "homunculus problem" in theories of cognition, and suggest that personifying components of cognition is both an inevitable and productive way to make cognitive objects meaningful.

While Chapter 1 focuses on the ERP as held together by cognitive scientists, Chapter 2, "Making Brainwaves", turns to subjects' situated and embodied performances of making ERP data in the BLL. This chapter describes the BLL's space and focuses on how subjects are disciplined to perform as competent data sources. I situate this chapter in a set of arguments by historians, anthropologists and sociologists who have traced the role of subjectivity in psychology and neuroscience experiments. These scholars argue in various ways that scientific psychology systematically evacuates subjectivity. I complicate the narrative of complete evacuation or banishment, arguing that while the subject's own experience may not be of immediate scientific interest, researchers nonetheless rely on subjects' ability to self-monitor in order to produce legible EEG data.

I describe how experimenters engage subjects in a guided biofeedback session with the EEG in order to show them how it *feels* to produce "clean" brainwaves unblemished by bodily artifacts. Playing off of Vincianne Despret's concept of rendering-capable, I describe how a subject is "rendered experiment-able" for ERP experiments, which depends on subjects' capability to experience themselves - and perform as - subjects and objects simultaneously.

In Chapter 3. "Reading Rhythm", I move from the embodied performances of subjects performing in ERP experiments, to how researchers understand, manipulate, and inhabit one another's experimental designs. I analyze a meeting of the BLL where members gather together to read a journal article on a study that investigates physiological signatures of differences between "real" and "imagined" experiences of rhythm. I describe how cognitive scientists, through reading, activate and inhabit an experiment as a performance, moving that experimental design through time and space. This chapter complicates canonical STS accounts of scientific inscriptions that emphasize its their power-accruing immutability and mobility (Latour 1986) and their related ability to circulate, enabling virtual witnessing (Shapin and Schaffer 1985). In contrast to accounts locate inscriptions' power in their immutability or mobility, I argue that in reading as a lab, texts are open, affording opportunities to inhabit others' past research activity. I describe how lab members use local and embodied resources to enact the experiment as an architecture, that is, a composed structure to be experienced from within, and manipulated from without. At the same time as describing a porous relationship between scientific action and inscription, my situated account of reading rhythm also highlights the dilemmas of materializing a distinction between “physical” and “imagined” phenomena experimentally.

In Chapter 4, “Shaping Experiment”, I actively include myself in the activity that I am studying. Chapter 4 brings together themes from the previous chapters (performative entanglement, subjects’ interiority, performance structure of experimental designs) with methodological concerns about how to take STS’s own methodological entanglement seriously. While much has been written about how scientists are performatively entangled with their research objects, STS scholars tend to reproduce empirical distance and transparency in their descriptions of scientific practice. This chapter explores a possible configuration for taking scientific performativity seriously and literally, by making performances together.

This chapter documents a collaborative performance (“EXPF”) made by myself and cognitive scientist Tyler Marghetis, for the cognitive psychology lab (2015). In EXPF, we inverted the agential structure of the cognitive psychology experiment, rendering it responsive to the impressions of its subjects rather than testing a hypothesis of the researchers. After bringing subjects to the lab and having them carry out what appeared to be a standard, computer-based cognitive psychology task, we elicited impressions about the experiment’s purpose and suggestions for improvement. Our performance score required us to respond to subjects’ feedback by making revisions the experiment before the next subject arrived, whose impressions revised the next version of the experiment, and so on in an iterated chain of performance and revision.The chapter considers the outcome and the process of performing EXPF as a methodological experiment in responsive research methodology. I show that in becoming responsive, experiment and experimenters became instruments to register the invisible routines, expectations, and agential relations that make the experiment possible at the scale of laboratory interaction, this forms the basis for my case for collaborative performance-making as an empirical method.

Chapter 1

Writing with Brains

"Can you read my mind with that?" an experimental subject asks, in a half-joking way, perhaps smoothing over some apprehension, as a graduate student researcher fits his EEG cap. Electroencephalography means "electric brain writing", but EEG does not, at this point, produce an inscription that can be transparently "read", as one would a book, for a smooth transmission of the content of another's experience, in spite of the popular fantasies of transparency that have followed EEG through its history. Historian of psychology Cornelius Borck traces the pervasive popular notion that EEG will enable transparent reading of the psyche as far back as 1930, when Berger's first report was published. He cites Finkler, a journalist contemporary of Berger:

> Today, the brain still writes secret signs. Tomorrow, we will probably be able to read neurologic and psychiatric diseases in it. And the day following tomorrow, we will start to write our first honest letters in brainscript (Finkler 1930, 7, in Borck 2005, 91).

Eighty-odd years later, this dream of transparency continues to shape research and development of technical applications for EEG. EEG data, and in particular the Event-Related-Potential technique that I will describe in detail shortly, is being harnessed into so-called "brain fingerprinting" systems which figure a more ominous application of mind-reading than the utopian vision of "honest letters in brainscript" dreamt of by Finkler. Brain fingerprinting attempts mind-reading in the form of an of electroencephalographic polygraph test for use in intelligence and interrogation contexts[11] (Farwell 2012, Rose 2016, Engber 2017).

"Reading" EEG in the Brain and Language Lab is neither as simple nor as supernatural as the notion of mind-reading, imagined as a superposition of subjectivities. In practice, EEG research in the Brain and Language Lab is a process of writing and reading inscriptions where the writing and reading are so tightly and cyclically coupled as to be difficult to pull apart. Rather than enabling the fantasy/nightmare of private, subjective experience becoming transparently legible, EEG research on cognition materializes mind as scientific object, through what I will argue are processes of folding.

The practice of making/making sense of EEG resembles, on one hand, the inferential process by which scientists use instruments and experiments to make sense of other kinds of 'natural phenomena'. EEG and an EKG (electrocardiogram), for instance, work by similar mechanisms and make similar inscriptions for representing the electrical activity of the brain and heart, respectively. Researchers and clinicians use these inscriptions to infer what the brain or heart are doing. On the other hand, using EEG to study cognition as a brain-generated activity involves rhetorical and practical negotiations and transformations of subjectivity and objectivity, interiority and "observable behavior"

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[11] Brain fingerprinting functions under the contested scientific premise that if you have seen an object, your P300 brain response to that object will differ in predictable ways from the brain response of someone who has not seen that thing (Engbers 2017). For the purposes of my argument in this chapter, I would note that even if accurately detecting deception using this technique is possible, "naked" EEG remains quite opaque. Detecting deception is not done by a human analyst looking at the EEG, but by a pattern-recognition algorithm that essentially repurposes mathematical features of the ERP apparatus, while black-boxing the rest of the semiotic work that I will go on to describe in this chapter.

that are unique to cognitive psychology and neuroscience. This chapter traces these negotiations and transformations in the semiotic structure of EEG research in the Brain and Language Lab (BLL).

In the BLL, EEG inscribes a record of brain activity that researchers work with to make inferences about the cognitive processes that produced them. They do this using a procedure called the Event-Related Potential (ERP) technique. Scientists use the ERP technique to produce and analyze averaged EEG recordings of human brain activity in order to stabilize "components" in the EEG waveform that predictably correspond to particular sensory, motor, or (as is the focus of this lab) cognitive events.

EEG is an imaging technology that inscribes the brain's activity; the ERP technique is an experimental and analytic approach that uses EEG to ask and answer questions about cognition. This does not neatly cast EEG as about writing and ERP as about reading. The interpretive work of ERP research that I will describe in this chapter is not limited to the end-point of data analysis, but pervades every step in the experimental practice, from reading others' studies, to the design of an experiment, to its implementation and its analysis. It is difficult to pinpoint where writing ends and reading begins. Instead of asking "how do cognition researchers read EEG?", or even "what does the brain write?", this chapter asks a more ethnographic, processual question: "how do cognition researchers use EEG and ERPs to write with brains?" This question places brains, (technologies, subjects) and researchers as entangled processual partners, in contrast to linear account of graphical production and interpretation. This chapter describes EEG research and its objects as enacted, in particular, how interpretations or accounts of cognition are entangled (or, as I will specify, enfolded) with *lab and brain* activity in and through its varied materializations.

In this chapter, I will describe how cognition researchers "write with brains" using ERPs. After introducing the technology and technique, I will review how ERPs are configured in foundational accounts in the cognitive neuroscience literature. Next to these formal scientific accounts, I will outline and analyze the colloquial means by which researchers understand and communicate what is going on in, or "indexed by" an ERP. First, I will show how (lab orchestrated) events are related to (brain-recorded) potentials in order to enact cognition. ERPs function as part of assembly of experimental performances to hold together and create correspondences between three processual domains: the brain, the lab, and the mind. Having laid out the semiotic processes involved when researchers *relate* worldly Events to their brainy Potentials (the Event-Related Potential is written and read *as a relation)*, I will argue that ERPs bump up against the limits of onto-epistemological entanglement theory that has become prevalent in STS. My analysis will specify STS accounts of onto-epistemological "entanglement" to develop an account of psychological and cognitive objects as "enfolded".

The instrument

In the late 19th century, Hans Berger originated and named the "electroencephalogram"[12], which is an inscription of electrical activity from the brain via

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[12]La Vaque (1999) notes that an early alternate name for this technology was "electrocerebrogram" (Pravich-Neminksy's preferred name) which Berger rejected as a linguistic barbarism because it combined greek and latin roots.

an array of electrodes placed on the scalp. In plainer terms, EEG records “brain waves”. Today, EEG is used clinically, to study states like sleep, meditation, and arousal, to diagnose brain conditions like epilepsy, and to determine brain death. In the cognitive sciences, particularly cognitive neuroscience and cognitive psychology, EEG is widely used because of its excellent temporal resolution - it can record electrical potentials to the scale of the millisecond. It does not primarily do so by providing a “map”, as do newer brain imaging technologies like fMRI[13]. EEG’s low spatial resolution is a weakness, but its high temporal resolution is its strength. The way electricity flows through the gel-like conductive medium of the brain means that activity recorded by a given electrode will not necessarily originate from the nearest anatomical structure. How current travels and whether it can be picked up on the scalp depends largely on the orientation of neural cells, which when activated function individually as dipoles (having equal positive and negative charge at each pole). When similarly oriented neurons fire at once, their dipoles sum together and can be picked up by the scalp electrodes. Nearby similarly oriented positive signals will add to each other, while positive and negative signals might cancel one another out. While EEG researchers do register and represent the spatial patterns of brain activity using topographical maps of EEG’s scalp distribution, they are largely subordinate to the temporal features of the EEG. While on its own, EEG is not reliable for mapping functions onto physiology, its inscriptions plot “changes in voltage over

[13] Popular media tends to equate brain “imaging” with spatial imaging technologies, particularly with the colorful maps produced by fMRI and PET. While ERPs are often accompanied in the literature by a topographical “map” based on which electrodes recorded the ERP activity, the strength of EEG is in its temporal resolution.

time” (Luck 2011, 4), which can help answer questions like “what happens in the brain during sleep/a seizure/listening to a sentence?”.

The earliest electroencephalograms were inscribed on paper. Today, in the cognition lab, as in most modern hospitals, live EEG appears on computer monitors as a set of horizontal vacillating lines, each line a channel corresponding to an electrode[14]. Despite its name, EEG does not produce a transparent record through which cognition can easily be “read”. There are certain states that are legible with the naked eye on an individual’s EEG: a trained observer can learn to recognize whether a subject is sleeping, drowsy, or having seizure activity by distinctive pattern made by the wavelength or frequency (measured in cycles/waves per second, or Hz). An awake, alert brain exhibits wavelengths of around 15-20 Hz (Coulson 2007, 402). The appearance of the slower “alpha pattern” (wavelengths at a frequency of 9-12 Hz) in the EEG of a subject whose eyes were closed, and the blocking of the same pattern when their eyes were open, was one of the first regularities to be observed by Hans Berger in his research (Borck 2005, 87). A person who fully falls asleep shows the even slower delta wave pattern . These rhythmic wave patterns are a feature of EEG that can be “read” by a trained, naked eye. Additionally, a trained observer can identify *bodily* artifacts in the ongoing EEG, which

[14] Most of the channels correspond to scalp electrodes, but there is nearly always a reference electrode placed on a relatively electrophysiologically ‘quiet’ part of the body, in order to calculate the difference in amplitude between itself and a given scalp electrode. There is some debate among practitioners about which location provides the best reference, with preferred locations for certain researchers (and particular methods/questions) ranging from the mastoid, ears, and tip of the nose. The BLL used the left mastoid, which is the name of the bony ridge behind the ear. Additionally, an electrode was often placed below one eye to record/monitor eye movements.

are muscular movements of the face and body that actually interfere with the recording of the lower-amplitude brain activity.

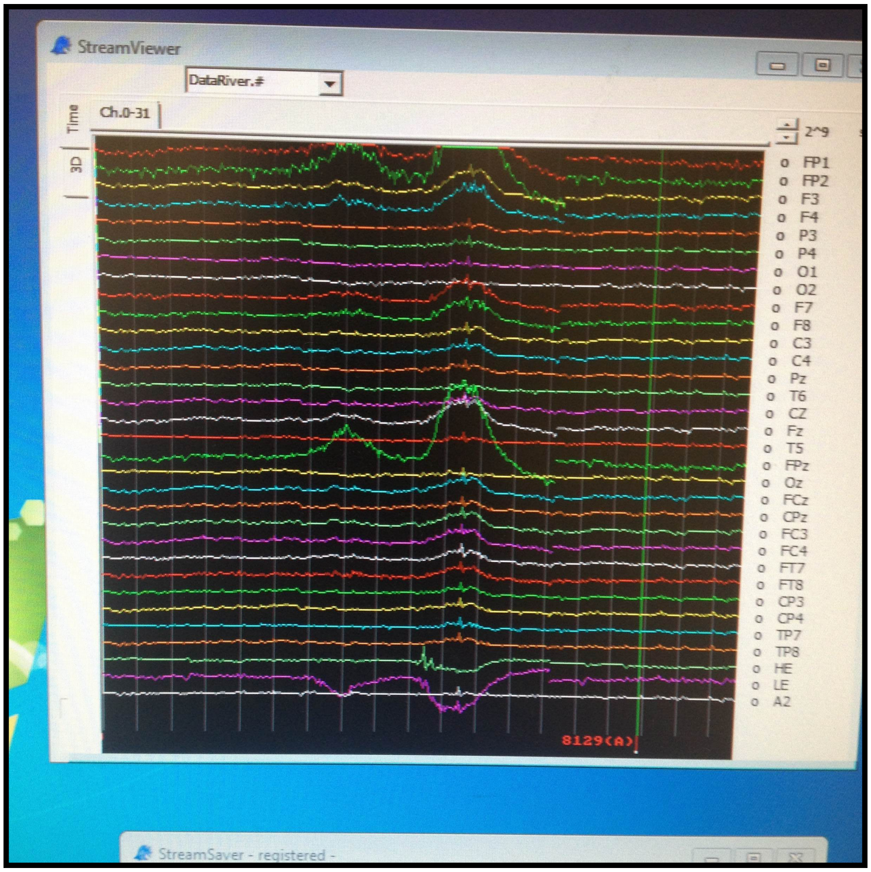

Figure 1.1. Video still of Raw EEG on a monitor during an experiment at the BLL

Because brainwaves recorded by EEG are small in amplitude and must travel through the skull to the surface of the scalp, they are easily drowned out by the stronger signals from muscular movements of the body, including tiny movements of the head, eyes, jaw, throat, and face, including unconscious or automatic movements like blinking, eye movements, swallowing, and muscle tension.

I found that in the day to day work of experimental data collection, BLL researchers interacted with EEG by monitoring the ongoing EEG for bodily artifacts, the most common type being the blink. If a subject's EEG had too many blinks, that subject's whole data set would have to be trashed. In my time observing ERP experiments in the lab, I saw researchers identify subject's blinks, a yawn, tension in the forehead or jaw, and the direction and size of a subject's eye movements. The BLL's policy was that if blinks affected 25% of experimental trials, that subject's data would be discarded (Interview with lab member, 2013). Blinking is such a pervasive artifact that scientists, in addition or sometimes as an alternative to monitoring the EEG with the naked eye, have developed software to analyze and remove blink artifacts. I analyze at length the disciplinary strategies directed at the subject's body that are implemented in the BLL's experimental practice in Chapter 2; for now, I wish only to flag the irony that in order to practically implement a technology for "brain writing", researchers learn to read a rich set of visual signs to monitor the EEG for *bodily* artifacts that get in the way of the 'real thing'. In other words, in order to be able to make a legible brain recording, which will be averaged and analyzed, researchers read the live EEG as an index of the non-brain body, as well the EEG proper for signs of a participant's state of arousal (alert, relaxed, or sleepy). As I heard a grad student researcher explain to a subject, "it's ok if you're sleepy, but it would be bad if you fell asleep." Another time, when I asked another researcher how easily he could understand what the subject was physically doing from monitoring the raw EEG, he told me that when he saw a subject yawn on the EEG, he too would reflexively yawn. The artifact had become so transparent to him, that the researcher found himself susceptible to the yawn's contagion, as if there were no heavy metal door between them.

This way of reading and relating to EEG, relying on distinctive rhythmic wave patterns and artifacts in the raw EEG, can be used to monitor the subject's body and arousal state, but it is not the primary research focus of the BLL. This is because these transparent features of EEG do not convey much information about how the brain responds to a specific stimulus. Because a brain is understood to have much activity going on in a given moment, it is impossible, with the naked eye, to reliably separate the "background" activity from the activity that is relevant to the processing of the particular object or task of interest at a given moment in time. In the mid 1950s, signal averaging began to change how researchers worked with EEG (Woodman 2010, 2031). Averaging the signals from a number of trials increased the likelihood that the pattern inscribed by the averaged EEG reflects processing related to a time-locked event rather than the other "background activity".

It is important to note that in ERP research, there are different classes of "noise" in relation to the signal: brain and non-brain sources of noise. Non-brain sources of noise include the body artifacts of blinking and other muscular electrophysiological distortions that interfere with the brain recording. Bodily noise that manifests from "outside" the target system is undesirable and is preventively managed through the interactional register[15], or after the fact, by removing trials contaminated by body artifacts, either manually or using computer software for artifact-detection. Brain-based "background"

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[15] I analyze this disciplinary management of subjects' bodies in Chapter 2, "Making Brainwaves"

noise, on the other hand, is an accepted feature of brain activity, and the entire ERP apparatus is organized around reducing this noise by gathering a large enough number of trials and then averaging them to allow the event-related activity to become visible. This averaged inscription is called the event-related-potential, or ERP.

The technique

The method by which scientists in the Brain and Language Lab write with brains is called the Event-Related-Potential technique (figure 1.2). The Event-Related-Potential (ERP) Technique is an experimental and analytic procedure that uses EEG to analyze the brain's activity in relation to a specific event in time. The event is typically an externally-delivered ("exogenous") stimulus designed by researchers and the corresponding electrical potential is the brain activity that occurs in a consistent time course to that type of stimulus. In many of the language experiments I observed and participated in, the 'event' was often the presentation of a word, which was either related or unrelated to a preceding sentence, played over speakers or displayed one word at a time on the monitor. Because a subject's brain may be doing various things in a given moment beyond the processing of the "event", and because of the small size of the voltage fluctuations associated with the event, ERPs are produced by averaging across trials, so that the non-event-related activity is cancelled out and the relevant fluctuations remain available to make up the ERP waveform. As Tim, a PhD student at the BLL, explained,

> The subject's brain is doing a lot of different things at once, it's, like, keeping the heart beating, it's uh, going oh my god the experimenter is so handsome, and so on, but it's also responding to the event, and so the part of the brain activity that's the response to the event is going to bear a predictable relationship to the event, like a predictable temporal

> relationship, whereas the part of the brain response that's not in response to the event is basically gonna be random. (S - uh huh) with respect to the event. So if you take like fifty trials you know, where they were looking at an unexpected word, in each trial, and you average together the EEG response to each of those trials, basically the stuff that is predictably related to the event will sort of stay there and be consistent in the signal, whereas the stuff that's not related to the event, like I want a sandwich, (S - uh huh) better keep breathing (S - ha ha) that kind of thing is um is just gonna like sort of average out to zero. (Tim, interview 05/03/13)

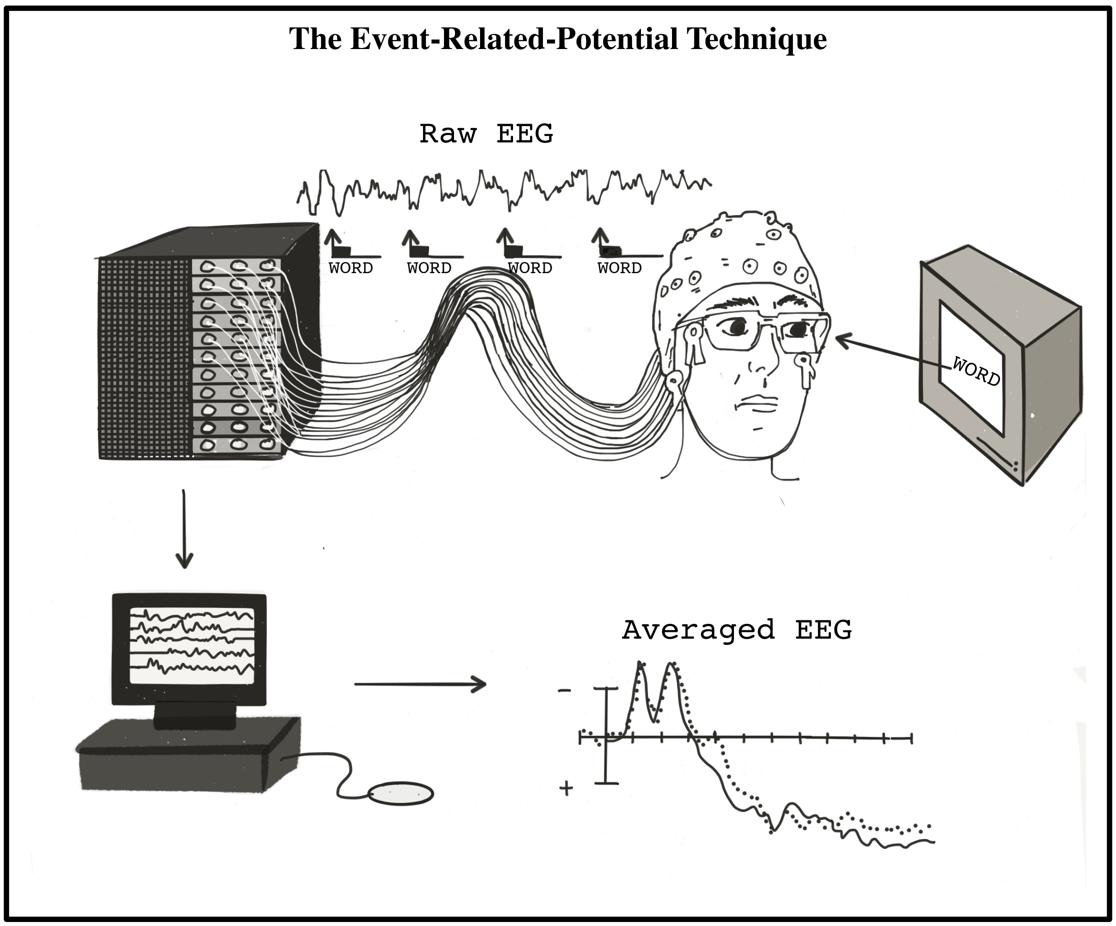

Figure 1.2. The ERP Technique

Through averaging, the "stuff that is predictably related to the event" becomes visible, and "stuff that's not related to the event" will be "random", not predictably related to the event, and thus "average out to zero". In this way, the averaging process is meant to lift relevant signal out of irrelevant noise. Relevant parts of the ERP waveform (positive and negative inflections in particular) that have *predictable* relationships to certain kinds of events are called "components". Different components are linked, through the experimental tasks/stimuli that elicit them, to different sensory, motor, or cognitive processes. In other words, researchers orchestrate different kinds of events to evoke/capture and analyze different kinds of morphologically predictable regularities in the EEG: these are called Event-related-potential components. Components are often stabilized with names like "P300" or "N400" that refer to their polarity (positive or negative) and latency (~number of ms after the onset of the stimulus). However, as I will explain, the process of pinning down an ERP component is more difficult than the clean alphanumeric name indicates.

Worldly Events and Brainy Potentials

The name, "Event-Related-Potential" acknowledges itself as a relation. It is a relation between a world of experimental "events" and brain "potentials" which points to a third entity, cognition. Because of this, a component is a difficult object to abstract from its event-making context - it carries its making with it. The structure of this relation, and the territory of cognition it enacts, are the subject of this section.

Because of its high temporal resolution, Event-Related-Potentials have become a valuable tool for electrophysiological cognition research. In an influential review of ERP research, Emanuel Donchin (1978) expressed optimism about the ERP's ability to link brain and mind, writing "It is becoming increasingly clear that the endogenous ERP components manifest are those very processes whose existence is inferred by cognitive psychologists" (351). At the BLL, "those processes" include musical perception, memory, processing of language and meaning, and various forms of reasoning. These processes are, of course, evoked by real, carefully delivered experimental situations, or "events". In the simplest terms, in an ERP experiment, *something* is made to happen in the lab, in order to make *something* happen in the brain. Through the regularities experimentalists are able to create between these two scales/loci of activity, they ground their inferences about cognition. My aim in the sections that follow is to describe how ERPs hold brain and world together in order to stabilize 'mind'. Beginning with foundational and textbook accounts, including influential definitions and debates around naming conventions, I will outline how ERPs are configured by their leading and foundational practitioners. The authors whose texts I focus on are Emmanuel Donchin, a foundational figure in ERP research, Marta Kutas, who is a prominent expert in psycholinguistics, and along with Steven Hillyard, the first to characterize the N400 ERP component (Kutas and Hillyard 1980), and Steven Luck, who, in addition to his own research on attention and memory, is at the forefront of ERP practice and pedagogy, having authored a widely used practical handbook about ERPs, developed an open source ERP analysis software package (EEGLab), and runs an ERP training bootcamp every summer.

'Textbook' definitions of the ERP

An ERP component only comes into existence when it is "shown to vary systematically as a function of some (…) independent variable" (Donchin 1978, 353). Factors that go into the interpretation of an ERP include, on the one hand, the features of the ERP inscription itself (polarity, latency, amplitude, and scalp distribution), and on the other, comparisons between eliciting conditions (independent variables) “to determine which experimental manipulation influenced a particular temporal region of the waveform” (Kutas and Van Petten 1994, 86). An example from the BLL is the N400 component, which is a negative-going component peaking around 400 ms after the stimulus that is understood to index meaning processing. All kinds of meaningful objects (including words, faces, pictures, gestures, objects) evoke an N400, but it has been through the manipulation of these objects in experiments that the N400 continues to be understood. Its amplitude is sensitive to semantic manipulations of all kinds, especially those that have to do with expectancy. An often-cited paradigm has subjects read sentences by showing them one word at a time on a computer monitor, using sentences half of which have congruous endings, and half incongruous endings. The more incongruous the sentence’s final word, the larger the N400 amplitude: “I take my coffee with cream and **sugar**” produces a smaller N400 than the sentence, “I take my coffee with cream and **dog.**” (Kutas and Hillyard 1980).

This kind of experiment helps scientists develop functional descriptions of the N400, like: the N400 is sensitive to “the processing difficulty of the object that elicits it” (Coulson 2007, 405) and it “indexes the activation of a word's meaning.” (Tim, lab interview 05/03/13). Functional interpretations, even more than naming conventions, may reflect a scientist’s broader theory of cognition, one notable distinction being between modular and interactive accounts of language processing. For example, Kutas and Federmeier (2011) give an account of the N400 which differentiates itself from the widely-held interpretation of the N400 that emphasizes its semantic character (and thus implies a semantic "module"), instead offering a more general purpose, interactive interpretation:

> Rather than reflecting the activation of "a word's meaning," then, the N400 region of the ERP is more accurately described as reflecting the activity in a multimodal long-term memory system that is induced by a given input stimulus during a delimited time window as meaning is dynamically constructed (Kutas and Federmeier 2010, 1420)

I will not go in depth into the issue of competing theories here, but include this quote as an example of how functional explanations of an ERP component can be attached to broader theoretical commitments. As the PI of the BLL, Penny, explained:

> When two components are the same or different is like this big thing in psychophysiology and people love to argue about it. And it's because different components come to take on explanatory value - if you can relate it to some known component then you can say, well, this means it's related to, perception, or this means it's related to memory, attention, whatever. (Penny, 07/11/2014)

An individual ERP component, as one (variable) region of the waveform, gets its meaning always alongside, in contrast to, and inevitably in friction with other components, whose identities may be collapsed or differentiated depending on the broader explanatory framework to which they belong.

Luck (2014) writes in his introduction to the ERP technique that to do good ERP science, researchers should know about all the major ERP components (71). This is why most introductions to ERPs (including many of those cited here) include a "primer", "catalog", or another kind of list or index of known ERP components (see Donchin et al 1978, Kutas and Van Petten 1994, Key et al 2005, Coulson 2007, Luck 2014). As I hope to make clear through the rest of the chapter, in order to be meaningful, ERPs must carry a great deal of their productive context with them, such that even the individual experimental manipulation for a given ERP is embedded in the broader context of ERP research more generally. The explanations in these "primers" consist of detailed accounts of what experimental manipulations produced what changes to the waveforms, so that researchers can hold onto a whole ensemble of related components, and plan their own experiments accordingly.

The Event-Related-Potential bridges mind and brain by having a foot in the outside world of events and a foot in the interior world of brain activity. This dual-worldedness is evident in attempts to give a general definition of an ERP component. Donchin et al defined an ERP component as "a set of potential changes that can be shown to be functionally related to an experimental variable or to a combination of experimental variables … a source of controlled, observable variability", and then as "a subsegment of the ERP whose activity presents a functionally distinct neural aggregate"(Donchin 1978, 353). The first definition is anchored to the activity of the researchers and the experimental design, while the second definition is defined by the material particularity of the brain response. However, Donchin cautioned against conflating a component with a given peak or inflection, arguing that scientists should "not use the morphology of the wave as our prime datum". Instead, the task is to "dissect this morphology in terms of the manipulated experimental variables…*all we can study is that which varies*" (354). In other words, a component cannot be defined by its morphology (latency, amplitude, and scalp distribution) alone, but always depends on its eliciting conditions in order to make sense.

Luck (2014), characterizes Donchin's definitions as "operational" and "conceptual" respectively, implying that each completes the other. Luck's revision of

Donchin's operational and conceptual definitions are instructive insofar as they each reflect the conjoined dualism of worldly event with brainy potentials. Ultimately, Luck brings a bit more brain into his operational definition by specifying what counts as "systematic variability":

> An ERP component can be operationally defined as a set of voltage changes *that are consistent with a single neural generator site and that systematically vary in amplitude across conditions, time, individuals, and so forth*. That is, an ERP component is a source of systematic and reliable variability in an ERP data set. (Luck 2014, 68, my italics)

Luck's revision of Donchin's conceptual definition sounds exclusively "brainy": "Conceptually, an ERP component is a scalp-recorded neural signal that is generated in a specific neuroanatomical module when a specific computational operation is performed" (66). At second glance, however, Luck's temporal anchoring of the neural signal "*when* a specific computational operation is performed" builds a plausible bridge to the experimental performance, to the worldly stage where and when a "computational operation" is "performed".

These textbook definitions help illustrate the semiotic structure of the ERP: ERPs hold together worldly events with brainy potentials in order to make and accumulate inferences about how cognition works. In ERP research, cognitive scientists write with brains, not in order to read their messages, but to explain why and how the writing takes the forms it takes. There is a recursiveness to the structure of the ERP: it is made to point back to itself, in order to describe the invisible processes by which it is done.

Name games

As I've explained above, an ERP component makes space for an account of cognition by holding together an averaged waveform's morphological features with its eliciting experimental event. The constitutive tension between the morphology of the ERP and its eliciting experiment persists in the non-standard manner in which ERP components are named. There are a number of coexisting naming conventions for ERP components; some of these naming conventions describe the morphology of the waveform, while some names refer to the eliciting function or experimental condition (and by extension, the process being investigated by that condition).

The most common convention involves naming a component for the polarity of its peak (P for positive or N for negative). Following the P or N, the convention bifurcates: it is either named for its latency in milliseconds, or its ordinal position. For the latency convention, a positive peak at 100 ms is called the P100, at 300 ms is P300, and so on. For the ordinal position convention, the first positive peak in a waveform is P1, first negative peak N1, followed by P2, N2, and so on. However, neither of these 'morphological' naming conventions is perfect - both end up stretching and breaking their own rules. For example, the P300 was so named because of its latency when it was first discovered, but since then, "in most studies … the same functional brain activity peaks between 350 and 600 ms, but this component is still often named P300." (Luck 72). For this reason, some scientists prefer the ordinal convention, which allows for variability in latency, but has its own inconsistencies[16]. These so-called “objective” (Key et al 2005, 184) or “theory-free” naming conventions” (Luck 72) ends up getting push back from the world of the event.

“Functional names”, like syntactic positive shift (SPS), lexical processing negativity (LPN) and error-related negativity (ERN), have the inverse of this problem. They “are often easier to remember”, writes Luck, because they reference their functional interpretation and the world of the event, but “can become problematic when subsequent research shows that the same component can be observed under other conditions” (73). In other words, when a component is defined in terms of its eliciting event, it faces problems when a different kind of experimental event produces a segment of waveform that looks the same. In this case, the shape of a waveform, produced under new conditions, may come back to haunt a component that was thought to be functionally stable.

No single naming convention addresses the problem of balancing between ERP morphology and ERP conditions, which is also the problem of a name becoming inaccurate due to new evidence. This is, in large part, because, as “sources of controlled variability”, ERP components are perpetually revised as new research accumulates. The result is a mishmash of different naming conventions, which require expertise to discern.

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[16] Luck notes that what counts as the “Nth positive/negative peak” varies with electrode site: The first positive peak for a visual stimulus is the P1, recorded at ~100 ms at the posterior electrodes, but is not usually picked up by the anterior electrodes, which see their first positive visual peak at around 200 ms. Because of its timing, this anterior positive peak is called P2 even though it is the first peak recorded at that electrode site (Luck 72). Additionally, he writes of the early sensory components, “a given label may refer to a completely different component when different sensory modalities are considered” (ibid) -

In his textbook, Luck compares the mastery of these conventions to the mastery of a natural language:

> Although the conventions for naming ERP components can be very confusing to novices, experts usually have no trouble understanding exactly what is meant by these names. This is just like the problem of learning words in natural languages: two words that mean different things may sound exactly the same (homophones); two different words may have the same meaning (synonyms); and a given word may be used either literally or metaphorically. (Luck 73)

From my perspective, the language analogy here is especially apt. Not only because of the implication that for a novice, learning the "language" of ERPs takes time and experience, but also because, as with a natural language, the co-existence of multiple rules and logics for ERP naming reflects ERP research as social and historical process.

ERP component names imperfectly and ambiguously register what have been the most salient variable features for stabilizing a given component over time. At the same time, they also signal research genealogies and theoretical commitments. That these imperfect names are stretched into contradicting themselves to incorporate new research also points to the fact that their stabilization process is ongoing, provisional, and involves an audience of readers and scientists outside of the lab.

Experienced ERP researchers acknowledge and fluently mix multiple naming conventions. They understand, based on context, when two names refer to the same component or when the same name in different contexts refers to a different component, but also that an ERP may not be as stable as its name might suggest. A component, as a "source of controlled variability", is a dynamic epistemic object. At its most basic, an ERP component means "this kind of activity has this effect on this part of the waveform". Its layered, relational structure is expressed by Donchin et al (1978), when they write, "By our definition of components a single ERP waveform can never reveal components; only an ensemble of ERPs representing the systematic effects of a set of experimental conditions can reveal the presence or absence, and the behavior of, ERP components" (354) .

An ERP relation is stabilized by various "ensembles" at different dimensions - at the level of ERP components in a given study, at the level of a given component across many research sites, and crucially, at the level of components in relation to one another. In other words, an ERP component is at once layered and networked: it relates worldly events to brainy potentials within and between components. This is why Luck and others say that it is necessary for researchers to understand *all* known ERP components in order to do good research, and why introductions and reviews of ERP research usually include a primer, index, or catalog of "known components".

Indexing Cognition: ERP Primers / Catalogs

Primers and catalogs of ERPs for students of psychophysiology and cognitive neuroscience reflect the holding together of worlds described in the naming section above: their explanations include morphological descriptions and accounts of the experimental manipulations that produced them, as well as functional explanations of what cognitive processes are thought to underlie the component. In these functional explanations, ERP researchers use the language of *indexing* to describe what kind of processing or computation a particular component of the ERP is thought to reflect[17]. ERP

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[17] For instance: "On Donchin's model, the p300 indexes processes involved in updating an individual's mental model of the environment." (Coulson et al 1998, 48)

catalogs and primers also hold together these worlds in a historical sense, reviewing how components have been produced and the variations observed by their researchers over time. As reference collections, they catalog the work of producing “controlled variability” in the ERP waveform, compiling a bigger picture of all ERP research than an account of a single component can contain.

Primers and catalogs of ERPs, like the scientific atlases described by Daston and Galison (1992; 2007), function through collecting multiple examples, entraining their readers’ perception into their particular form of objectivity. The mode by which these compilations of ERPs operate, however, is not only visual, but narrative and indexical. A clear difference is that the inscriptions produced by EEG are not representations of physical objects, but of physical processes indexing cognitive processes. Like the atlases of the 19th century, ERP primers compile a network of ERP components in order to cultivate expertise through pattern recognition. The patterns that ERP researchers are entrained to recognize are not only visual patterns (even though the ERPs have a morphological component), but patterns among and between layered ERP relations, building a sense of what manipulations can produce what variations. In other words, ERP lists/primers hold together a set of performances stabilizing relations between activity in the brain and the lab, cataloging ERP research as performative world-making.

What kind of object is the mind/brain? Specifying cognition’s entanglement as enfolded.

ERP research is in some senses emblematic of the performative, material-semiotic depiction of science described in feminist and posthumanist STS. ERPs are difficult objects, requiring a great deal of contextual know-how within and across components (and a lot of holding-together on the part of its ‘readers’) in order to travel. Because they are temporal objects and explanatory accounts relating activity in the lab with activity in the brain, ERPs’ structure resists the abstraction from context that sometimes befalls more material and spatial scientific entities or mechanisms (ie: the neuron, the gene, the PET scan). However, I would like to suggest that to stop here, at saying ERPs are entangled, is not enough. The account of ERPs I have given illustrates entanglement insofar as they are objects that are deeply, constitutively embedded in their practical and material contexts, indivisible from the experimental performances that produce them. Yet, to stop at entanglement would be to gloss over the particular structure and implications of cognition as a kind of scientific object. My account also describes a material-semiotic scientific procedure by which a kind of interiority, reinvented as cognition - becomes objectified. This species of entanglement can be more precisely described as *enfolded*.

To account for the specific entanglements of cognition as a research object, I ground my analogy in the specifics of cognitive scientific knowledge-making practices. In the same sense that I understand Barad’s language of agential *cuts* as emerging from her close reading of Bohr’s quantum physics, I propose *folding*, not as an alternative, but as a local specification of cognitive neuroscientific knowledge-making as entangled, as material-semiotic, or as worlding. I will briefly explain the utility of folding as a specification of entanglement for cognition, before turning back to the ERP to illustrate this folding at different levels of its enactment.

My claim is that studying cognition experimentally - making cognitive objects - is a material-semiotic process that can be more precisely understood through the analogy of folding, than by sticking to a generalized characterization of entanglement. STS theories of entanglement, worlding, or material-semiotics describe an 'onto-epistemological' condition where meaning and materiality, culture and nature, are entwined. Entanglement has been a generative concept for STS and is engaged to describe complex, co-constructed processes and objects ranging from subatomic particles (Barad 2007), multispecies assemblages (Haraway 2008), and interdisciplinary collaboration (Callard and Fitzgerald 2015). My aim is not to dispute these frameworks, but to argue that the language of generalized entanglement is a blunt tool for describing the maneuvers involved in mattering the mind. This is because cognitive neuroscience invokes a local "challenging materialism" (Rose 2016, 158) in objectifying cognition.

While worlding, onto-epistemology, and entanglement describe an ongoing dynamic interaction from which nature and culture emerge as deceptively stable categories, the cognitive neurosciences position themselves in order to stabilize a version *of this same interaction* in the brain. Cognitive neuroscientific research configures the brain as *the material interface* between the world and the mind, between the outside and inside, materiality and meaning. The brain becomes the material interface through which humans encounter the wider world. Cognition research enfolds a local theory of material-semiotics within a materialist notion of the brain.

By locating the mind in the brain, cognitive neuroscientists orient around a material substrate whose "behaviors" they can observe. This move, instrumental to the cognitive turn, objectifies processes previously understood by behaviorists to be interior and thus unobservable. Folding creates new possible insides and outsides, and thus layered subject-object relations. A fold might place subjective self in relation to objective brain so that they appear to be on the same surface. The architectural detail afforded by the folding analogy would remain vague within Haraway's "cat's cradle" metaphor of knots and tangles, and vague again in terms of the quantum entanglement which Barad aims to render fundamental through the "agential cut". The layerings of inside and outside, and the kinds of indeterminacies that undergird them, are not resolved in momentary, if contingent "cuts", but are held-together, simultaneous, layered, inside of performances through which scientists make mind matter.

ERPs are cognitive objects that are not only entangled, insofar as they are onto-epistemically embedded in their performative contexts, but also enfolded. As with the muddled identities of components, the cognition enacted by ERPs is neither one thing (subjective) nor another (objective), but is an ongoing, paradoxical negotiation of turning interiority into an object without losing hold of what makes it interior.

I will give two examples of how ERPs exhibit folding. The first example will turn again to foundational/introductory accounts of ERPs to discuss the way that ERPs delineate territories of interiority and exteriority directly onto the waveform, which simultaneously makes a distinction between physical and cognitive properties of the world. The second example will turn to colloquial accounts of ERP components, where researchers understand functional explanations by personifying the cognitive processes they are aiming to stabilize.

How a waveform folds the world

I have mostly discussed cognitive ERP components so far, because they are the primary focus of psycholinguists and other cognitive researchers. However, it is important to note that these cognitive components linked with memory, learning, perception, and meaning share the waveform with components thought to index "obligatory sensory responses" to stimuli. In other words, the ERP waveform is broadly understood to reflect the brain's response to physical and cognitive properties of phenomena - in that order.

ERP researchers makes a distinction between early "sensory" components (occurring in the first 100ms after a stimulus) and later "cognitive" components. The early components are considered "exogenous" because they are "evoked by events extrinsic to the nervous system" (Donchin 355). The later components are considered "endogenous" because, as Kutas and Van Petten (1994) put it, "endogenous ERP components are not "evoked" by a stimulus but are elicited by the perceptual and cognitive operations that are engendered by that stimulus." (86). The distinction between "evoked" and "elicited" seems slippery, but this language reinforces a distinction between sensory processing as a blunt, lower order, one-way operation that is basic and largely consciousness-independent, and cognitive processing, which depends on context and reflects an unfolding interactive process. Kutas and Van Petten locate this interaction between the stimulus and the "cognitive operations that are engendered by that stimulus", which is embedded, as I have shown above, in interactions between subjects and experimental designs they encounter in laboratory activity.

As with the ERP relations described in the previous sections, a component is defined as sensory or cognitive by the kind of experimental manipulations that produced it, along with the assumption that "lower order" perceptual processes precede "higher order" cognitive ones. Early components are understood to index "obligatory sensory responses" to stimuli because they are sensitive to changes in *physical* parameters like brightness, size, volume, etc, and because they have been produced independently of whether a subject is awake or asleep. In contrast, the 'later-endogenous' components are sensitive to manipulations having to do with meaning, or cognitive content. Below, Kutas contrasts exogenous and endogenous components by anchoring them to the kinds of experimental manipulations to which they are sensitive: "The relative (although not total) insensitivity of endogenous components to variations in physical stimulus parameters contrasts with their *exquisite responsivity* to task demands, instructions, and subject's intentions, decisions, expectancies, strategies, mental set, and so on" (Kutas et al 2006, 663 my italics). Thus the same stimulus "event", like the appearance of a word, is split by this description of the waveform as sensory followed by cognitive processes, which is at the same time a division of the world into physical and cognitive properties[18]. This division of a stimulus, such as a word, into physical and cognitive properties (or as we might say in STS, material and semiotic) stakes out territory proper to thinking[19].

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[18] To illustrate with possible experimental conditions of a P300 experiment: The subject is instructed to press a key when they see a target letter. Letters of the alphabet are flashed very quickly one at a time in the center of the screen, with varying levels of display brightness, and weighted so that the target letter either appears often or rarely. The early P1 response to any letter, including a target, would have greater amplitude the brighter the stimulus. The P300 component, which can be elicited by any binary decision, would increase in amplitude with the rarity of the target. The endogenous P300 response, then, depends on the task/instructions/cognitive operation the subject is assigned, while the exogenous P1 does not.

[19] Another fascinating example of how cognitive neuroscience research painstakingly divides up cognitive stimuli into meaningful and non-meaningful is the introduction of stimuli that are "pseudo-objects", "pseudo-fonts", "pseudo-words" and "pseudo-faces" in order to probe the difference in responses to meaningful and pseudo-meaningful stimuli. These "pseudo" meaningful stimuli are found in developmental research, psycholinguistics, and research on facial processing (see for example: Schendan, Ganis, and Kutas 1998, Münte, Matzke and Johannes 1997, and Gauthier and Tarr 1997).

In the local, enfolded material semiotic of ERPs, an averaged waveform describes the human interface with the empirical world, anchoring in the brain what counts as material and what counts as meaningful. The exo/endo // low/high // sensory/cognitive distinction divides functions of the brain at the same time as it divides the world. The waveform, divided into sensory and cognitive responses, enacts the brain as both automatically sensing body and thinking, experiencing mind. Sensory components, being "obligatory", "reflexive", or "bottom up" are cast as operationally independent of both consciousness and individual history, while cognitive components are sensitive to past and immediate experience. Both sensory and cognitive processes are materialized in the waveform, but cognitive components, understood as higher order processes, are engineered by researchers acting upon on the experiences, expectations, and mindsets of other humans.

Folding minds and brains in laboratory talk

Another way that cognitive objects and ERPs in particular exhibit folding comes from lab members' talk, as they attempt to explain or understand the electrophysiological activity recorded by EEG/ERP. In reviewing my audio and video recordings, I noticed that researchers would slip between first and third person accounts when discussing cognitive activity. The first example comes from Tim the PhD student's explanation of signal averaging that I recounted at the start of the paper. In explaining how signal averaging sorts out event-related activity from non-event-related noise, Tim lists several kinds of "background activity", some of which are narrated objectively as something the brain does, and some of which are narrated as something that is subjectively experienced.

In reproducing this passage (abridged), I've bolded the brain activities that are in the third person, and italicized activities that are narrated in the first person.

> The subject's brain is doing a lot of different things at once, **it's, like, keeping the heart beating, it's uh, going** *oh my god the experimenter is so handsome*, and so on, but **it's also responding to the event,** and so the part of the brain activity that's the response to the event is going to bear a predictable relationship to the event, like a predictable temporal relationship (…) whereas the stuff that's not related to the event, like *I want a sandwich,* (S - uh huh) *better keep breathing* (S - ha ha) that kind of thing is just gonna like sort of average out to zero. (Tim, lab interview 03/05/2013)

At first glance it seems as though the objective brain gets the automatic, regulatory processes ("**keeping the heart beating**") while the subjective brain gets thoughts like "*oh my god the experimenter is so handsome*" and "*I want a sandwich*" However, the last activity Tim lists, "*better keep breathing*", troubles this distinction, as breathing is not typically a process that needs to be consciously regulated. Interestingly, as the interviewer, I laughed when Tim gave that example ("(S - haha)"). In this light, Tim is personifying the voice of the brain, which us not necessarily simultaneous or identical with an "inner" or experiential voice of the subject. After all, Tim does not say "the subject is thinking Oh my god the experimenter is so handsome", but "**it's going** oh my god the experimenter is so handsome", "it" being the subject's brain. The slipperiness of Tim's grammar mirrors the slipperiness of the attribution of experience and agency. Who wants a sandwich? Who keeps the heart beating?

Identifying with or personifying scientific objects or even processes is not unique to cognitive science. Ochs, Gonzalez and Jacoby (1996) describe how physicists occupy the position of the physical entity they are explaining, by incorporating themselves into diagrams using gesture and first person language, and Myers (2015) describes similar slippages in the embodied work of molecular modeling. What distinguishes this kind of talk for cognitive activity is not the process of identification per se, but the uncanny relationship between brain process and subjective experience. We get to cognitive constructs by way of having subjective experiences of thinking, feeling, remembering, etc. To turn these into an objective, observable phenomenon, cognitive science attributes them to the brain. Slipping between subjective and objective accounts of cognition is not only an expedient way to explain something, it also helps cognition to become an object the only way it can - from outside in, and inside out. Talk can fold subjective brain and objective mind so that they appear to be on the same surface from one angle, while from another they are differentiated.

Your brain goes "whoa"

In colloquial explanations of ERP components, I've observed a similar personification process. In print, the language of ERP components is very distanced and objective, describing a cognitive process in computational terms like updating and integrating, and referencing constructs like working memory, mental models, and mental lexicon. In ordinary talk between lab members, however, the mappings between the ERP component and the process thought to be indexed are much more subjectively inflected, with members personifying the ERP as they attempt to pin down its meaning.

The following examples come from a lab meeting where the group is discussing a review article about ERPs in psycholinguistics. Junior and senior lab members are discussing a section in this article that discusses the P600 component, sometimes also referred to as "late positivities", a late component best known for being elicited by "syntactic violations", usually in experimental paradigms that present grammatical and ungrammatical sentence-final words. Rita, a 1st year graduate student, tries to clarify the relationship between the N400 and P600/late positivities, by giving two different narrations of the later part of the waveform.

Rita: there's something unexpected happening and the N400 would be like the initial "**whoa**" and then like a couple hundred milliseconds later you're like integrating that somehow that's the positivity?

a moment later, Rita gives a second attempt to narrate the waveform:

Rita: It's like "**that's wrong**" and then it's adjusting or re-analysis.

Penny, the PI of the lab, responds with an account that still uses first person, thought-like language, but also incorporates the more technical language of expectancy violation, which refers back to the experimental manipulation.

Penny: The idea is if you get something ungrammatical it's **like "oh, that violates my expectations"**

In order to jointly reach an understanding of this component (at least the interpretation promoted by this lab) these lab members personify the cognitive activity that they imagine the waveform is indexing - activity that *may or may not* be identical with what the participants were experiencing subjectively. When they say "whoa", "That's wrong", and "that violates my expectations" they are not precisely (and certainly not only) describing the phenomenal experience of a subject reacting to a stimulus, but semiotically riding on something that resembles subjective experience in order to personify brain activity. Identification here provides a semiotic pathway for inference about cognition, and first person utterances by the brain are its vehicle.

The relative sophistication of these personifications as we shift from novice to expert suggests that they function by bringing the researcher's experience to complete the link between the inscription and the activity that produced it - the experimental manipulation. Penny's personification is more technical than those of the student, and could serve as a bridge between the rather unscientific sounding "your brain goes whoa" account, and the complex written accounts like the ones quoted throughout the chapter. The brain is a character who can speak with variable complexity.

Personifying brain activity again illustrates the enfolded character of cognition as a scientific object. ERPs are objectified and networked inscriptions of interior, mental process. At the same time as producing an ERP waveform as a material object, polishing its shape through filtering and averaging, researchers pour themselves back into its abandoned interior through verbal description. This enacts the brain as a character whose reactions to "events" fill an explanatory gap between experimental manipulations and more formalized accounts.

If personifying objects and processes is an both emergent feature of communication, and especially unavoidable when talking about cognition, it poses particular problems for the project of a materialist cognitive science. The appearance of the brain as a character in lab members' accounts of ERPs invites us into a longstanding conversation within cognitive science about the problem of the brain as a character, or more precisely, as a collection of (mostly maligned) characters known as homunculi[20]. I want to flag the figure of the homunculus as a site where cognitive scientists explicitly wrestle with what I have here called the work of folding, and the contradictions it entails.

Cognitive science has long been concerned with banishing from their theories anthropomorphic agents overseeing cognitive functions. The figure of the homunculus considered a fallacy leading to infinite regress: if there is a "little man" inside your head perceiving sensory input/representations/possible actions, then inside him must be another little man seeing what he sees, and so on. The most famous image of this regress is of nested cinematic viewers in visual processing (See Cantrell 1985), but homunculi have are found in (and shooed out) of accounts of emotion, information processing and executive control systems as well.

Having the infamous status of a logical fallacy, and seen as a hangover from Cartesian dualism, homunculi have a bad reputation among psychologists and cognitive scientists. E.G. Boring (1929/1950) bemoans the "less thoughtful men" who, "influenced no doubt by Descartes, unconsciously think in terms of *homunculus es machina*" (Boring 1950, 677). This admonition was not enough to get rid of this kind of thinking. Banishing

[20] Here I refer to the figure of the homunculus that is discussed by cognitive scientists and philosophers of mind, rather than the idea of the cortical or sensori-motor homunculus that Wilder Penfield is known for developing from his surgical experiments in brain stimulation. The cortical homunculus is a mapping of the body onto the brain, and is seen as an important neuroscientific discovery. In contrast, the homunculi that concern cognitive scientists are not mappings between brain and body, but little agents inside of an account of a cognitive system. They arguably fill in spaces in cognitive theories left by incomplete explanations. In general, they are understood by cognitive scientists and philosphers of mind as impediments to fully developed theories.

the homunculus was again identified as "a major item on the agenda of cognitive psychology" by Alan Newell (1980):

> A major item on the agenda of cognitive psychology is to banish the homunculus (i.e., the assumption of an intelligent agent (little man) residing elsewhere in the system, usually off stage, who does all the marvelous things that need to be done actually to generate the total behavior of the subject). (Newell 1980, 715)

Since 1980, the continued publication of new articles discussing how to banish the homunculus from theories working memory, executive control, and cognitive scientific theory generally[21] attests to the resilience of this theoretical pest. Despite being shooed out repeatedly, the little dudes seem to haunt cognitive theories.

Attneave (1961) provided a rare defense of homunculi, arguing that homunculi can be restored to "scientific respectability" (781) without inviting "ghostly" immaterialism or infinite regressivity (778). What is noteworthy about Attneave's defense of the homunculus for my purposes is that he remains agnostic about its literal existence while affirming its utility as a tool to think with: "What I shall present has very nearly the methodological status of a descriptive language: it is not intended as a theory, but rather as a framework within which a certain class of theories might be developed" (Attneave 1961: 778)

Attneave goes on to describe a psychoneural system that bears interesting resemblances to a cybernetic system of feedback loops, and which locates a homunculus (if it exists) as composed of neurons which coordinate between perceptual, motor, and

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[21] see, for example, Hazy, Frank, and O'Reilly 2006 for banishment from working memory, Monsell and Driver 2000 for banishment from executive control, and Barlow 1996 for general banishment.

affective systems. He willingly admits this system is incomplete and “may in fact be quite wrong” (781). In this context, his “psychoneural system” is not presented as a definitive new theory, but as evidence for the generativity of the homunculus as a tool to theorize with. Attneave’s defense suggests that anthropomorphism of this kind can be applied carefully and self-consciously at the level of descriptive language and frameworks.

Of course, not all of the disparaged homunculi are used as “frameworks” or tools to think with, and it may be true that evicting some of them would improve the theories they infest. But the persistence of homunculi in spite of decades of attempting to banish them could also suggest that there is something about these little guys that makes them compelling to think with. Attneave’s defense models a way for homunculi to co-exist in contradiction with brain-based, materialist cognitive objects. They can be tools for thinking with, with “nearly the methodological status of descriptive language” (778). It is quite wonderful how Attneave incorporates language as a part of methodology. It is emblematic of a self-awareness of psychology’s local material-semiotics, or what I have called folding.

The personified brain that emerges as a character in “descriptive language” about ERPs resembles both the homunculus that haunts theories of cognition, and Attneave’s “scientifically respectable” tool for theorizing. It resembles the pest of cognitive theory by virtue of its pervasive intuitiveness - it just pops up. It also resemble the more generous characterization, per Attneave, as a descriptive strategy for stabilizing cognitive processes. A homunculus or personified brain can be generative for developing cognitive theories as well as for stabilizing cognitive objects. Each example shows the work of psychology and cognitive neuroscience as enacting interior positions from which either to build theories, or to stabilize objects that in turn shape theories.

The promise that electrophysiology could provide transparent inscription of thought never materialized. One thing that developed instead was a set of networked, temporal indices stabilizing relations between brain and world - ERPs. In order to close the gap between electrophysiological accounts and functional explanations of ERPs, scientists carry out uncanny enactments of the brain as a character that is not, but not-not, the experiencing self[22]. In the broader history of psychology, homunculi, little anthropomorphized agents inside various cognitive systems, seem to continually crop up and get rooted out. The tension and indeterminacy of similar nested agencies in lab talk is not an obstacle to theorizing, but an engine. Both are products of local material-semiotic folding, emergent constructs for enabling inferences about a materialized mind.

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[22] "not, but not-not" is a reference to Schechner's (1985) work on liminality in performance. He argues, drawing on Winnicott, that in the spaces of rehearsal and performance, actors enter a liminal space where they lose-but-don't-lose themselves - they become "not me" but also "not not me" (and conversely their characters are not, but not-not, identical with their actors (110). In Schechners account, the space of "not, not-not" is a space of play and possibility. Here, too, in cognitive science, productive liminal spaces are opened by simultaneously holding together and distinguishing brains and selves.

Chapter 2

Making Brainwaves: How subjects turn their minds into brains for EEG

The previous chapter described the Event-Related-Potential, the object and technique at the center of the Brain and Language Lab's experimental practice. I argued that the ERP is a relational, enfolded inscription that holds together activity across scales - the lab and the brain - in order to materialize cognition as a scientific object. I showed how the semiotic stabilization of ERPs happens through their collection in primers and indices on one hand, and in everyday lab talk on the other, and I highlighted the identificatory maneuvers involved in rendering an objective brain as a character distinct from, but simultaneous with a subjective mind. I began with this technical analysis of the ERP because its particular needs fan out and organize many features of lab practice, from the challenge of devising unique linguistic stimuli, to the lengthy process of EEG capping, to the problem of managing bodily artifacts. ERP experiments requires a particular kind of bodily discipline because the non-brain body gets in the way of recording a clean EEG signal from the brain. This problem of the body as both locus of and obstacle to cognition shapes the peculiar experimental choreography of experimental subjects that is the focus of this chapter. This chapter will describe another site at which folding happens to produce cognitive objects - in the embodied performance of the subject.

While integrally directed toward explaining what goes on inside the human mind, psychology and cognitive science experiments exhibit a notable indifference to the actual experiences of the subjects participating in them. For instance, in a study that investigates memory, the researchers do not typically ask about the subjects' specific reported experience of memory, but rather focus on what the subject's measurable responses (like accuracy, eye gaze, response time) can tell them about the aspect of memory that the experiment is designed to investigate. This is typical of the methodological behaviorism that characterizes most cognitive psychology and cognitive science research. In contrast to radical behaviorism, which does not permit reference to "mental states" (Skinner 1945), methodological behaviorism allows reference to interior processes as long as they are anchored by "publicly observable behavior" (Day 1983, 90). The materialization of cognition in EEG that I described in Chapter 1 is another example of how interiority is inferred via publicly observable graphic inscriptions of EEG.

When cognition researchers do ask about subject's experiences, it is usually after the experiment, in order to manage the risk of "expectancy effects" and "demand characteristics", the problem of subjects shaping their performance to fit the perceived aims of the researchers (Orne 1962). In this context, the subject's experience is not the direct object of investigation and does not count as data, but is engaged as a means to ensure the authenticity and objectivity of the experimental performance[23].

Becoming a subject in cognitive science means producing observable, measurable responses, in other words, becoming a data-source. I argue in this chapter that this is not a simple feat, but a complex one that contains and sustains contradictions. In particular, I am interested in the contradictory position that experience occupies in experimental

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[23] I engage and intervene in the problem of expectancy and demand characteristics in Chapter 4

performances. In describing the work that goes into turning people into experimental subjects, I demonstrate how the data-productive experimental subject is produced as a self-disciplining entity. I argue that in order to produce a disciplined subject, the experienced and experiencing body is cleaned of its noisy, messy, naturalistic attributes (with debatable success), while simultaneously relying on these attributes in order to carry out the work of cleaning.

In an ERP experiment, researchers are recording processes that occur in time, often with respect to linguistic "events". There are thus particular *events* in the experiment, specifically, an event during each experimental trial, when it is especially crucial that the subject performs as a good data source. Unlike many cognitive science experiments, many of the ERP studies carried out at the Brain and Language Lab do not involve a behavioral "task", culminating in something like a button push or a verbal response. Subjects may not need to do anything active in response to these stimuli, other than pay attention to them and allow their brain's responses to them be measured. This turns out to be a complicated feat. The human body provides many sources of "noise" that potentially disturb the sensitive measurement of brain activity by the EEG. The fact that brain waves, as measured through scalp-level electrodes, must travel through the skull means that they yield a much smaller signal than muscular movements of the body, especially the face. Blinks, eye movements, and other body motions produce "non-brain contamination of the brainwaves", or artifacts (Tim, lab interview 05/03/13). While these experiments may not demand a behavioral response to a stimulus, they do require other kinds of behaviors, namely control over the body's voluntary and semi-voluntary movements (blinking, yawning, eye movements, etc.), in order to have "clean" data, that is, access to an 'undistorted' representation of the brain's response to stimuli.

This chapter focuses on how people who participate in these laboratory experiments become competent data sources, in particular the preparation that they undergo in order to carry out their task in the experiment and produce the embodied discipline that the experimental apparatus requires. In the first part of this chapter, I will review the work of several other scholars who have approached the problem of how experimental subjects are produced, highlighting the contributions that are most generative, as well as pointing to some frictions or limitations. These authors attend, in various ways, to the depersonalization of experiments and their results by researchers. Kurt Danziger provides a critique of scientific psychology on the grounds that it has, since the turn of the 20th century, mistakenly bracketed the social existence of its subjects (Danziger 1990); Michael Billig gives an account of how research articles in social psychology are rhetorically "depopulated" of their human characters, both scientist and subject (Billig 1994); Michael Lynch shows how laboratory rats undergo a transition from "naturalistic" to "analytic animal" through everyday practices ("rituals") in a neuroscience lab (Lynch 1988), and most recently, Emily Martin investigates the "banishment" of subjectivity from contemporary scientific psychology by studying historical and present-day traces of introspectionism (Martin 2013). What these authors have overlooked, in my view, is the way in which experimental subjects actively participate in the processes by which they become data sources**.** Building on their insights, I contend with the experimental subject's agency using a material-semiotic, ethnomethodological and performative approach to practice. In the second part of this chapter, I will analyze a segment of laboratory life in which researchers work with an experimental subject to achieve what they hope will be a data-productive performance.

Kurt Danziger's *Constructing the Subject* (1990) is a social constructivist history of scientific psychology based on published research reports in the field between the 1870s and the 1930s. He traces shifts in subject-experimenter configuration through what he identifies as three distinct modes of investigative practice - introspectionist approaches developed by Wundt and systematized by Titchener; the clinical demonstration, most iconically characterized by Charcot; and Galtonian anthropometric testing. He understands contemporary American investigative practice as the result of a merging of "the manipulative aspects of experimental procedure with statistically constituted objects of investigation." (Danziger 1990: 111) The result is a practice which turns socially entangled humans into data points in order to generalize about psychological processes.

Danziger criticizes this practice for its isolation of human subjects from their social existence in order to fashion them in the image of a "natural object" (187). He traces this trend to the late 19th century when psychology began in earnest to emulate the natural sciences such as physics and biology : "the split between the natural sciences and the humanistic disciplines had finally become an unbridgeable chasm and psychology was caught in the middle, forced to one side or the other." (41). The history of scientific psychology as he describes it develops from this dilemma[24].

Danziger views this emulation of the natural sciences as a mistake. He believes that psychology is different "in principle" from natural science, because human data-sources "are unable to behave simply as natural objects" (8-9). The borrowing of legitimacy from natural scientific methods, in combination with the long history of individualism in a civilization that found value in knowledge that helped to explain, classify, and manage individuals, produced a situation where, "[m]ore than the contributions of other scientists, the work of psychologists represented a kind of celebration of the myth of the independent individual in its pure form" (186). I am sympathetic to Danziger's critical stance toward psychology's role in upholding "the myth of the independent individual", and I am willing to accept that the relationship of the of researcher to their subject in psychological experiments differs in important ways from that of physicists working with particles. However, Danziger's claim that humans cannot behave like natural objects is underpinned by a problematic human exceptionalism. While he notes that all scientific activity is social activity (186), he seems to place its investigative objects on a hierarchy of constructedness, on the basis that the human data source and the experimenter must be engaged in a social relationship, and thus are more socially constructed than their material counterparts.

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[24] I read the title of his book, Constructing the Subject, as being at once about the construction of the human experimental subject, and about the history of experimental psychology itself as a field, or 'subject'. The way that Danziger structures the book to move through several levels of contexts of practice (the lab, the scientific publication, broader societal applications for research) supports this reading.

Danziger's critique is based on an understanding that humans are social while matter is not; that humans have agency while matter does not. Humans can behave (but not like natural objects); matter lacks behavior and so can 'behave' like a natural object (that is, await the imprint of culture). In holding on to this natural/cultural binary, Danziger's critique downplays several important things: First, the crucial role that the nonhuman plays in psychology experiments;[25] second, the ways in which which experimental practices already trouble the boundary between human and nonhuman; and finally, and most significantly for this chapter, what it looks like to behave, successfully or unsuccessfully, as a "natural object".

If, following STS scholars of posthumanism and material agency[26], objects and other nonhumans can act, and are integrally entangled with humans, we can perhaps no longer claim a difference "in principle" between psychological and physical experiments. Still, the ways in which he describes the psychological experiment as *differing* from other kinds of experiments are consequential (if not 'in principle'). I accept Danziger's description of scientific psychology while questioning the grounds of his critique. Rather than being doubly constructed and therefore different in principle, I seek to specify the local character of cognitive objects' entanglement.

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[25] Including animals, designed spaces, technologies of recording and measurement, stimuli, software and hardware that coordinate the delivery of stimuli and record, measure, and analyze data.

[26] Scholars who have influenced my critical reading of Danziger include Barad 2007; Haraway 2008, 2012; and Latour 1996, 2005. John Law (2009) gives an account of Actor-Network Theory that dates its naming to 1982 and argues that it achieved a recognizable form in 1990, which would make it contemporaneous with Danziger's book. However, Danziger, from a position adjacent to STS/Science Studies in History and Theory of Psychology, aligns himself more with the Sociology of Scientific Knowledge in terms of both his references and his stated approach (Danziger, 2).

Danziger's critique of scientific psychology's inevitable *failure* to turn humans into natural objects doesn't eagerly invite a description of what exactly they *are* doing when they enter into their inevitable "social relationship" (9). Regardless of Danziger's distinction between humans and natural objects, the category of "the natural object" appears to hold power to shape and organize scientific practice in the psychology lab. The categories of "the human" and "the natural object" operate in the form of life of the experiment whether I accept them ontologically or not. If we consider the psychology experiment in its material-discursive dimensions, then the question ceases to be whether humans *can* become natural objects, and becomes a question of how the category of the natural object (or, more precisely, the subject-as-natural-object, or the human-as-data) is materially-discursively lived/produced in the lab. My modification to Danziger's contribution is as follows: The question is not whether humans *can* behave like natural objects, but what happens when they try?

Like Danziger, discourse analyst Michael Billig is interested in the processes by which individuals are abstracted in scientific psychology, and like Danziger, he finds his evidence in published research reports. Billig bases his arguments on an in-depth analysis of two issues of the European Journal of Social Psychology from 1991, whereas Danziger drew from a large number of research reports published between 1870 and 1930. Unlike Danziger, Billig does not mine them for a wide range of details about investigative practice, but reads them rhetorically, as an important layer of investigative practice. Ultimately Billig mirrors Danziger's claim about the social isolation of subjects, arguing that the pages of academic social psychology are "depopulated", meaning that the individuality of the people involved has been evacuated (both the subjects, and the experimenters, in this account). Furthermore, he argues that this abstract treatment of individuals as interchangeable data points is performatively naturalized as an appropriate feature of the genre. Billig's point is to take seriously how academic disciplines are written, and to pay attention to the rhetorical strategies that do the work of de-populating these texts. He identifies the strategy of "variable vagueness" in the presentation of subjects in experimental texts. That is, "All are vague in some respects, but not in the same respects: what is stipulated precisely and vaguely varies from one report to another." (Billig 314) Variable vagueness offers a rhetorical solution to the problem of how much information to give - if you don't give enough, you risk coming off as unscientific, but if you give too much specific information, the generalizability of your results might come into question (317). Billig points out that this "solution" is unjustifiable if identified as such:

> Imagine an openly declared editorial policy (or a teaching instruction for doctoral students): 'Authors cannot be expected to check for the effects of all major demographic variables on their data, and so they are advised to mix precise and imprecise descriptions of their subjects.' As soon as the solution is stated, it is undermined. It needs to be practised as a 'natural', or unconsidered, routine of writing. (Billig 317)

Next, he focuses on the rhetorical routines around the presentation of results, and how they maintain the 'depopulation' of the genre. He notes that averaged scores are presented rather than individual results, favoring the presentation of a smooth "action story-line" where between-group differences and within-group similarities are emphasized, and obfuscating cases where the data are messier, such as instances where there subjects' results overlap between groups.

Finally, Billig gives recommendations of how to “re-populate” these accounts. He suggests the introduction of a procedure called “Median Case Reconstruction” (328), through which every research project should select and present at least one individual “reconstructed case-study” as part of its written report. Not only would this give the readers a sense of how at least one (statistically determined median) subject reacted to the experimental situation, but it would also ask researchers to attend to this level of detail, taking extensive notes and presenting information about themselves. Billig suggests that the introduction of such a procedure would have implications for the experiment itself - “repopulation does not demand the abandonment of experimentation per se, but its rewriting, and thus, its reconstitution” (327).

Billig’s proposed solution of ‘repopulation’ through the “Median Case Reconstruction” makes the assumption that the problem lies in psychology’s strategically paltry descriptive practices, and that by including more detail we can bring the representation and the reality more in synch. Billig hopes that this will transform experimental practice, and thus social psychology, for the better. What he may not anticipate is that alongside detail that “repopulates” the scene, the reflexive scientist may find extensions, traces, and echoes of the same strategies of depopulation entrenched in their experimental practice.

Billig’s emphasis on the text as the thing that depopulates, and, crucially, that holds the promise of repopulating, seems to focus on the power of the text while giving little attention to the role that embodied practices play in the cycles of experiment and scientific publication. That is, I think that Billig has given language too much power: he sees rhetoric as performative at the expense of other performative modes.[27] My position is that while remaining inextricably linked to performative rhetorical and textual strategies, laboratory activities are themselves already geared toward becoming data. Billig's account of the rhetorical depopulation of socially rich laboratory practices points to a missed opportunity to consider the ways in which the practices themselves may be already performing their own depopulation. I suggest that we deepen Billig's concept of "depopulation" by looking beyond the rhetorical strategies found in research articles, toward an examination of the on-the-ground practices with which they are necessarily entangled. In other words, laboratory practices do not depend deterministically on written rhetoric to become depopulated. They are already depopulating themselves.

In order to inform my study of complex, embedded laboratory practices, I turn to ethnomethodology, particularly the ethnomethodological laboratory studies of Michael Lynch. Lynch is particularly interested in the circuits between local, everyday practices and and scientific knowledge more broadly. A thread that runs across all his work is the argument that scientific knowledge is tacitly supported by everyday practices and locally produced orders.[28] In his article "Sacrifice and the Transformation of the Animal Body into a Scientific Object" (1988), Lynch focuses on everyday laboratory practices by which rats are turned into data. Unlike Danziger and Billig, Lynch brings his

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[27] My critique of Billig is compatible with critiques of representationalism in Science Studies, (see See Pickering 1995, Hacking 1983, Barad 2003; 2007; 2012) and particularly resonates with Karen Barad's assertion, against the many representationalist turns, that "language has been granted too much power." The quote continues: "The linguistic turn, the semiotic turn, the interpretive turn, the cultural turn: it seems that at every turn lately every "thing" - even materiality - is turned into a matter of language or some other form of cultural representation." (Barad 2003:1)

[28] See Lynch 1985; 1988; 1993

ethnomethodological analysis to the laboratory itself in order to explore the everyday practices underpinning these transformations. He describes everyday lab practices in a neuroscience laboratory which function to transform laboratory mice from 'naturalistic' animals into 'analytic' animals, that is "rendered" : "the living laboratory rat is transformed through a series of mechanized and methodical actions into the cultural object, 'data'. " (Lynch 1988: 272) A key moment in this process entails the death of the rat, which the scientists term "sacrifice" - however, death alone does not ensure the rat's transformation into analytic animal: "Inadequately performed sacrifices and other procedures sometimes result in the production of 'merely dead' animals rather than mathematically organized data with generic representational significance."(281) Lynch discusses a range of local laboratory practices that includes scientists' everyday language (to what they refer when they say the words "sacrifice" and "animal", and what it means for an animal to be "good" or "bad") as well as methodical and ad-hoc techniques for handling the rats in the pivotal moments of sacrifice. "Through a series of practices," Lynch writes, "the lab worker begins with the naturalistic animal in order to supersede it." (280)

Lynch's attention to the everyday practices out of which the analytic animal is produced, as well as the delicacy and contingency of the process is something that inspires my own analysis. However, Lynch emphasizes the practices of the scientists, while the actions of the rats come across as contingencies to which they must react, or problems for which they must improvise solutions. While he gives a few brief scenarios that include an interaction with a live animal, what he does not discuss is the degree to which the rats participate in their own transformation (if at all). Perhaps there is something about Lynch's ethnomethodological frame, which considers analytic animal to be the derivative product of the 'naturalistic' animal *of common sense experience* (281), that falters when it comes to considering the agency of the rats. In this frame, it is the rats insofar as their are experienced by their human keepers that underpins what they are able to become in an economy of scientific representation. To be fair, much of his treatment of the rats may be a result of the particular brutality of these experiments - these animals whose brains are being surgically operated on and then methodically removed from their bodies do not have many behavioral avenues open to them. It makes sense, considering the context, that the animals are figured as victims rather than as collaborators. Whether the rats' agency is figured as limited because it is actually limited, or because of a humanist leaning on the part of Lynch's own ethnomethodological lens, it could be broadened by incorporating a more nuanced understanding of action and resistance. How do the rats shape how they become data, and what can be known about them?

In a move similar to Billig's suggestion of Median Case Reconstruction, Lynch ends the article with the suggestion that scientific experimentation with animals would become more respectable if its practitioners openly embraced the ritualistic aspects of its practices with animals, such that 'sacrifice' and other parts of the rendering process could be taken seriously instead of remaining the suppressed and unacknowledged basis of knowledge production. Perhaps an "explicitly worked-out ceremony expressing a coherent ethic" (283) would have to acknowledge the degree to which the rats help determine what can be known about them, and possibly enable shifts in practice that would allow them to become something like collaborators[29].

Emily Martin has undertaken an ethnographic study of experimental psychology that seems to begin from similar questions and problems as mine. She writes: "In a recent foray into an ethnography of experimental cognitive psychology, I encountered firsthand what the historical banishment of subjectivity from the experimental model means." (Martin 2013: 149) Like Martin, I drew many of my initial observations and question about the place of subjective experience in psychological science from the experience of participating as an experimental subject. However, unlike myself, Martin did not have easy access to a lab or to experimental cognitive psychologists from the start of her project. In part because of the difficulties of gaining ethnographic access, Martin's project has developed in historical directions (Martin 2012). Martin began participating in experiments *because* of the difficulty of gaining ethnographic access to a labs, and through her experience as a subject, came to be "struck by how irrelevant [her] experience as a subject was to the experimenters."(Martin 2013: 149).

In her paper, "The Potentiality of Ethnography and the Limits of Affect Theory", Martin understands the historical banishment of subjectivity from a cross-disciplinary perspective that broadens the narrative portrayed by historians of psychology like Danziger. Following Wundtian psychology from the labs of early introspectionists

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[29] This recalls the normative position, proposed by Vincianne Despret and taken up by Donna Haraway, Karen Barad, and Bruno Latour, that ties ethics to a revised notion of responsibility. In this view, "response-able" science is that which allows the phenomena under study to respond. Response-ability creates set-ups and questions in which its subjects are interested, or which allows them to become interesting. (See Despret 2004; 2008, Barad 2012, Haraway 2012, Latour 2001, 2004)f

through the physicalist innovations of James Cattell (a student of Wundt) and the Cambridge Anthropological Expedition to the Torres Straits, Martin locates, on the one hand, an experimental innovation which seemed to do away with introspection, and on the other hand, uncovers a surprisingly anthropological notion of subjectivity bound up with the early introspectionist experimental models. She recounts the development of James Cattell's lip key, which was a device he developed and added to some Wundtian setups designed to study the time of perception. The lip key "was an electric switch that the subject held between his lips" (151). It was used to capture assumed unconscious movements of the lip linked to perception, bypassing the need for time consuming introspection and subjective reporting in order to produce a response time. In Martin's account, Cattell's lip key paved the way for the banishment of subjectivity that she would later encounter in her laboratory experiences: "[i]t was at this moment Cattell joined the mind to the brain." (151)

Following another path for Wundtian psychology, Martin traces the uptake of introspective experimentation in late 19th century anthropology, in particular, the Cambridge Expedition, who in 1898 brought Wundt's introspective experimental apparatus to the Torres Straits to study the islanders. In order to be able to reveal truths about "the generalized mind", both Wundt and the anthropologists relied on a notion of "shared context" (152) to render experimenters and subjects able to switch roles. Back in Wundt's lab in Leipzig, introspective observers underwent long periods of introspective training before they got to a point where they were interchangeable as experimenters or subjects (150). In the Torres Straits, one of the ways in which the anthropologists attempted to become interchangeable and (thus access generalizable introspective data) was by immersing themselves in the daily worlds in which their subjects lived (151). Martin uses this anthropological notion of subjectivity as a counterpoint to both contemporary experimental psychology and to contemporary affect theory, which she argues posit equally problematic physicalist accounts of mind and affect, respectively. What (some) Wundtians and the Cambridge expeditioners had, and what contemporary experimental psychology and affect theory both lose out on, according to Martin, is a robust social theory of subjectivity that can account for intentional action without resorting to a pre-discursive, inaccessible physical substrate.[30]

Martin ultimately advocates for an anthropological understanding of mind and affect that accounts for the ways that human perceptions and emotions are social "all the way down" (157). In a certain way, this resonates with Danziger's claim that people are unable to act as "natural objects" because they are so inescapably social (Danziger 187). Martin's story about the banishment of subjectivity starts from a similar observation as my project. While Martin's research (including access difficulties) has led her to trace the historical paths of introspectionism, I am interested in how the "banishment" of subjectivity plays out in and through laboratory practice and how subjects are involved in their own processes of "banishment".

Danziger, Billig, Lynch, and Martin have each investigated the question of how an experimental subject is produced, or how a human (or nonhuman) becomes data. Looking at their projects alongside one another and alongside my site allows me to more clearly

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[30] Martin writes: "What is at stake is whether we understand intentional human action as gaining its meaning in an interior, hidden, and thus socially inaccessible space instead of in the light of social experience" (Martin 2013: 156)

articulate my own approach. I amend Danziger's work with the question: what happens when human beings try to behave as "natural objects"? To Billig, I ask: what embodied practices performatively "depopulate" the experimental setting? Lynch's sacrificial rats spur the question: what role do entities being studied play in the processes that 'render' them as data? Alongside Emily Martin, I approach a similar research question from a moment-by-moment, ethnomethodological perspective: alongside what *happened* to subjectivity in scientific psychology, I ask : what *happens*?

In approaching these questions, I am guided by especially by Vincianne Despret's work on anthropozoogenesis, and Donna Haraway's work on becoming-with companion species[31]. I ask: how do scientists and experimental subjects become-with one another? What new capacities are enabled? In moving toward a dynamic understanding of what it means to become a data source, I propose considering them experiment-able subjects[32]. Becoming experiment-able entails more than isolating the subject and controlling exogenous variables - it suggests that a new capacity is acquired, however local and context-bound. A close examination of experimental laboratory interactions is needed to describe how laboratory procedures that live between the lines of published methods sections engender new orientations to the specific experimental apparatus at hand, and in so doing engender experimenters and experiment-able subjects.

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[31] It is Despret whom Haraway cites when introducing the idea of "rendering capable" (Haraway 2016)

[32] Here I am playing off of Haraway's 'response-able' as having the capability to respond and Despret's 'rendering capable" (Haraway 2016, Despret 2008)

Methods

My analysis of laboratory interaction draws from ethnomethodology and conversation analysis. These approaches and tools share an affinity with theories of performativity, with their emphasis on the social as locally negotiated and enacted in interaction (See Garfinkel 2002; Lynch 1993). While these 'methods' have been typically used to illuminate interactional structures between humans, they do not necessarily have to be an anthropocentric tool. Multimodal studies of interaction demonstrate the unavoidable entanglement of material actors in human communication (see Alač 2011; Goodwin 2000), and conversation and interaction analysis has been engaged to challenge anthropocentric views by revealing interactional achievements between humans and animals (See Crist 1997) and humans and robots (Alač 2009; Alač et al, 2011). I frame this analysis as an opportunity to examine an apparatus through which a particular kind of human/mind is enacted. It is with this in mind that I employ these ethnomethodological tools.

In a framework like this one, it is especially important to consider my own position and practices with respect to the actors I am studying. Ethnography is its own kind of apparatus and ethnographers (as much as scientists) are neither neutral, passive observers of a dynamic world nor interventionist manipulators of a passive one. At the risk of becoming recursively reflexive, it is worth briefly thinking about what kind of ethnographer and subjects/actors/informants were enacted through these encounters. While I cannot know with certainty how my presence as a researcher changed the dynamics of the lab, I can do my best to describe the situation as I experienced it. In the following description of my research practice, I will not absent myself as is the convention in empirical research.

When I began my ethnography, I had participated in cognition experiments before, but never any that used EEG or specifically ERP. In participating as a subject in ERP experiments, I was struck with how the 'task' in an ERP experiment consisted mainly of controlling my body so that the brain's response could be measured. In other words, it was a matter of disciplining the body to stay out of the brain's way, insofar as the brain is mediated by the EEG. After several weeks of observation and note taking, I began recording subject-experimenter interactions using digital video. I tried to film as much of the process as possible, although because of battery and memory limitations I sometimes had to ration my filming. The process of getting 'capped' for the ERP experiment took a long time, at least 30 minutes, and depending on how many technical difficulties they had (and they always had some) it could take more than an hour before they were ready for the experiment to begin. I tried to capture as much of the capping and instruction process as possible because these processes were interactionally rich. Once the experiment began, I was not able to enter the experiment room unless the researchers entered the space in order to tinker with the equipment or talk to the subject. During this time, I either filmed the researchers as they monitored the EEG recording, or I saved my battery and took the opportunity to make field notes. After I had filmed several subjects through the capping and instruction process, and observed several more, I began to watch my videos to see whether I had captured anything interesting. I remembered one subject who I had found interesting because she had been anxious and difficult to record.[33] After the researchers had reminded her several times not to blink between experiment blocks, they noticed that on the monitor her brainwaves were now exhibiting 'drift', which instead of the brief jarring up and down distortion from a blink, is a longer lasting disturbance that makes all the signals appear to be "drifting" slightly. The researchers guessed that she was anxiously tensing her forehead muscles in an attempt not to blink, and that this was causing the drift. The senior researcher determined that perhaps she had been "scolded" too much,[34] and that they should avoid scolding her unless absolutely necessary. It seemed that, in trying to discipline the subject, they had created a new artifact in the data. In screening this subject's video, I had hoped to find some of this scenario, but it turned out that I had not been able to record it (instead I had hastily scrawled, but quite detailed notes). Still, when going through my video, I found an earlier bit of interaction that covered a segment of her post-capping instruction process.

I had been drawn to this scene and this subject because of the interesting way she had seemed to fail at producing good data, from what I had observed of the researchers interpreting what they saw on the monitors. In the interaction that follows, what emerged as most interesting (as I transcribed it) was the way in which all three people coordinated

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[33] She was difficult to record on the EEG - I had no trouble recording her on video. However, I don't know whether my recording added to her anxiety or not - it is quite possible.

[34] "Scolding" was the name that the senior grad student researcher gave it. It was used in conversation with the other researchers, and not to the subjects. This "scolding" had consisted of a phrase like "Just a reminder - please try not to blink during the second part of the audio and when the visual word appears" or " Please try to keep your blinks to the first part of the audio"

around the subject's real-time brainwaves with the goal of instilling in her a new orientation toward them.

Becoming Experiment-able in the Brain and Language Lab

The Brain and Language Lab is a suite of rooms on the inner part of an upper floor of a small building on the UCSD campus. When a subject visits, there is a locked door with a key code between the public part of the building and several labs including this one, and in order to be let in, they have to call the lab on the telephone mounted on the wall next to the locked door. On entering the lab, a subject will pass by an area with a few work stations on their right, and a short 'hallway' of small testing rooms for computer-based cognitive tests that are often used in combination with the ERP data. Moving into the main room of the lab, there is a common space with a long table and chairs around it and a counter on the back wall with a sink. Subjects are brought into this room first to read and sign their consent forms[35] - this is also the common space where lab meetings are held, lunches are eaten, and researchers chat. On the lefthand wall there is a wall-mounted shelf with cubbies and hooks for lab member's (and visitors') coats and bags. During lab meetings, lab members use the whiteboard that is on the righthand wall of this space. Along the back wall, there is an electric kettle and a fridge, a sink, and some dishes. There are often EEG caps hanging to dry above the sink, because they must

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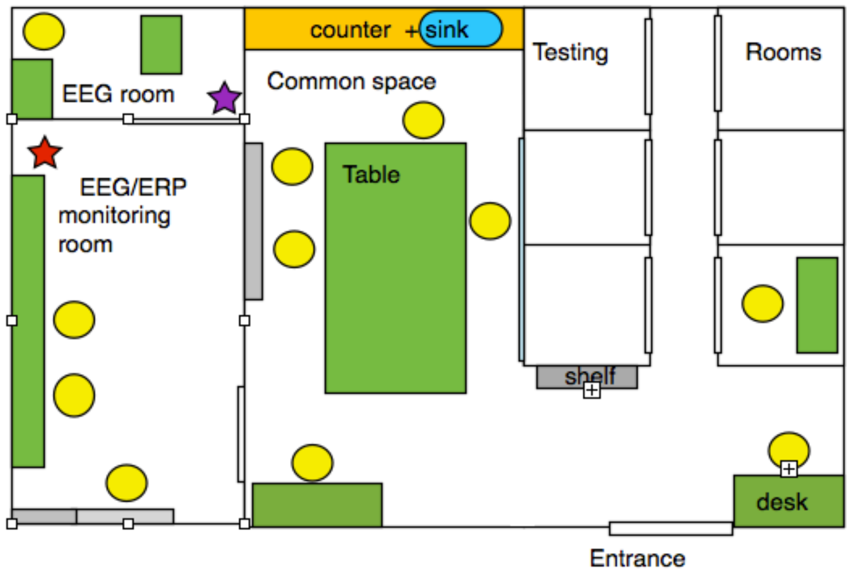
[35] The subjects that I observed and recorded read and signed my ethnographic and video consent forms along with the form for the experiment proper. For the scientific study, subjects with a history of head injury or mental illness were excluded; subjects taking psychoactive medications were excluded, and subjects who were not fluent in English were excluded. If excluded from the scientific study, they could not participate in my ethnographic study either.

be rinsed after each experiment, and need to be completely dry by their next use. Depending on the experiment, after the subject fills out their consent forms they may either be led back towards the entrance of the lab to one of the testing rooms for a computer-based test, or straight into the monitoring room to be capped. The monitoring space is the vestibule between the EEG chamber and the rest of the lab. When a subject is being “capped” they sit in a chair on the short end if the monitoring space opposite the door to the EEG chamber. When they are running the experiment, the researchers monitor the subjects’ brainwaves from the desks and computer monitors that run the long left-hand side of the monitoring room. The EEG room is a soundproof metal box with a double layer door, the purpose of which is negated somewhat by a hole that has been cut into the wall for the EEG wires to pass through. Inside, the subject sits in a chair facing a computer monitor and speakers on a small table. To their right is the table with the amplifier into which their cap is plugged, and from which the wires run through the hole in the box to the computer system in the monitoring room.



Where I did much of my filming

Where I was filming from in the interaction discussed in this chapter.

Figure 2.1 The Lab Space

The following is a transcript of an interaction between two experimenters, Eric (E) and Tim (T), and a subject, Megan (M), in the Cognition and Language Lab. There are several relationships of relative expertise to call attention to. Eric is an undergraduate student in Cognitive Science who is doing a placement in this lab for the quarter as part of his honors program requirements. Tim is a PhD student with several years of experience in this lab. In this relationship (in the context of Eric's placement in the lab), Tim is the expert/teacher and Eric is the novice/student. Megan is a freshman undergraduate student who is taking courses in both Cognitive Science and Psychology and who is participating in this experiment for course credit. In the context of the interaction, the two researchers ("expert" Tim and "novice" Eric) are guiding the subject, Megan, through part of the process of becoming a competent EEG subject for this experiment.

Before this interaction, Megan had just spent about an hour getting “capped” and helping the researchers check the electrodes’ connectivity one by one by pressing buttons corresponding to the electrodes on an Ohmmeter. When an electrode’s impedance reads too high (which happens with many of them), the researchers proceeds exfoliate that site by gently scratching with a pin or small piece of wooden dowelling, until the impedance was low enough. I introduce this information merely to show that prior to the interaction, Megan has already begun a process of being introduced to her experimental body - skin, sweat, hair, and cosmetic products can interfere with the cap’s functioning before the scientists even begin to look at the EEG channels on the monitor. Once capped, Megan is brought into the experiment room and her cap is plugged into the headboard. Megan’s brainwaves are displayed on the experiment room monitor, and become a dynamic actor around which she and the researchers coordinate.

The interaction takes place in the EEG room, which is a small, carpeted soundproof chamber. In it the subject sits on a chair that faces a computer monitor and speakers atop a small desk, with the screen about 2.5 feet away from where Megan sits. To the right of the Megan’s chair is a table that holds the headboard for the EEG (the wires from the cap plug into this device). There is enough space for Megan to sit on the chair and for the two (very tall) researchers to stand in the room. I was stationed opposite the subject, in the corner by the door. At the beginning of the interaction, Tim monitors Megan’s brainwaves from a computer monitor outside the room, and enters the room as he speaks in line 18. After this point, the both researchers orient to Megan and to the computer monitor that faces her as they work with her to convey how she should manage her body so that she produces “clean” data. The interaction is transcribed using symbols and conventions from Jefferson (2004) (See Appendix 2 for transcription key).

1 E: °Think he’s going to put aah: (2.0) he might show you (0.5)°°whu-
yur°° brain (.) waves look like °°(ruh)°°. Yep°=

2 M: = ↑Yay BRA:ain (0.2)

3 E: There’s your bra:in (0.3)

4 M: That’s awesome. (0.5)

5 E: •hhh=

6 =My mom has an a[larm clock that like measures your sleep cycles?
(0.3) °It’s r*hh*eally fU-*h*n°]((almost laughing))=
7 E: [=mm.]
8 T: [Oka::y (0.3) so uhh:::m Megan could you just stare] at thee:: um (0.4)
the pointer↑ and just kind of=

9 E: =°Breathe relax°=

10 T: = Be cool (0.2) don’t blink, just kind of stare at it (0.5)

11 O::h, beau::tiful [(2.0)]

12 E: [°( )°]

13 T: >Ok you can blink↓< =

14 M: =Hhh heh=

15 T: =U:::hm=

16 E: =°see↑ th[ese are°=

17 T: [so do you notice how when you ↑bl]ink, ther::e's (1.8)
((making his way in from the monitoring room outside))

18 M: = °'ts' cool°]

19 T: ((in the room)) do you notice how when you blink [there's uh ki]nd of
(0.3) a lot of crap goes on?

20 M: [Yea : : : h↓] (.)
21 yeh=

22 T: =Ye:ah, try rolling your eyes in a circle?↑ [(1.6)]
23 M: [((rolls her eyes in a circle during above pause))]

24 E: °Ye:ah look at th[at°

25 T: [o:O:oh my GO::d that was awful. [Ok give us -a-]=

26 E: ((chuckles)) [a-heh heh heh]

27 M: =I'm sorry

28 T: >no:no no no no↓< (1.0)
29 No i*h*:it's fine, I'm just sh-I'm just sho:wing you what ha:ppens,
30 •hhh [u::uhm give us a:::a]

31 E: [what iv you uh (.) swallow?]=

32 T: = oooh swallow yeah [(1.3)]

33 M: [((swallows))]

34 T: O:: oh, lo[ok at th]at. (•) Give us a ya:wn? [(2.2)]

35 M: ((little laugh)) [↑he-eh]

36 [((gives “yawn”))]

37 T: •hhhh o:::Oo*h*h god ye::a*hh*h, do you see how there’s that dr:ift?=

38 M: =°mm°=

39 T: =↑That’s ↓interest:ing↑.
40 [•hhh O]:kay so u::hm=

41 E: [°yeah°]

42 M: ((laughs)) =huh-heh (0.3)
43 uh-oh, I shouldn’t laugh=

44 E: =No, you can do all- all you want right n:ow, we’re just [showing you how-] h[ow the] smallest things.=

45 M: ((laughs)) [huh-heh heh he↑]

46 T: [Ye:::ah]

47 =It’s important though, when w::e, when we s:ay something to you↑ try not to no::: d vigorously↑= ((almost laughing, nodding))

48 M: =Okay, I won’[nod]

49 T: [Cuz that c]an, like shake the cap loose↑
50 (•)hhhh uuh:hm. Oka:y.=

51 M: =‘S’l[ong as I don’t start laughing °(--- I can try not to)°]

52 T: [Ye:::ah]=
53 =°alright° yeah, go back to your sort of Zen monk (.) mode.

Figure 2.2. Video Still of experimenters T and E and subject M in the guided biofeedback session. 28-29 T: “No no no no no it’s fine I’m just showing you what happens”

This part of the pre-experiment process seems to have at least two functions: one, as a final opportunity for the researchers to check and adjust the cap before the experiment begins, and two, as a period of practice and instruction for the subject with the EEG apparatus. This second function will be the focus of the following analysis.

This pre-experiment instruction session is the only point at which Megan gets to see her brainwaves (during the experiment the monitor in the EEG room is used to display stimuli), and as such, operates as a brief, guided biofeedback session. Before Megan can competently control the effect of blinks or other movements in the context of the experiment (ie, when it will be ok to blink and when it won’t be), she learns what it looks and feels like to produce ‘good’ and ‘bad’ waves in the first place. In other words, Megan must learn to operate the apparatus (of which she is a part) before she takes it for a spin. Being a good EEG subject requires control and suppression of certain everyday modes of being. I will focus on two facets of the process of producing Megan as an EEG subject. The first is how Megan learns to see, feel, and make EEG data through the interplay of her own and the researcher's responses to the brainwave visuals; the second is the way in which everyday social responses, mediated through the same biofeedback process, are both excluded and enrolled as a part of producing Megan as a data source.

In the course of this interaction, Megan encounters visualizations of her brainwaves, her actions' effects on them, and the researcher's responses to these effects. As the three actors coordinate around the screen, their respective assessments of Megan's 'output' surface as the interaction progresses. Because she sees her brainwaves basically in real time, this is a kind of biofeedback. Megan's initial, unschooled reactions to seeing her brainwaves on the monitor are enthusiastic - "↑Yay BRA:ain" (line 2) and "That's awesome." (line 4). As the biofeedback lesson progresses, the reactions of the two researchers, especially of the more senior researcher, Tim, inform Megan's understanding of what kind of brainwaves are valued by the researchers, and the kind of physical and mental performance required for her to produce them.

After instructing Megan to "be cool", "breathe, relax" "stare at the screen", and not blink (lines 8-10), Tim calls the resulting brainwaves "beautiful" (line 11). In contrast to these "beautiful" waves, after allowing her to blink, Tim directs her attention to the effect the blink has on her brainwave pattern, and characterizes the blip in the EEG as "crap [that] goes on" (line 17). Tim's explanation overlaps and interrupts Eric's attempt to explain “See these are” (line 16) and Megan’s truncated response “ ‘ts’ cool” (line 18). What is a “cool” effect on the monitor for Megan is “a lot of crap goes on” (line 19) for Tim. After Megan follows Tim’s instruction to roll her eyes in a circle, Tim responds with “o:O:oh my GO::d that was awful.” (line 25) This exaggerated response elicits laughter from Eric and an apology from Megan (line 27) which is corrected by Tim, “>no:no no no no↓< (1.0) No i*h:*it’s fine, I’m just sh-I’m just sho:wing you what ha:ppens,” (lines 28-29). I can’t know to what degree Megan believes she has done something wrong - but regardless, the apology is interesting because it allows Megan to test her emerging understanding of herself as data source. Her apology gives Tim the opportunity to clarify the meaning of his negative assessments. Megan reacts to “Oh my God that was awful” (line 25) with a socially appropriate apology, as if her performance was being evaluated in that moment. Tim clarifies - “Oh my God that was awful” was not an evaluation of Megan’s performance - after all, she followed his instructions to roll her eyes perfectly. It was, in combination with her performance and the EEG visuals, about “just showing [her] what happens” (line 29). As with “a lot of crap goes on” (line 19), the language is impersonal - it describes the data, not her performance - though this may not be initially apparent to Megan. There is a tension between Tim’s exaggerated, aesthetic characterizations of the brainwaves and the impersonal language that frames the brainwaves as what “goes on” or “what happens”. A split is being enacted here. Megan’s socially appropriate apology seems to come from an everyday world where selves and their behaviors are mostly indivisible. Tim’s correction brings us into a world where selves, in behaving, produce data which are separate from them. A strip of EEG data is “beautiful” if it is clear enough to be usable; it is “awful” when muscular movements or other ‘noise’ disturb it. Megan can begin to understand her brainwaves, and her actions’s effect on them, as data.

By this point, Megan’s apology has been corrected and perhaps they have reached an understanding that she is properly, or at least adequately oriented toward her brainwaves. This may be why, for the last few instructed actions (swallowing and yawning), Tim and Eric’s responses aren’t explicit as positive or negative assessments, but simply mark the effect of Megan’s actions on the EEG as something visible - “Yeah, look at that” (line 24). “Ooh, look at that” (line 34) and “hhhh o:::Oo*h*h god ye::a*hh*h, do you see how there’s that dr:ift?” (line 37). Between Tim and Eric, there may also be some amount of teaching going on here (especially the comment about “drift”, which is not a term Megan would know), but it is clear from their tone that they are directed at Megan as well. All in all, these comments seem to be directed at eliciting, in Megan, a mode where she is hyper-aware of her semi-conscious bodily actions and their effects on the data. Through the combination of the immediacy of the biofeedback, and the strong positive and negative aesthetic character of the researchers’ evaluations of her data performance, Megan can learn how it feels to produce data that looks “beautiful”.

Beyond learning to see and make the desired kind of brain waves, this interaction also shows how Megan learns to manage her body and social presence accordingly. To adapt Danziger’s term, Megan is learning how to “bracket” behaviors that are not welcome in the experimental context. We can understand bracketing simply as ‘what not to do’ - don’t blink, move your eyes, or yawn at the wrong times. But not doing those things is not as simple as, say, leaving your cell phone outside the room. Not-blinking is an active process which requires awareness and suppression of what is normally an unconscious or semi-conscious physical impulse. The experimental body is not an everyday body, as the experiment is not an everyday activity. In collaborating with Megan to produce her experimental body, the researchers make use of an instructed action sequence (asking her to blink, roll her eyes, swallow, and yawn), as described above. They also *make use of the interaction itself*, that is, they take advantage of 'naturally' occurring events in the interaction to further delineate what behaviors and actions do not belong in this context.

There are several instances in the transcript where Megan reacts in a socially conventional way, by apologizing (line 27), laughing (line 42) or nodding (line 47) and this reaction, and its corresponding EEG blip, can become another point around which they coordinate their attention. The first case, of Megan's apology, has already been outlined - her socially conventional apology is dismissed as inappropriate in this context. The second case is when Megan laughs (line 42) and then, presumably in response to the blip her laugh produces on the EEG monitor, says "Uh-oh I shouldn't laugh." (line 43) This time, Eric chimes in to reassure her "No, you can do all- all you want right n:ow, we're just showing you how- how the smallest things" (line 44) . This exchange is interesting because it mirrors the pattern of instructed action that the researchers took her through several times earlier only this time, with emergent instead of directed actions. As with the apology earlier, Megan can be seen as demonstrating and testing a new understanding of herself as a data source.

During line 46, presumably Megan nods in response to Eric's reassurance (she is off-screen at that moment). Tim, in response to her nod, says "t's important though, when w::e, when we s:ay something to you↑ try not to no::: d vigorously↑" (line 47). Megan assents, "Okay, I won'nod" (line 48) as Tim goes on "Cuz that c]an, like shake the cap loose" (line 49). This might be a correction both for Megan and for Eric, whose reassurance "you can do all you want right now" Tim might have found overly permissive.

In this context, 'bracketing the social', means gradually replacing a colloquial, socially responsive body it with a disciplined experiment-able body. But in order to achieve this, Megan's everyday body and her everyday social impulses are employed as examples of how *not* to be. In addition to using a feedback loop of her actions and the EEG visuals to guide her toward awareness and suppression of unconscious and semi-conscious bodily impulses, the researchers' use Megan's social impulses as additional opportunities to give her feedback on her role as a data-producing body. The transcript and analysis above shows that Megan's experience of the experimental apparatus *is not* simply ignored, subtracted, bracketed, depopulated, sacrificed, or banished. I argue that the subject's experience never becomes completely irrelevant for the experiment, but remains relevant on a level that underlies the objects of investigation. Megan's new awareness of her bodily impulses is called on to produce "beautiful" data; she is actively involved in her own disciplining.

Megan's experience in and of the experimental apparatus plays an integral role in the socially coordinated achievement of new embodied mode of being in the apparatus, that is, Megan as experiment-able subject. Unlike an introspective experiment, which uses the subject's experience as a "way in" to the mind, these experiments use the EEG to link “mind to brain”, like Cattell’s lip key (Martin 2013: 151). Once in the experiment, it is true, the subject’s experiences are no longer relevant to the researchers - but they are relevant in producing an experiment-able subject to sit in the EEG chamber in the first place.

The question remains: did Megan succeed in becoming experiment-able? As I mentioned earlier, Megan’s lab performances initially drew my interest because of the interesting way she had seemed to fail at producing good data. Despite her apparent mastery of her brainwaves during the pre-experiment biofeedback session, during the experiment itself, Megan was not suppressing her blinks well enough to be left alone. The researchers interrupted her run several times to “scold” her. However, that did not necessarily determine whether her data was unusable, as there are other layers of practice, rules, and conventions that add another layer onto the story of what it means to produce “good data”. To ask whether Megan became experiment-able begs the question, “on what terms”?

In an interview with a lab member, I learned that they had a lab-wide policy that if more than 25% of a subject’s trials were bad, they had to toss out that whole subject’s data. This is because ERP data is illustrated by averaging the subjects’ waveforms together (called a grand average). If a subject has lost too many trials, they are no longer statistically comparable with the rest of the group. It is the whole averaged waveform that answers or fails to answer a hypothesis. Sometimes, if a subject was having a particularly difficult time producing usable data - that is, it looked like more than 25% of their trials were going to be contaminated by blinks or other artifacts, they would be allowed to leave before completing the experiment. Additionally, there is a convention in the field that a full data set that is rejected because of too many artifacts should to be reported in the paper (Lab Member, 05/03/13). Not only is it a waste of time, and likely frustrating for the subject, to continue if the data are destined to be discarded, it also looks bad to have too many subjects rejected for "unacceptable levels of artifacts" (ibid).

Megan completed the experiment and provided the researchers with a full data set - by this standard, she became experiment-able. While some trials of her data set were undoubtedly "contaminated" by blinks and other artifacts, I don't know whether or not the set was contaminated to an "unnacceptable level". If a subject's data is discarded/ excluded after the fact, does that retroactively render them un-experiment-able, even if they completed the experiment? What is interesting to note is that this more quantitative cut-off for "good data" is distinct yet entangled with the aesthetic and experiential facets of "beautiful brain waves" that circulate between the researcher and subject in the pre-experiment routine. Becoming experiment-able is on the one hand a cultivated capability, and on the other hand a conventional standard. The interaction above can be read, in part, as the standard acting through the researcher's schooling processes to produce a cultivated capability.

When Megan arrives in the lab, she is not-yet transformed into a data source. Her role, as it becomes apparent through various processes, including the capping process and the interaction that I describe, will be to behave as a natural object. My analysis reveals the contradictory labor of this task. Megan's job is precisely *not* to behave normally, not to behave in an everyday, colloquial, 'natural' manner, but to actively "bracket", to discipline physical and social impulses to keep them out of the time and space of the experiment. Producing the ‘natural object’ of her brainwaves is a sustained, novel performance of its own.

These novel performances, and their successes or failures, are not discussed in published research reports, except indirectly in instances where data had to be discarded (ie, “28 subjects were tested; 3 had to be excluded because of unacceptable levels of artifacts”). Neither are the kinds of pre-experiment routines through which researchers try to maximize their chances of collecting good data. I have shown that the research report is not fully responsible for “depopulating” the experiment of its social richness; I have tried to account for some of the embodied, interactional depopulating practices that unfold in laboratory life. In fact, one of the socially rich features that published accounts “depopulate” by omission are the depopulating practices themselves.

Megan is actively involved in “depopulating” herself. Her colloquial body and sociality are enrolled to show her the difference between this and her “natural object”, data-productive body. She is motivated to please the researchers, and apologetic when she thinks she has done something wrong. When Tim and Eric repair Megan’s apology, this is a key moment exemplifying the maintained ‘as-subject/as-object’ splitting that is required of Megan as a data source. When the researchers say “No no I’m just showing you what happens”, or “You can do all you want right now, we’re just showing you how the smallest things”, they are saying, “Look. It’s not you - it’s you.”, or more properly “It’s not personal, it’s your brainwaves.” ; “It’s not you(sub), it’s you (ob).” But they need both of “you” to make the experiment go.

The purpose of the guided biofeedback is to effect this doubling as an integral part of the transformation to competent data-source. In order to ensure good data, they need

Mind minding Brain. They need Megan-as-subject minding and making Megan-as-object. Subjectivity, then, has not been banished from the cognitive science experiment. It has become enfolded into method.

Chapter 3

Reading Rhythm - Inhabiting experimental architecture between people and paper

Experimental cognitive scientists engage with one another's experiments in a number of ways, including collaboration, piloting as subjects, and designing experiments of their own. But most of the experiments a researcher encounters will be encountered virtually - through reading about them in journal articles. Journal articles are the descendants of Boyle's literary technology, as described by Shapin and Schaffer, and they still do their job by creating "virtual witnesses" in order to secure assent for their claims (Shapin and Schaffer 1985). However, looking closely at social practices of reading in the lab provides an account of these inscriptions and of the practice of reading that goes beyond the optics of witnessing a performance or of securing assent for claims.

Shapin and Schaffer also discuss how literary technology created social conventions and enabled a collective experimental "form of life" which helped to secure its truth claims[36]. They describe how literary technology, and the virtual witnessing it engendered, was an integral part of the experimental method and its rise to prominence. The experimental form of life was in its infancy, and faced "natural and legitimate suspicion" (83) as well as outright opposition. Thus the "multiplication of witnesses" (ibid) they attribute to Boyle's literary technology had both the function of helping to establish the experimental form of life as a legitimate and authoritative method

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[36] Shapin and Schaffer (1985) consider this form of life to be the "technical, literary, and social practices whereby experimental matters of fact come to be generated " (18).The form of life does not separate social practices from language - it is the "total pattern of activities which includes discursive practices" (52).

of knowledge-making, and the intertwined aim of encouraging experimental replication. They write, "The technology of virtual witnessing was not different in kind to that used for actual replication. One could deploy the same linguistic resources in order to encourage the physical replication of experiments or to trigger in the reader's mind a naturalistic image of the experimental scene" (60). It turned out, though, that few scientists were able to replicate Boyle's experiments from these "linguistic resources", and Shapin and Schaffer recount a chapter full of replication struggles centered on the difficulty of crafting and calibrating the many components of the air pump instrument. The air pump, apparently, harbored secrets that were not easily transmitted by its literary technology.

Research in psychology and cognitive science today is also mired in a replication crisis of its own[37]. While there is no consensus on its cause or on an overarching solution, responses to this crisis tend to target the incentive structure of science publication (which privileges novelty and positive results over replication studies), or build infrastructures of accountability (like preregistration of studies) and open science (ie, sharing of data and statistical instruments). Interestingly, these latter responses function under a similar logic as Shapin and Schaffer's literary technology of multiplying witnesses. Since the conventional literary technology for psychological science seems to be broken in terms of ensuring replication, these responses instead gather witnesses around particular components of research, namely hypotheses, data, and statistical analyses. But what if the

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[37] In 2015, the Open Science Collaboration (OSC) made headlines by reporting in the journal *Science* that a disturbingly large proportion of psychological studies cannot be replicated. Failures to replicate highly publicized findings pepper the news cycle.

difficulty, as with the air pump, lies elsewhere in the apparatus? What kind of shared form of life enables cognition researchers to tinker with their experimental designs? It is this question that I want to explore in ethnographic detail by examining how the action-structure of cognitive scientific experimentation is materialized in the interactions between people and paper.

Latour (1986) has written influentially on the "paperwork" through which science achieves dominance. Like Shapin and Schaffer's emphasis on how Boyle's literary technology "amasses assent", Latour focuses on the inscription's power to amass allies, which he attributes to its immutability and mobility. But how, in practice, does this happen? What are scientists doing when they read other scientific texts? My intention is to supplement Latour's account of immutable mobiles and Shapin and Schaffer's account of an experimental form of life by returning to the site of their production, the laboratory, and focus my analysis on the pragmatic interaction with particular inscriptions - in other words, their reading. While it has certainly been my experience that cognitive scientists focus on figures, this is not the only or perhaps even primary way that they interact with a scientific paper. Part of the trouble lies, I think, in considering inscriptions primarily as *collections of statements* or descriptions working to stabilize phenomena ("facts"), which are ultimately stabilized through agreement/assent and consensus, when they contain not only statements describing phenomena but records and instructions for how to bring phenomena into being. It is not only through accruing rhetorical allies that science gains its power, but also by replicating its structures of activity and helping to make not only virtual witnesses and *co-performers*. In this way, inscriptions, including figures as well as prose descriptions of activity in methods sections, “draw things together” (Latour 1986) by making possible the transmission of techniques, set-ups, procedures, questions which are embedded in action structures of the past and future as much as in the textual account which shuttles between them. While Latour examines the features of inscription that allow the text itself to “draws things together”, I look at the work that is done by researchers *with* texts to draw together action in the past, present and future. In this chapter, I will examine how the action contained in one scientific paper is re-enacted by a group of cognitive scientists discussing it. Rather than considering inscriptions as collections of statements, I consider them collections of resources for action, in particular, traces of past scientific action. This allows me to think about how they are part of cycles of scientific practice, not solely as endpoints or products of the work of science. While I agree with Latour that without inscription, science would not have the power it does, I take issue with the implication that goes along with that thought experiment - that action and inscription are fully distinct categories. I consider texts not as objects or tools separate from action but as repositories of condensed action, which is activated and materialized differently depending on the individuals and material and embodied resources brought to the table. In the interaction that makes up the empirical core of this chapter, these resources are brought to a literal table as part of a lab meeting.

My approach is informed by the work of scholars who have looked to scientists’ situated action in order to understand how science and its objects are enacted - a group more closely linked through their use of ethnomethodologically informed analyses and oftentimes multimodal transcriptions of situated action than the specific location of these practices. [38] One of the significant contributions of this work has been to demonstrate how scientific objects are enacted as a part of the social interactions that make up research practice, that is, how scientific objects do not pre-exist their research encounters, but are done through the unfolding, embodied work of researchers combining and recombining their available semiotic resources (bodies, voices, graphic representations, instruments, and objects). Where classic and contemporary work in laboratory studies has described and unpacked the complex, often embodied work that goes into making inscriptions[39], I look here further downstream at what happens to those texts[40] as they are taken up by their readers. My attention to the situated practice of reading, rather than the writing of scientific inscriptions, broaders my focus beyond the phenomenal objects of cognitive scientific research, to the highly structured performances of experiment itself. In other words, this chapter describes cognitive scientists apprehending not experimental objects, facts or claims, but experimental process.

Building on the insights of these ethnographers and ethnomethodologists, again I apply the instrument of multimodal transcription and analysis in order to illuminate the materialization of experimental architecture. I am interested in what materially happens when scientists virtually encounter the experimental designs of other researchers; I

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[38] See, for instance Alač 2011, 2013; Goodwin 1994,1995; Lynch 1986, 1997; Ochs, Gonzalez and Jacoby 1996, Suchman 2007; Vertesi 2015.

[39]See for example, Latour 1979, Lynch 1985, Knorr-Cetina 1981, Alač 2011.

[40] While Latour (1987) and Knorr Cetina (1981) have written about the social negotiations through citational practices that endow a scientific article more or less epistemic weight, this follows the approach, indicated above, that considers texts as collections of statements or facts.

choose the analogy of architecture to talk about experiments, because architectures are designed structures of variable complexity which are designed to be inhabited. The architect, like the cognitive scientific experimenter, must design their structure with their subject, and the performance they imagine their structure will contain, in mind. Architectures, like experiments, are designed for someone to be, something to happen, inside.

"Journal Clubs", as spaces for the enculturation of junior researchers[41], are one site where training in experimental design occurs - in the form of encountering, and oftentimes disassembling and reassembling the experiments carried out by other researchers. As a pedagogical practice, journal clubs are situations where members work together to make sense of research in their field, to take apart articles, assess them, and make use of their working components. The purpose of journal club seems be multiple: introducing new students to the main concerns in the field, modeling how to read a research article, and tacking between the experiments they engage in the journal article, with their attendant questions and problems, and the experiments they plan and produce in their own lab research practice.

This chapter centers on an interaction from a cognitive science lab's "journal club" in which the lab members work together (not entirely harmoniously) to reconstitute a crucial component of a music perception experiment: the stimuli. Working from a multi-modal analysis of member's situated talk, embodied action, gesture, and non-vocal

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[41] See Golde 2007 for a review and evaluation of the practice of Journal Club in doctoral education in Neuroscience. Much of the research on Journal Clubs has concerned the function and effectiveness of journal clubs in medical education. See Linzer 1987, Sidorov 1997, Ebbert et al 2001.

sounds, I show that it is in and through this embodied interaction that the structure, activity, and experience contained in the research paper emerges as shared, actionable material. This empirical core supports the two central claims of this chapter: First, that the inscriptions we call scientific journal articles are not only dry paper - inactive, end-points of research, consisting of collections of statements and mainly good for mobilizing rhetorical allies after the fact. In addition to this rhetorical, fact-based function, they also participate in the perpetuation of particular forms of action and the enculturation of co-performers. In other words, inscriptions are not only used to convince new allies, they are also, and possibly in the first place, used to make them. I show how journal articles can be wellsprings of past research action around which develop an embodied, social practice of reading.

Second, in cognitive science, this practice of reading requires getting inside, inhabiting the experiment to imaginatively assume the position of the subject, in addition to occupying the position of experimenter. In examining the social and embodied practice of reading in journal club, I will illuminate the cyclic and continuous relationship between action and inscription. How do cognitive scientists get inside their and others' experiments? In what follows, I will first give a short ethnographic outline of the lab's journal club. Then, I will describe and introduce the interaction, and incorporate its transcript and analysis.

Lab Meeting/Journal Club[42]

Nearly every Friday, members of the lab and interested colleagues from other labs meet to discuss a research article together. The PI emails a broader group of members and affiliates to let them know of the meeting time and the paper to be read, and so sometimes members of other labs (mainly graduate students) attend. The membership of the lab ranges from undergraduates (usually advanced, in their 3rd or 4th year), early and late graduate students, sometimes postdocs, and the PI. The articles are often chosen by the PI but selections are sometimes suggested or guided by graduate students. I asked if I could attend these meetings as part of my ethnographic observation and was granted permission; at the first few meetings of the school year I introduced myself to the group (a few knew me already) as an ethnographer studying cognitive scientific practice. After the first few meetings, I asked whether I could videotape. From then on, whenever I was able to attend, I would set up a tripod and camera and record the meeting. I continued to participate in the discussion and ask occasional questions, even though my background did not match those of the other students. Over the course of 10 weeks there were 6

[42] Members of this group did not call these meetings "journal club" but "lab meeting". However, I call it "journal club" here because the activities of these meetings closely resemble the practices of what other scientists call journal clubs in neuroscience and medical education, and it distinguishes "lab meeting" from other lab meetings held for other purposes (such as data analysis, training, etc).

meetings, in which we read 5 articles and one book chapter[43]. As part of the lab's focus on the psychophysiological components of meaning-making, the researchers in the group are broadly interested in questions about the perception of meaningful difference, as well as research investigating the sometimes contested boundary between endogenous (internally generated, sometimes called "top-down") and exogenous (externally generated) processing. On the week in question, the group read a paper about the perception of rhythm and its corresponding EEG patterns. This is the text that is being addressed in the interaction transcribed below.

In journal club, lab members actively worked to make various components (measures, procedures, tasks, tests, stimuli, figures, etc) embedded in the texts relevant and usable. I observed several kinds of modes/orientations to the articles - animating and manipulating the article's moving parts by drawing on direct and indirect experience to reanimate the action contained in the article, critically engaging with these "moving parts", and using parts of the article to revise or devise current or future research practice. By way of comparing my own ability in connecting with the material with that of the of the lab members, I observed that lab members' practical experiences *activate and are activated by* the action, structure, and experience embedded in the research paper in the

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[43]Over the course my observations of these meetings, one article focused on children's language learning, finding a predictive relationship between oromotor (mouth) control and the ability to repeat novel words. Another two examined the role of gesture that co-occurs with speech, in one article looking at the cycle of gesture-speech match and mismatch between math teachers and children's solving arithmetic problems; in the other investigating whether and how gesture adds to semantic understanding. A final article examined difference in the EEG in relation to physical versus imagined changes in rhythm, or metrical organization of beats.

social act of reading as a lab. In this case, my unavoidably imperfect "unique adequacy"[44] helped me to apprehend the different perspectives, experiences, and resources that all members, beginning with myself, brought to the table. In the case of the paper being discussed in this meeting, some members were very familiar with the type of research, having both read the paper and having carried out, (or in the process of starting) similar research themselves. Additionally, this seemed to be a relatively simple study for those present[45], and one which addressed a problematic and longstanding divide in the field - the distinction between endogenous and exogenous processing. The study addressed this through investigating a phenomenon that is both understood as more "basic" than language processing, and has a long history in the history of psychology - the perception of meter[46]. All of these factors combined to make the architecture of the experiment (if not the conclusions) relatively accessible to all members, myself included.

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[44] "Unique adequacy", coined by Harold Garfinkel, is the principle underlying competent membership in a social situation. Unique adequacy is a guiding principle for ethnomethodological research: For ethnomethodological research on specialized social contexts, such as the specialized contexts of work, the principle of unique adequacy requires the analyst's immersion in the social phenomenon at hand. See Garfinkel 2002:6, ten Have 2005.

[45] From my own perspective, this study seemed simpler for several reasons. 1. Compared with other papers, review papers, and chapters I had joined the group in reading, this one only discussed only one experiment, 2. The experiment investigated the perception of simple repeating sounds, rather than complex semantic and syntactic stimuli (in the form of carefully crafted sentences and stories), as many of the lab's own experiments investigate.

[46] Wilhelm Wundt, known as the father of experimental psychology, carried out introspective experiments about the perceptual organization of time and rhythm using metronomes. See Wundt 1897: 142-153

The paper that the group had gotten together to discuss was of particular interest to one grad student, Cameron. The article was closest to his research interests and has immediate relevance to the experiment he was in the process of piloting, so he was the one presenting the article. The paper that Cameron presents is called “Top-Down Control of Rhythm Perception Modulates Early Auditory Responses”, by Iversen, Repp, and Patel (2009), in an issue of the *Annals of the New York Academy of Sciences* entitled *The Neurosciences and Music III: Disorders and Plasticity*. When this interaction opens, they are discussing the experimental design, in particular, the stimuli. The experiment investigated differences in evoked brain activity in relation to rhythms that were metrically organized from without or from within: that is, subjects heard a rhythm which contained a physically accented downbeat, or they heard a rhythm for which there was no physical accent, and they were asked to imagine the downbeat. The “real” versus “imagined” stimuli conditions, as well as the two accent patterns used, were the main topic of conversation in the interaction.

Clockwise from Cameron, around one long side of the table, are Greg (another new grad student,) Mary (a more senior grad student), and Penny (the PI). Across the table from Cameron, at the other short end, is Victoria, a professor with specific expertise in the area of music cognition, who is visiting from another lab. Along the other long side are Rita (another new grad student) and Sarah (myself)[47]. Penny, Mary and Rita have laptops in front of them on the table; Greg has a tablet. They appear to be using the laptops and tablet to view and scroll through the article that Cameron is presenting.

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[47] All names are pseudonyms, with the exception of my own (Sarah).

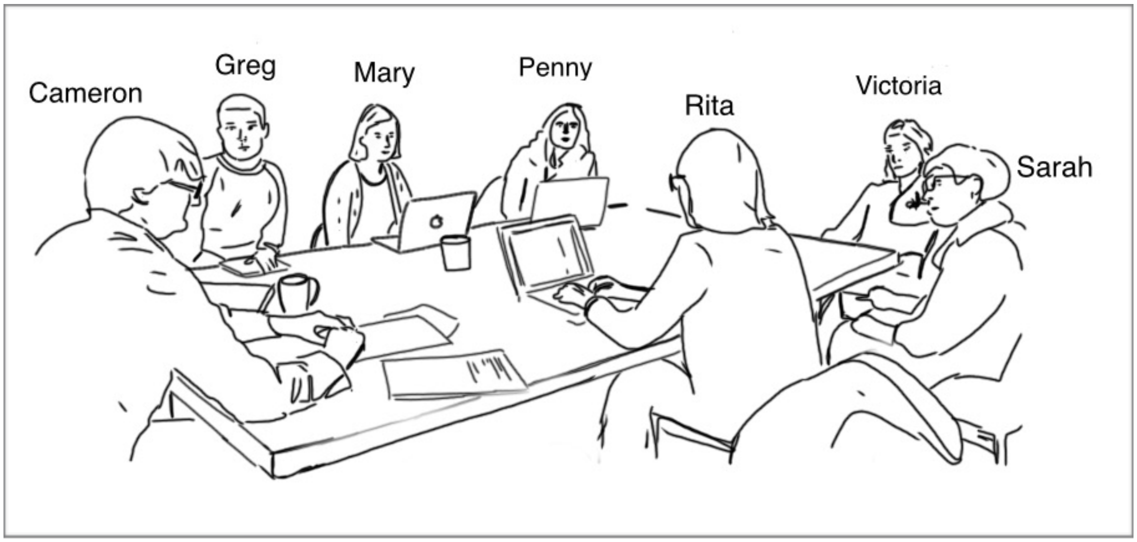

Figure 3.1. The meeting/journal club

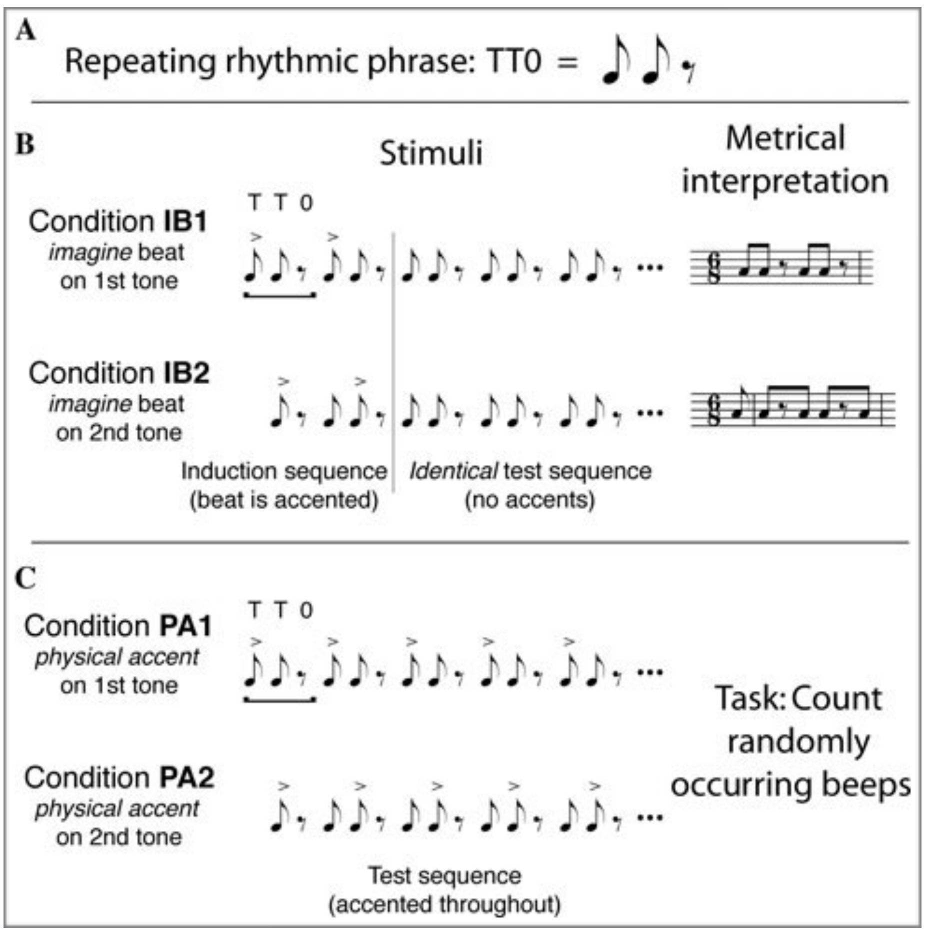

Figure 3.2. Experimental conditions from Iversen et al (2009), reproduced with permission from the publisher.

Figure 3.2 shows the figure from Iversen et al (2009) that Cameron is in the midst of discussing, and that several of the members have in front of them. This figure lays out the 4 stimuli conditions, which were made from a repeating rhythmic phrase with two accent patterns: first tone and second tone accent, and two conditions for perceiving these patterns: imagined and physical. Depending on familiarity with musical notation, readers may have an easier or harder time making sense of the figure - in this case, turning it into sensory information so that you can understand what question about cognition the experiment is asking. Are you among those that can look at the eighth notes and rests above, and with more or less effort, hear or feel the simple rhythmic pattern that they convey? If so, attend to what you did with your body as you read the figure.

If the above figure is illegible to you, then I can (perhaps clumsily) try to convey the two accent patterns in a few other ways. One is an alternate visual representation: The large dot represents the accented tone, the small dot the un-accented tone, and the dash represents a silence. All are the same duration.

accent pattern 1: ● • ¯ ● • ¯ ● • ¯ ● • ¯ ● • ¯ ● • ¯

accent pattern 2: • ● ¯ • ● ¯ • ● ¯ • ● ¯ • ● ¯ • ● ¯

Or, alternately, a verbal analogy: The first-beat accent pattern is akin to the word “programmer” repeated, only imagine that the last syllable, - the “er”, was so quiet as to be silent, so the rhythm that you hear is “program(mer)program(mer)program(mer)program(mer)“ and so on. The second-beat accent pattern is akin to the word “professor” repeated, only imagine that the last syllable - the ‘or’, was so quiet as to be silent, so the rhythm that you hear is “profess(or)profess(or)profess(or)profess(or)profess(or)profess(or)“ and so on.

These are the two accent patterns - first beat, or second beat accent. The experiment had the subjects listen to a physically accented rhythm pattern in some trials, and in other trials, to briefly play for them the physically accented pattern (“induction pattern”) but then to play an un-accented pattern (. . - . . - . . - . . -) and ask them to retain the induced accent pattern in their imagination. In addition to asking subjects to count randomly occurring beats and pressing a button when they “lost” the beat pattern, subjects’ brain waves were recorded to look for differences in the “real” and “imagined” conditions. In other words, the experiment looked at the differences in subjects’ brainwave patterns when an actually accented rhythm is pumped into their ears, versus when a non-accented rhythm is pumped into their ears and they are asked to imaginatively “hear” one or the other accent pattern. They also tracked which rhythm pattern was easier to imagine by asking subjects to press a button when they lost the beat (Iversen et al, 62).

I have given the above account of the experimental setup for two reasons. First, so that readers are prepared to follow the sequence of interaction I am about to describe. Second, I wish to draw attention to alternate sets of resources that one might engage in reading the experiment. However you made sense of/sensible the above figure and explanation, I want to argue that what you did was a part of the sense-making, and that how you did it makes a difference in the kind of sense that is made. The text is in a sense, theatrical: It requires activation by its readers.

Art historian Michael Fried famously attacked minimalist art for its “degenerate” theatricality, claiming that its situatedness and dependency on an audience’s presence diminishes it from authentic art to mere theater, in contrast to the self-contained, “instantaneous” masterworks of the modernists (Fried 1998). I wish to use Fried’s very apt description of theater to argue against his underlying assumption that a work of art (or writing) can be a self-contained entity. While wholeheartedly rejecting Fried’s contemptuous view of theater, and his related misguided notion that a given artwork or object can transcend its situatedness, I adopt Fried’s meaning of theater in the sense that I understand these texts to be radically contingent on the situated contexts of their re-performance, that is their reading. The situated work of reading that helps specify how scientific articles come to appear as autonomous (immutable) is analogous to the work of disappearing the relations that make a work of art appear to stand alone.

In the transcript that follows, Cameron (with the help of others present) will attempt to convey the same stimuli conditions as I have, using a different set of available resources than “you” and “I” have here/between us now. Cameron and the lab members are visually, verbally, and aurally available to one another in order to activate the structure and action embedded in the text and make sense of the stimuli conditions. The transcript combines conversation analytic conventions from Gail Jefferson (2004), with conventions for transcribing gesture from and gaze from Hindmarsh and Heath (2000). I have adapted some of these conventions in order to provide more clarity in instances of dense multimodal complexity. Additionally, I have treated relevant non-verbal sounds, such as demonstrative banging and tapping, as though they are utterances (see Appendix 3 for a full list of conventions adopted and adaptations).

As Cameron opens his discussion of the stimuli, he attempts to give a verbal account of the stimuli conditions. His explanation is interrupted by the PI, Penny, with a request to “tap out the stimuli” (line 4) so we can hear “the way that it sound[s]” (line 6). Cameron then continues his explanation with a combination of novel, semi-iconic hand gestures and tapping the pattern out on the table with his finger [Figure 3] . He does this this until line 12, when Victoria asks him to continue “for several measures” so that we can hear “what the people are hearing”. Cameron proceeds to explain verbally, combining hand/finger gestures with brief, accented tapping the table, but does not continue for several measures as had been requested by Victoria. After Mary poses a clarification question, Victoria begins to use the table to loudly bang out the two accent patterns on the table for several measures, during which the conversation between Cameron and Mary continues at the same time as the other members coordinate their comments in relation to the rhythmic sounds. After this rhythmic interlude ends, members continue to discuss the significance of a finding about which condition is “easier" or “harder” for subjects, while intermittently bobbing their heads and moving their bodies to a now-imagined, now-embodied rhythm.

One way to read this interaction is as a narrative of novices and experts, with the student, Cameron, not heeding the requests by the two more experienced members to materially and sensibly demonstrate “how it should sound”. While the PI, Penny is more hospitable to Cameron's explanations, Victoria is less satisfied and takes demonstrating the stimuli into her own hands. Thereafter, the group has absorbed/embodied the stimuli conditions, as evidenced by the bobbing heads and the shift in conversation. This account, while in certain senses true, misses the complexity of the attempts that Cameron first makes to convey the stimuli's underlying, if abstract, structure and the distinction between the two kinds of conditions. What can Cameron's action teach us about the process of re-animating action from an inscription of it? In other words, what can Cameron's materializations show us about reading, in particular, reading about experiments? Looking closely at how Cameron takes the group through the stimuli, and how he responds to requests for sense-able demonstration through his multi-modal performances of the stimuli conditions, reveals the work of maintaining *continuity between* inscription and action, that is, the process of reading.

Analytically, I divide the interaction into two acts: the first half of the interaction (lines 1-23) is marked by Cameron's multiple attempts to embody the stimuli conditions using varying combinations of resources; the second half (lines 24-48) is marked by coordination and gathering of attention around percussive sounds co-occuring with discussion about the "difficulty" of one of the conditions. Both "acts" demonstrate how past experimental activity embedded in the text is animated through situated, embodied practices of reading; and how animating the experimental architecture involves shifting between various orientations to it/positions within it. In doing so, each act depicts different materializations of this activity, and these differences matter. In the first act, Cameron's talk and gestures are foregrounded, whereas in the second act, Victoria's percussive banging on the table competes for the foreground.

Act 1: Cameron Materializes the Stimuli - between Abstract and Concrete

Just prior to the first excerpt, Cameron is in the midst of introducing the experiment described in Iversen et al., in particular referencing the choice between a "perceived beat" versus a "physical beat", when the PI, Penny, whether he wants to "tap out" the stimuli, "the way that it should sound". In response to Penny's request to tap out the stimuli, Cameron responds by introducing the "basic" rhythmic structure:

1.1 Introducing the T-T-0 pattern using sound and gesture

1 C: They have as they describe it a [tee tee zero rhythm which] is,
[*"air quotes" gesture with both hands raised, lowers hands to table*]

2 [basically is just (.)]
[*both hands raised from table, palms facing table, shift up slightly and to the left, and then move back to in front of him as if in preparation to play a keyboard*]

3 C: [TAP [TAP (0.5) TAP TAP (0.5)]]
[*Tapping right index finger on table and lifting it up in the pauses/rests*]

4 V: [They being Iversen et al?]
[*moves RH with pen in rightward movement along table's edge*]

This excerpt contains the first time in the meeting that sound is used to convey the stimuli of the experiment. In this first attempt, Cameron's demonstration, compared with the attempts to come, is relatively unannotated and simple. The only thing 'added' to the sound of tapping is that Cameron marks the rests (0.5 second pauses in line 3) by raising his right hand index finger in a slightly exaggerated way as though to draw attention to the empty beat (rest).

Following Cameron's first attempt at tapping the stimuli, Victoria asks a clarification question ("They being Iversen et al? (line 4). Cameron then re-situates his explanation and attempts to begin again - "I'll describe the stimuli and then what they're doing because it's sort of a lot easier to understand once you have the actual stimuli"[48]. Then, Cameron goes on to give a second explanation incorporating audible tapping that is gesturally annotated using both hands and clear, repeated gestures (Lines 5-12).

1.2 2nd Materialization

5[49] C: [basically the one where its (0.5) where there's no accent]=
[R hand, fingers together and facing the table moves first towards C's body, then during the 0.5s pause, quickly away horizontally in a kind of "nil" or "zero" gesture. This gesture is held till the end of the word "accent"]

6 =[(°wu-they most like°)] testing is just [(.)]
[*hands move back to rest on table*] [*raises R hand index finger as if preparing to tap*]

7 is [essentially] [one]=
[*raises L hand from wrist, palm facing out*]
[°TAP° *with right index finger*]

8 ((voice changes to deeper, theatrical)) = <[one two three TAP TAP] (.)
[*raises left hand from forearm, "counting down" gesture, bending one finger for each number. R hand, still resting on table, taps with index finger.*]

---

[48] This utterance occurs in between the first excerpt and the second excerpt, but this in between exchange was not transcribed here because it was not the focus of this analysis

[49] Line 5 does not represent the turn immediately follow line 4; there were intermediate utterances that are not transcribed here for analytic expediency.

9 [and then blank]
[*both hands contract toward one another slightly and then flatten and move apart to land on "blank"*]

10 [and then TAP TAP blank]>
[*holds L hand up during tapping and repeats and "blank" flattening gestures, right index taps*]

11 C: Uhm (0.5) [*picks up paper and begins to turn page with L hand*]

12 V: [Can you do that for several measures just like what the people are hearing]

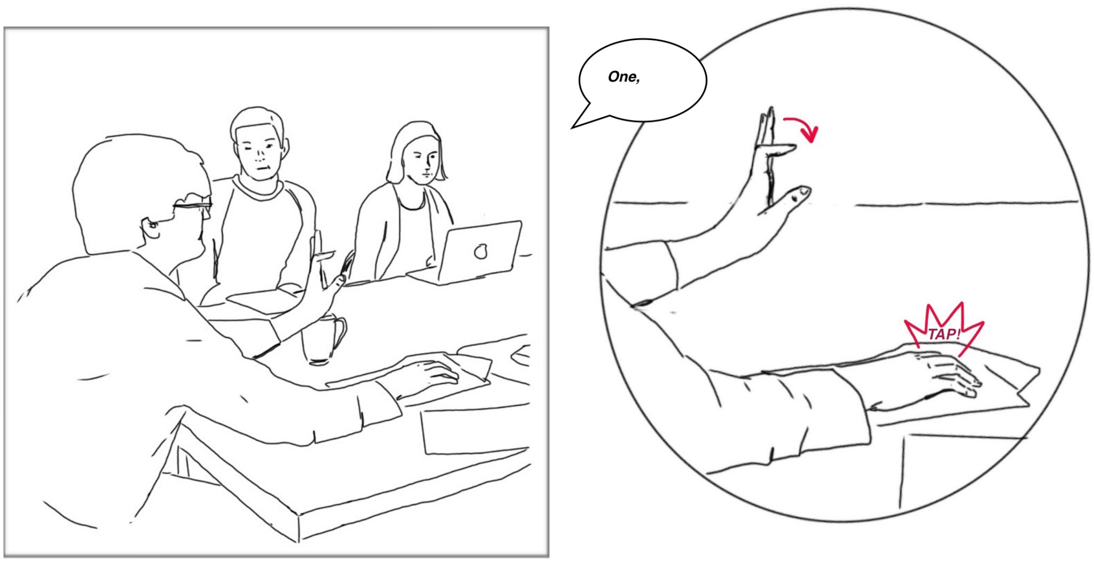

Figure 3.3. Demonstrating the T-T-0 pattern. Counting down gesture (left hand) with non-accented tapping (right hand).

In this excerpt, we see the 2nd of 4 uses of sound to convey the stimuli. This time, Cameron incorporates a stylized, repetitive gesture where the rhythmic tones are mapped both onto the tapping sounds and onto the "counting down" gestures of his left hand, which precedes the actual tapping and so seems to have the function of setting up, spatially and verbally, that the rhythmic pattern consists of groupings of 3 (line 8).

Cameron emphasizes the distinction between rests and tones, by saying “and then” when the pattern switches between tones and rests. Cameron also marks the rests by making a flattening gesture with both hands moving slightly outwards, reminiscent of the “nil” gesture from line 5. Victoria then asks Cameron to tap the stimuli for longer (“several measures” (12)) so that we can hear “just like what the people are hearing”(12). This echoes Penny’s request about tapping the stimuli so that we can hear “how it should sound”. What didn’t work about the first two attempts? How have we not, in Victoria’s estimation at least, experienced “what the people are hearing”?

It is important to note that Cameron’s first two attempts consisted of trying to convey the *unaccented* pattern. In the following excerpt, it becomes clear that the “basic” form that Cameron has been trying to convey is the unaccented rhythm structure which underlies all four conditions. In other words, it *is* what people physically *hear* in the “perceived condition”, even if it is not what they are asked to perceive: the “basic” form is what is pumped into subjects’ ears as they are asked to imagine one or the other rhythm pattern. Finally, in response to Victoria’s request, Cameron makes a third attempt, one which delineates between the “basic” underlying form and the two accent patterns, and then audibly performs the two accent patterns for the first time.

1.3 Distinguishing the “basic form” and the two conditions

12 V: [Can you do that for several measures just like what the people are hearing]
[*moves right hand across table from left to right in front of her twice, with thumb and forefinger extended; 2nd time gesture includes small up and down motions accenting “what the people are hearing”*]

13 C: *Holds paper up and turns page* Yeh (0.5)

14 [well ok so that's the basic form of it]
[*straightening paper, then pass paper to RH, L hand open and facing out/down punctuates "basic" then returns briefly to paper in RH*]

15 where it's just you know [<one two blank> so tone tone blank]
[*L hand up, counting up gesture with 3 fingers repeated 2x*]

16 C: And in <theee> (1.0) they sort of have [(.) they have two basic conditions,]
[*returns paper to table, then a gesture with both hands facing each other just above table surface accenting "two"*]

17 One where [they are wanting people to imagine them] uhm (0.5)
[*RH sweeps up, to ear-level, open-palm gesture away and back*]

18 One where they actually have [physical differences in how that's actually executed and one where they want it to be imagined differently]
[*RH punctuates accented words*]

19 (0.5) [And (1.0)]
[*left forearm bends up in front of C's body and palm turns upwards, as if holding something small; RH moves from ear level to front to land side of R hand on L open palm, with R palm open facing body*]

20 C: the idea is that you can uh you can [choose any of those two actual tones to accent so it would be (0.5) er]
[*RH index and middle fingers move back and forth between two spots on L palm, seeming to map "choice between tones to accent", then RH returns to table, left palm stays facing up*]

21 C: [TAP TAP (1.0) TAP TAP](1.0)
[*tapping with RH thumb, which makes a louder sound than the index, left hand remains upturned*]

22 C: versus (1.0)

23 C: [TAP TAP (1.0) TAP TAP (1.0) TAP TAP] (0.5) um=
[*tapping with RH thumb, left hand remains upturned*]

24 P: =And they do sound really different (.) °yeah?°=

In this excerpt, Cameron ultimately materializes the two different accent patterns that subjects either hear and/or perceive. However, contrary to what Penny and Victoria seem to be requesting, he gets there by moving from abstract to more concrete, from a sense of structure and manipulability, to a plain physical demonstration. During the first part of this explanation, Cameron enacts the stimuli conditions as more or less manipulable 'stuff' in relation to his own body: First, he refers back to what he previously demonstrated as "the basic form of it … the tone tone blank" (lines 14-15). Then, he delineates the two "basic conditions" - the "imagined" condition, which is accompanied by a righthand sweeping gesture which first seems to place "imagine" (17) in the space above and behind his right shoulder; and then the "physical condition", which is accompanied by a right hand forwards punctuating gesture, followed again by the "imagined" condition using the same right hand punctuating gesture (18). Cameron then goes on to introduce the idea of the two different accent patterns. He does so first with a phrase and gesture that seems reference to the job of experimental design and the researcher's agency: "the idea is you can choose any of those two actual tones to accent" (line 20). This is accompanied by a gesture which places the "tones" into Cameron's upheld left palm, and the "choosing" between which tones to accent is mirrored by the right hand moving back and forth to touch two spots on the left palm. (Fig 3.4)

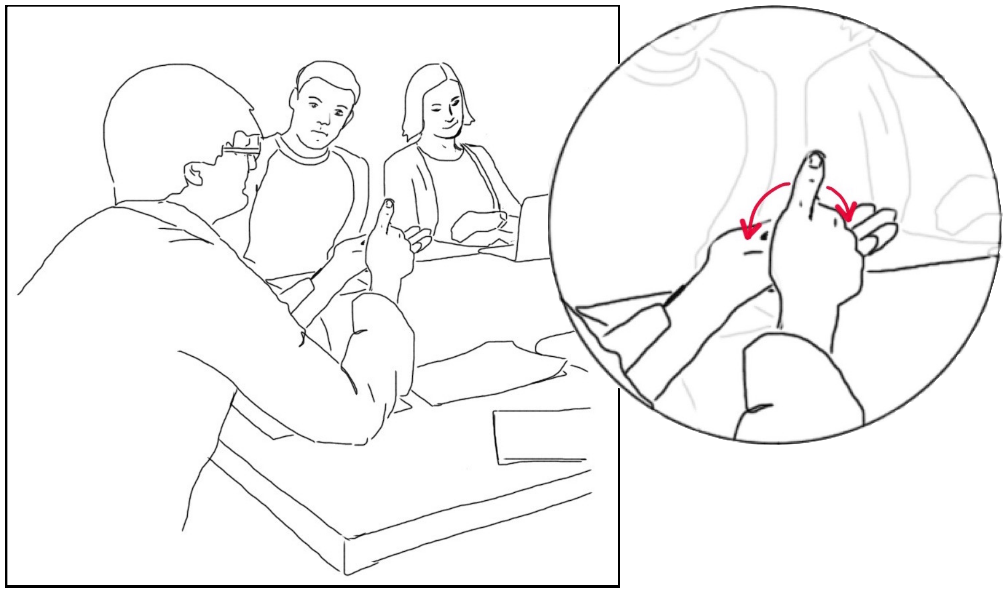

Figure 3.4. “you can choose any of those two actual tones to accent ” (line 20)

Cameron holds the components of the stimuli in the palm of his hand. But is the generic “you” who chooses which tone to accent in line 20 automatically the researcher? Could it not also refer to the subject who is asked, and so assumed to be capable, of choosing which tone to accent in his or her imagination? His utterance in line 20, “the idea is you can choose any of those two actual tones to accent”, is followed by the first demonstration of “what the people hear” that makes itself legible by materializing for the first time a physical, sensible difference - the tapping in lines 21 and 23. With his right hand, Cameron taps out the two accent patterns that “the people hear”, while his left hand continues to be cupped upwards (fig 3.4). The right hand materializes the physical accent conditions, or “what the people hear”. His upheld left hand continues to reference the “choice” of which tone to accent, a choice that could be attributed to the researchers in designing the stimuli, as well as by subjects in performing the direction to “imagine” a particular accent pattern in a given trial.

In moving from abstract to concrete, several different conceptual compressions are being enacted. First, Cameron references the stimuli in the abstract, underlying, “basic” form - “the tone-tone blank” (line 15). Second, mapping the “tones” onto his left palm and touching them with his right fingers, he references the “choice” of which tones to accent, a choice which could ambiguously apply to both the experimenter or of the subject, the director or the performer, the architect or the inhabitant of the structure under discussion. This “choice” collapses the distinction between the work of experimental design, and the cognitive and perceptual labor of the experimental subject that is under investigation, and thus imaginatively projected by that design. His use of a “royal ‘you’” contributes to this ambiguity (“You can choose any of those actual tones to accent” (line 20). Third, Cameron maintains a reference to the ambiguous “choice” between accent patterns in his upheld left hand (a distinction that could be applied physically OR perceptually), while simultaneously tapping the sensible difference between them for the first time. By splitting them between his left and right hands, Cameron simultaneously materializes the ‘imagined’ and ‘real’ conditions. Interestingly, while these conditions are simultaneously collapsed and differentiated between Cameron’s hands, the distinction between them is what the experiment itself is attempting to materially differentiate in the brain - the difference between something “real” and something “imagined”.

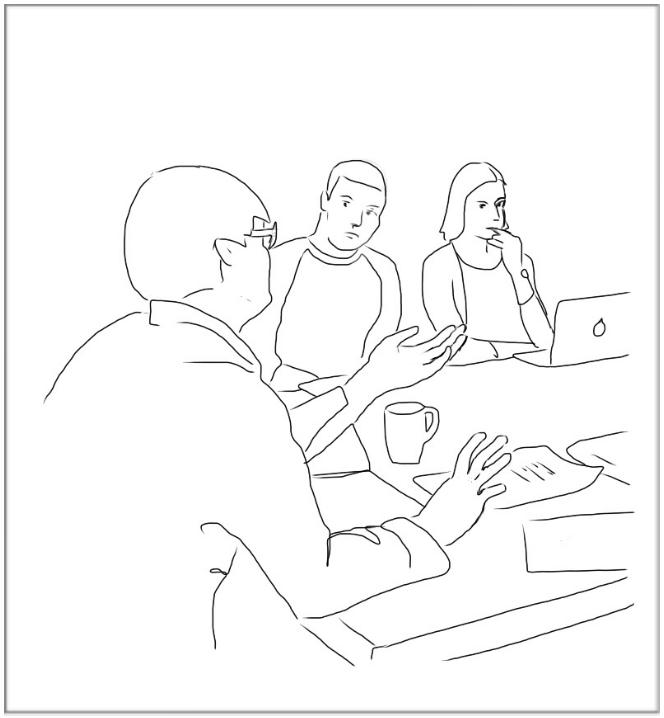

Figure 3.5. C's Left hand holds manipulable "tones", Right hand TAPS "what the people hear"(lines 21-23).

Seen in this light, the "you" who chooses which tone to accent embodies the vacillation between experimenter as architect of abstract components, and experimental subject as experiencer of (and performer within) the architectural interior. In other words, the simultaneous collapse and distinction between abstract and concrete, between imagined and real, is also the collapse/distinction between between the position of being outside and inside the experiment This simultaneous collapse and distinction in Cameron's gesture and talk resonates with the elisions between the identities of the scientists and their phenomena that Ochs, Gonzalez and Jacoby (1996) find in the grammar and interpretive action physicists discussing physical phenomena. In their article "When I come down I'm in the domain state", Ochs et al describe the ambiguous collapsing of researchers' identities with the phenomena they study, and suggest that "indeterminate constructions draw interlocutors into an intersection of multiple worlds, including the world of here-and-now interaction, the world of graphic space, and the world of physical events symbolically" (Ochs et al 365). Like the physicists enacting, side by side, worlds where they are external observers and worlds where they are the phenomena, the members of the journal club meeting enact the experiment as a vacillating structure that can be apprehended from the "inside" and from the "outside". This is the vacillation that the members of the lab make as they read and make sense of "what happened" in the experiment under discussion. I maintain that this vacillation is a necessary part of designing experiments in cognitive science: and further, that imaginatively occupying the position of subject is part of what constitutes "mastery" of experimental architecture, or becoming competent at understanding and designing experiments.

In the second "act" of this interaction, this imaginative substitution is enacted again in a discussion around the relative "difficulty" of the rhythm patterns. Victoria's percussive banging is enfolded into a simultaneous discussion of the relative "difficulty" of the rhythm patterns, each unfolding as relevant context for the other, sequentially and simultaneously.

Act 2: "What's more difficult?" Orientation to audible differences and durational experience

Immediately following Cameron's demonstration (line 23), Penny gathers the group's attention to the audible difference between the two accent patterns by saying "And they do sound really different, yeah?" (line 24) and nodding first to the members across the table from her (Rita and Sarah) and then to those to her right (Mary and Greg). Each member of the group immediately directs their gaze to Penny as she is speaking and returns a nod at the end of her question:

2.1 Penny's gathering of attention

```
24   P:    And they do sound really different (.) °yeah?°=
                                    [nods to R, S across table, then
                                          turns to look towards M, G]
     Pg    c____________________________r___s_____mg_______c_______
     Vg:   c_____________________p_________________________________c°°nod°°
     Sg:   c_____________________p____________________°°nod°°_______c_______
     Rg:   c_____________________p______________________°°nod°°_____c_______
     Mg:   c_____________________p____________________________°°nod°°_______
     Gg:   c_____________________p_______________________________°nod°__c__
25   C:                                                      =Yeh (.) and (1.0)
```

Penny's gathering of the group's attention is significant, because it bookends her initial request to Cameron (just prior to the transcribed interaction) to "tap out the stimuli". Both Penny and Victoria, who are the more senior researchers present, had encouraged Cameron to demonstrate the sensible difference between the stimuli conditions. As we saw through Cameron's earlier unfolding enactments, he does not go directly to the concrete, sensible difference, but builds from more abstract ("the basic form of it - the tone tone blank") to more concrete, finally making the difference between the accent patterns audible. However, while Cameron has finally (if briefly) tapped out the two beat patterns, it becomes clear in the following passage that he has not satisfied Victoria, who had requested that he "do that for several measures" (line 12). While Penny's directing of the group's attention to the sensible difference indicates that she is satisfied with Cameron's demonstration, Victoria did not have her request for a longer duration met. In the midst of the conversation that follows the excerpt above, Victoria takes it upon herself to bang out the stimuli on the table, more loudly and for a longer duration than Cameron had. During the interaction that follows, the extended rhythmic sounds respond to, act as context for, and ultimately become an explicit object of a discussion around the relative “difficulty” of the stimulus conditions.

After Penny directs members’ attention to the audible different in rhythm patterns, Cameron moves on to discuss an incidental finding of the experiment: that the “first beat” accent pattern was more difficult for subjects to maintain in the imagined beat condition (Iversen et al 62) : “in fact one of them they find is a lot more difficult than the other” (line 26). Mary, who has so far been quiet throughout the meeting, asks him to clarify - “what is more difficult?” (line 31). Cameron clarifies which accent pattern was more difficult by redescribing it in abstract terms again, labeling the tones “accent” and “unaccent” (line 33). During the initial part of this back and forth between Mary and Cameron, Victoria audibly and visibly prepares to interrupt.

2.2 Cameron introduces a “difficulty”, Mary asks for clarification, Victoria prepares to interrupt

25 C: =Yeh (.) and (1.0)

26 C: [in fact (0.5) and one (.) in fact one [(0.5)] of them they find is a lot more difficult than the other]
[*hands come together in front of chest and then move to his chin*]
27 V: [((clears throat, tilts head))]

28 C: [if it’s accented on the first beat it’s a lot more difficult= [(0.5)
[*RH touching chin*]
= [*hands back to paper]*
29 P: [*nodding to C*]
g: c______________________________

30 C [um (0.5) which they]=

[*picking up paper*]

31 M: =what's more difficult? [*looks up at C*]
g: computer______________________c______________________________

32 V: [*brings R hand to hover on edge of table, then fingers resting*]

33 C: *drops paper=* So if you [have accent unaccent blank]=
[*puts L palm face up again and touches it twice with R index on "accent and "unaccent", then points ahead and to the right on "blank"*]

34 V: =*raises right hand in preparation*[50] =

35 M: =yep

Victoria makes three separate indications that she is preparing to interrupt, and these appear to occur in response to moments of ambiguity or confusion in Cameron and Mary's exchange. First, while Cameron introduces the finding of one rhythm pattern being more difficult than the other (line 26), Victoria audibly clears her throat and tilts her head side to side. Next, when Mary asks "What's more difficult?" (31), Victoria brings her right hand to hover over the table, then brings her fingers to on the table, her hand and arm still active. Finally, when Cameron answers Mary by combining a new verbal explanation ("accent-unaccent-blank", line 33) with a repetition of his earlier gesture that maps the tones onto the upheld left palm with the righthand fingers, Victoria raises her right hand in preparation to hit the table (34). Given Victoria's earlier (unmet) request for a longer demonstration, and the long percussive interlude that follows, these indications seem to be responses to a perceived absence of sensible context for Cameron's claim,

[50]in the following turn V will begin hitting right hand slowly and rhythmically on table; volume decreases gradually; this continues through next several turns of talk; where they occur temporally is represented spatially by the location of the BAM

which might have been contextualized differently had Victoria's prior request for a longer demonstration been met.

On the following turn, Victoria addresses this absence by beginning to loudly bang a rhythm pattern on the table. The conversation about what is meant by "more difficult" continues, with Victoria's banging remaining in the background, not explicitly referenced in Cameron and Mary's exchange. Cameron has misunderstood Mary's question: Mary re-states it, clarifying that she was not asking about which accent pattern was more difficult, but about what was meant by "more difficult" (line 37). Cameron answers that difficulty is understood as how hard it is for people to "keep the beat" (line 38) and this is further elaborated by Greg, who supplements Cameron's explanation more operationally - "yeh they just ask them subjectively" (line 41). Simultaneous with Greg's clarification, Victoria's sounds are brought into the foreground when Penny explicitly references them, saying "I feel like *that* would be easier" (line 39). Victoria responds with a combination of words and sounds, saying "I think it's not as easy as" (line 43), and switching to the alternate accent pattern. As Victoria's rhythmic interlude ends, Cameron draws the attention back to himself by relating the newly contextualized "difficulty finding" to to a future study that he is working on. In this final part of the exchange, all members move their gaze to Victoria, some nodding, before returning their gaze to Cameron by his second attempt to transition the conversation to his future study.

2.3 Percussive Interlude

34 V: *=raises right hand in preparation=*

35 M: =yep

36 V: BAM BAM (0.5) BAM BAM (0.5)
C: It's [more difficult than if you have unaccent accent blank
[*points to the right on "more", touches hand on "accent" and "unaccent", points right again on "blank"*]
P:
Pg: c____

37 V: BAM BAM (0.5)
M: But what do you mean by whats what's difficult=
P:
Pg: c____m_________________

38 V: BAM BAM (0.5) BAM BAM (0.5)
C: =it's harder for people to >keep the beat (0.5) uhm=
P:
Pg: m__________________________c__________________________________

39 V: BAM BAM (0.5) BAM
P: ((to V)) [I feel like that would be easier]=
Pg: c______v____

40 M: =Okay=[*nods*]

41 G: ((to M)) =°yeh they just [ask them subjec]tively°=

42 C: =[Which is actually interest] (0.5) which (0.5)=
[*R hand pointing upward, wags index to accent*]

43 V: [I think I think it's not as easy as[51]](0.5)

44 V: [BAM BAM (0.5) BAM BAM (0.5) tBAM tBAM (0.5)
[*patting her chest with left hand while banging the table with right hand*]
Vg: p________frontdown______________up______________________________

---

[51]In the following turn, V begins hitting the table with the alternate accent pattern. On the third "set" of beats she begins patting her chest with her left hand at the same time as hitting the table with her right, indicated by "tBAM"

```
45    C:                               [this is actually an interesting point for us for why]=
      Sg:    p__________v____________________________________________c________
      Rg:    v/p_____________________________________________________________c_
      Cg:                       v_____________________________________________
      Gg                        v______________________nod__________________c_
      Mg:    comp.____________v________________________nod__comp____________
      Pg     v________________________________________________________c________

      V:               tBAM tBAM
46    C:     = [our study later is] interesting.
```

In this interaction, positions inside and outside the experiment again become subjectively available to members, this time in the coordination and dis-coordination between members, in the unfolding and layering across multiple members' enacted resources. In particular, as Victoria's percussive rhythms move from background to foreground, they address the earlier requests to "tap out the stimuli", and, in particular to "do that for several measures." In relation to the discussion of the relative difficulty of the accent patterns, Victoria's demonstration also makes the accent patterns available to subjectively calibrate which pattern "feels" more difficult.

These 'background' sounds move to the foreground as a resource for subjective calibration when Penny, who has been shifting her gaze between Cameron and Mary as they discuss the difficulty ambiguity, turns to Victoria and says, "I feel like that would be easier" (line 39). The percussive sounds are now an explicitly referenced object to which members direct their attention. Victoria incorporates her next rhythmic demonstration into her utterance, saying "I think it's not as easy as" (43) and switching to the second-beat-accent pattern. Another collapsing happens here, again between the position of being on the "outside" of the experiment (details of an incidental finding), and on the "inside" (the experience of feeling the patterns). It is by "feeling" the accent patterns that lab members can make a judgement about which pattern is more difficult. Hearing the accent pattern for an extended time potentially helps unlock both questions from the inside out (which accent pattern was more difficult/ what is meant by more difficult).

When entering into the work of subjectively calibrating the accent patterns, Penny and Victoria use the subjective language of feeling and thinking in their explicit orientation to the rhythm patterns: “I feel like” and “I think it’s not as easy as” (lines 39 and 43). In using this language, Penny and Victoria orient to the accent patterns as perceptual objects - in other words, they “get inside” the experiment to occupy the position that Victoria’s sounds had made available - they assess and discuss the stimuli by adopting the point of view of the imagined experimental subject. After Victoria says “I think it’s not as easy as” and demonstrates the second pattern, all members move their gaze toward Victoria. During this time, when she has all members’ visual attention (lines 43- 44) Victoria modifies the way she performs the second accent pattern partway through: while hitting the table in the same manner as before with her right hand, she also pats her chest in the same accent pattern with her right hand (lines 44-46). Victoria visibly performs “feeling” the accent pattern by doing it onto her own body as well as on the table (“tBAM”).

In contrast with Cameron’s briefer sensible demonstration in lines 21-23, the duration of Victoria’s rhythmic interlude enables members not only to note the difference between the conditions, but more closely simulates the experience of being a subject, or “what the people are hearing”. The temporality of Victoria’s lengthier rhythmic interlude makes an “inside” position more perceptually available to members. Next, in verbally and physically orienting to the sounds from the perspective of an experiencing subject, the senior members Penny and Victoria publicly demonstrate “getting inside” the experiment. These “public” demonstrations may function as an invitation for members to enter the experiment this way themselves. In the moments following this final part of transcribed interaction, several members can be seen quietly embodying the rhythm pattern on and for ourselves. Rita taps/moves her right fingers, crossed over her left arm; Greg bobs his head and upper body while looking at his tablet, and Sarah (myself) taps her pen on her lips. Like Victoria’s percussive banging, these actions unfold in the background of the continuing conversation, but they are distinct in that they are not an accessible resource for others to act upon. These movements were virtually private - done without exchanging eye contact, and with the exception of Greg’s rocking, barely noticeable on video, let alone to one another. These nearly-private self-stimulations are one observable culmination of this social practice of reading - as iterations of experimental activity move from the text, into the shared space of interaction, and into individual members’ bodies.

Figure 3.6. Rhythm patterns, privately embodied.

Between people and paper

This chapter depicts a social practice of reading in cognitive science. In the interaction transcribed, members encounter the experimental architecture as they work to reconstitute what was done by other scientists. As the interaction unfolds, the stimuli conditions of a rhythm perception experiment move from the page (figure 2) into the shared space of interaction (figures 3-5) and into the bodies of members (figure 6). The experimental conditions are performed and and re-performed using sequences and combinations of material and embodied resources. This account illuminates not only how embodied forms of action are supported and reproduced with the help of inscriptions, but also how the reading of inscriptions is always situated, that texts activate and are activated by the contingent resources brought to them. As I attempted to show in first introducing the experimental conditions, this is true regardless of whether or not the reading practice is literally social, ie, in the presence of others, or only "virtually" social, in the contact between a reader's own historically accumulated resources and the page. The inscriptions we call journal articles are forward-looking not only in the sense of advancing their claims, but also toward the project of replication (ensuring specific future experimental performances) and reproduction (making future researchers and maintaining a form of life). In this paper, I have focused specifically on the form of life that is cognitive scientific experimentation, capturing situated and embodied practices of reading by which inscribed experimental activity is made material and actionable. In the lab meeting, where members are semiotically available to each other, this reading practice rehearses different iterations of experimental architecture, materializing the experiment as activity that can be experienced from within and manipulated from without. For these cognitive scientists, the work of enacting and re-enacting the experimental architecture in order to inhabit its emergent spaces is the work of making and remaking experiments and experimenters.

Post Script

Shortly after the interaction as transcribed, Cameron begins to tell the group that he has begun collecting pilot data for his own experiment. It's not going well, because the data are very noisy, marred by a lot of artifacts. In the light of the account I've just given, whereby researchers bring the experimental design off the page and into their bodies, it seems probably that the participants are doing the same thing, possibly with very small, possibly unconsciously activated movements of the body. If the experimenters used physical resources to access the two rhythm patterns used in both "real" and "imaginary" conditions, should they expect subjects, as instructed, to "keep the beat" in their minds without somehow physicalizing? This predicament makes it a challenge to study imagined experiences experimentally, but it also troubles the experiment's underlying distinctions between imaginary and physical, interior and exterior, in the first place. Is imagination, traditionally defined by its disconnection and disembodiment, every really out of this world?

These kinds of contradiction in the apparatus should part of conversations about reproducibility in psycholology and cognitive science. Looking at the embodied activity of the lab members as they collectively read about this experiment can shed light on what subjects might be doing when they are inside the experiment. This can help scientists interpret their data. But even more than that, it can help with attuning to how the phenomenon under investigation takes to being studied in a particular way. In this interaction, the phenomenon of "imagining rhythm" clearly resists being held still. In addition to addressing replication problems by opening science and dispatching virtual witnesses into the data-analysis pipeline, the replication crisis could also benefit from systematic attention to the materializing practices scientists use to enact their phenomena, and the attunement to the apparatus that this approach can cultivate.

A version of Chapter 3 is currently being prepared for submission at *Social Studies of Science* and may appear in 2017 or 2018. Klein, Sarah. The dissertation author is the sole author on this paper.

Chapter 4

EXPF: Shaping experiment from the inside out

What would happen if experimental subjects, instead of being passively intervened upon, were involved in designing the experiment?

What would happen if experimental researchers, instead of being unobtrusively observed, were involved in studying their own practices?

These questions motivated the collaborative project documented in this final empirical chapter. We labeled its set of digital files and folders "EXPF" as an acronym for "experiment-performance". An experiment about experiment, EXPF reflexively addressed the performative character of research practice. A collaboration between myself and cognitive scientist Tyler Marghetis[52], EXPF looped theories of performative entanglement and reflexivity into our collaboratively devised research apparatus. EXPF, in rearranging materials and practices local to the cognitive psychology lab, aimed to enact "response-ability" between researchers and research subjects (ethnographer and cognitive scientist) and between researchers and research subjects (experimentalists and experimental subjects). Response-ability here is a normative position, proposed by Vincianne Despret and taken up by Donna Haraway, Karen Barad, and Bruno Latour, that ties ethics to a revised notion of responsibility. In this view, "response-able" science is that which allows the phenomena under study to respond. Response-ability creates set-

[52] The impurity of our respective intellectual identities is relevant to how our collaboration unfolded. As previously noted, I did not first encounter cognitive science via my STS training, but much earlier, as I grew up among cognitive psychologists (cognitive scientific encounters, on the contrary, prepared me for STS). Similarly, our collaboration was not Tyler's first encounter with STS, with which has a longstanding interest. This made it easier to share repertoires and vocabularies.

ups and questions in which its subjects are interested, or which allows them to become interesting. (See Despret 2004; 2008, Barad 2012, Haraway 2012, Latour 2000, 2004). What could we learn about research entanglements in our respective methodological lifeworlds by making those lifeworlds more response-able and responsive to the entities they studied?

If the preceding chapters shifted between different loci/perspectives in experimental apparatus in order to describe processes of folding in the making of cognitive scientific experiments and objects, this chapter reorients research methods in general and experiments in particular, by rearranging experiment's performance structure. By exploring what it means to become responsive, this chapter turns methods inside out. First, I aimed to get inside of the system I had been studying ethnographically, to explicitly intervene in the performative activity of experiment. From there, EXPF picks up on the theme of folding as creating relations between insides and outsides of/in subjects. In EXPF, we attempted to invert the agential structure of the typical cognition experiment in such a way that subjects would be able to modify the experimental design. After briefly introducing the design of EXPF and situating it within the themes of this dissertation, I will go on to elaborate what happened in EXPF in some detail. This exposition, first of the design of our performance, then of *what happened*, explores a possible configuration for collaborative performance making in STS, and for capturing, registering, and amplifying ephemeral subjective experiences of experiment.

Abstract (rather than abstract, I wish to embed)

EXPF was a performance made for the cognitive science laboratory that took place between May and July 2015. A collaboration between Sarah Klein (ethnographer of cognitive science) and Tyler Marghetis (cognitive scientist), EXPF entwined our respective questions, interests, and preoccupations. Our concerns converged on the figure of the experimental subject and on the phenomenon of expectancy effects (sometimes called pygmalion effects), which are a long-recognized form of experimenter/subject entanglement in psychological research on humans and nonhumans (Rosenthal 1963a, 1963b, 2009; Orne 1962). Cognitive psychology experiments require the ongoing enrollment of participants, who are regimented in subtle ways to perform both as data sources and as ideal subjects. What emerges when, instead of imposing a static experimental design[53] on passive subjects, the experiment becomes malleable and responsive, conforming to subjects' impressions of and aspirations for science?

In order to answer this question, we designed an experiment-performance that rearranged the materials and routines local to the cognitive psychology laboratory. EXPF inverted the agential structure of the cognitive psychology experiment, so that instead of being structured around testing a hypothesis about cognition, we made its design responsive to the impressions of its subjects. After having subjects complete what

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[53] By static, I mean that the design is implemented independently of what happens inside of it. Of course, an experiment may have two or more conditions that different subjects experience. Piloting an experiment is one standard practice where "what happens" informs the experimental design. Piloting collects preliminary data and "rehearses" the experimental design, which enables practical and technological troubleshooting. Experiments are often piloted on lab members. However, after a typical experiment is out of the "piloting" stage and into the data-collection stage, its design does not change.

appeared to be a standard, computer-based cognitive psychology task, we elicited impressions about the experiment's purpose and suggestions for improvement. Our performance score required that we respond to subjects' feedback by revising the experiment before the next subject arrived, whose impressions revised the next version of the experiment, and so on in an iterated chain of performance and revision. In becoming responsive, experiment and experimenters became instruments to capture the invisible routines, expectations, and power relations that make the experiment possible at the scale of laboratory interaction. By rendering the cognitive psychology experiment as malleable bodies-in-interaction, EXPF provides performative context for cognitive scientific facts, and intervenes in that activity, opening up possibilities for novel methodological relations, collaborations, and enactments.

Figure 4.1. Collage of video stills from EXPF.

Reflexivity and performative entanglement

Throughout the course of my ethnographic research, I have often been disoriented by a hall of mirrors that would appear when I examined the symmetry between what I was doing and what cognitive scientists were doing. For one, we both study people: I was studying people studying people. We are also both interested in the materialization of meaning, but locate and stabilize our target systems at different scales and with different boundaries. My target system is research activity in the lab; theirs is electrophysiological activity in the brain. My specification of entanglement as enfolding in the making of cognitive objects can also inform STS scholars in understanding our entanglement with our research subjects and objects. Arguably, STS scholarship's entanglement with our objects - be they scientific facts, beliefs, controversies, inscriptions, actor-networks, and so on - is more like that of cognition researchers than it is like that of physicists. This is true in a basic sense, in that both cognitive scientific and social scientific research locates its objects in and among humans. In a narrower sense, too, key clusters in both STS and cognitive scientific research have organized themselves around questions of what makes empirical experience and knowledge possible. The strategies and resources we have available to pursue these questions, the research apparatuses we design and implement, are modes of being-together with other humans. The preceding chapters have documented how experiments as ways of being-together (literally and virtually) entail intersubjective interdependencies and strategic identification and differentiation between cognitive scientific researchers, subjects, and objects.

Through EXPF, I attempt to deal with the disorienting recognition that, like the cognitive scientists I have studied, I am part of a layered research apparatus of observers and observed. One strategy to deal with this has been to use reflexivity as a tool to limit, withdraw, and draw boundaries between signal and noise. Awareness of a researcher's effects on the system they are studying can lead them to be more careful, and to develop a better sense of whether an effect they are seeing is the research design working as desired, or is (in scientific terms) an artifact. This is often the approach taken by scientists in attempting to improve data collection in order to be more certain that their data answers the question they are asking of it. This approach appears in experimental cognitive science when, for example, research subjects are, through vagueness, misdirection, or deception, led away from the research question of the experiment in which they are participating. Knowing that subjects have been found to adjust their performance depending on what they believe the researcher is looking for, researchers often attempt to manage these so-called "expectancy effects" by withholding or masking the details of what the experiment is set up to ask, or its "demand characteristics". Whether such concealment qualifies as deception has been debated (Broder 1998, Ortmann and Hertwig, 1998)). This approach crops up in this dissertation when I qualify an ethnographic observation with disclaimers like "it is possible that the interaction I observed was shaped by the presence of the camera", or flag my involvement, like "this was in response to a question posed by the ethnographer". This strategy imagines a division between real or authentic phenomena and an artifact, which are "human-made" or the effects of the observing apparatus. Operating from the (now widely accepted) principle that research practice is performative, and that researchers are entangled with our research objects, in the project that makes up the core of this chapter, I throw myself into this entanglement rather than attempting to know it only in order to limit it. Instead of focusing on drawing a line between authentic and inauthentic phenomena, I actively intervene in experimental practice, manipulating and rearranging it. In a broad sense, my approach here is classically experimental - I am manipulating a system in order to understand it.

In this case, the system is cognitive scientific experimental practice, in particular, circuits of experience and expectancy that are exchanged or trafficked between subjects and experimenters as they perform together in an experiment. EXPF is an experiment in enacting responsivity, or becoming response-able, to again invoke Haraway's term, on two relational scales - between one another as collaborators, and between our apparatus and its experimental subjects.

What kind of performance is this?

In collaboratively intervening in experiment, I am responding to calls for reflexivity in STS methods. While STS has spent years and volumes describing scientific performativity[54], there is a tendency to retain empirical distance from our own research sites, in many cases by remaining flies-on-the-walls in technoscientific contexts. As far back as when the principles of symmetry and reflexivity were proclaimed as as central

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[54] See Herzig (2004) and Law (2008) for accounts of the performative turn in STS. Herzig identifies Latour and Woolgar's *Laboratory Life* (1979) as the first explicit reference to performance in science studies (Herzig 129). From an emphasis on the embodiment of scientists (Biagoli 1995, Lawrence and Shapin 1998, Alac 2011), to on the hybrid assemblages of "natural" and "social" (Latour 2005), to a proliferation of material-semiotics and onto-epistemologies (Mol 2002; Haraway 1988, 2006, 2016; Barad 2008), Performance and performative idioms have been involved in STS' shift away from representationalist accounts of scientific knowledge, toward enactment, entanglement, and practice.

values for a fledgling Sociology of Scientific Knowledge (Bloor 1976) , STS scholars have periodically reminded one another that our knowledges, too, are practiced and situated. These reminders persisted with renewed urgency through feminist and posthumanist STS scholarship and the associated "performative turn", as the implications of belonging to a material-semiotic, ethico-onto-epistemic "worlding" meant we couldn't overlook our own performative entanglements and the world-making capacities of our research. Addressing STS's uptake of performativity, Law & Urry (2004) remind readers that STS (and social science in general) is performative and thus "*produces* realities". They go on to ask provocatively, "which realities? Which do we want to help to make more real, and which less real? How do we want to interfere (because interfere we will, one way or another)?" (404).

In spite of these reminders and provocations, there has been a lot of "rethinking methods" without much reshaping them. STS has become adept at rethinking its performativity, but, as Yelena Gluzman (2017) notes, this has often been limited to "literary or textual strategies" (9). For example, Barad (2007) models a scholarly mode of ethico-onto-epistemology by developing "diffraction" as an alternative to critique - a respecification of engagement with others' work that highlights mutual co-constitution and co-implication. Annemarie Mol (2002) both describes and demonstrates ontological multiplicity by unfolding her ethnographic and theoretical material in two parallel texts[55].

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[55] That is not to say that because an intervention is textual it does nothing. That would entrench the distinction between text and action that I've argued against in other parts of this work. More accurate would be to note that the performative intervention here is directed toward other STS scholars (who are the situated readers of the text), rather than earlier in the methodological process, toward the scientific contexts that make up the empirical data around which the texts are organized.

Beyond reminders and textual interventions, the methodological toolbox of STS research, however, seems to be slow or even resistant to reflexive intervention - even, some suggest, “black boxed”[56]. As a result (or as a symptom), “reminders” to rethink our own entanglement have become an almost continuous mantra.

EXPF explores a possible configuration for taking performativity seriously and literally, by making performances with scientists. Some such interventive approaches have recently been taken up in moves toward design, “Making and Doing” and what some have called a “collaborative turn”, characterized by a recognition among STS scholars that engagement with scientists need not be a choice between being distanced or oppositional (Klein and Gluzman 2015, Downey and Zuiderent-Jerak 2016). I locate EXPF in the midst of this collaborative turn, joining an emerging cluster of projects between the arts, social sciences and the cognitive/psychological/neuro-sciences aimed at exploring the boundaries and possibilities for interdisciplinarity[57].

With EXPF, I draw on and hope to magnify underexplored affinities between two approaches that run through this dissertation: ethnomethodology and performance-making. Ethnomethodology is compatible with theories of performativity in locating the reproduction of social worlds not just in discursive formations, but in the everyday, the

[56] In a description of a panel titled “Considering the performativity of our own research practices” at the 2016 Society for Social Studies of Science meeting, the conveners write: “What happens if we take Barad’s call for ethico−onto−epistemology seriously? How can we perform STS ‘by Other Means’, open the black box of ethnographies, and participate in their performative enactment more reflexively and creatively?” (Wood, Jarke and Introna, 2016)

[57] See, for example, Callard 2014, and Callard and Fitzgerald 2015 on collaboration across the social and neurosciences; and Zuiderent-Jerak (2015) on situated intervention in health care.

ephemeral, and the embodied. The ethnomethodological approach that has informed this dissertation typically manages the problem of the colliding, entangled worlds of the analyst and the worlds they analyze by requiring what Garfinkel (1992, 2002) called "unique adequacy". In order to achieve "unique adequacy" the analyst should become as close as possible to being a member of the community of practice under study. There is a presumption that good social research necessitates transforming the analyst, but it leaves the research site for all intents and purposes intact. This presumption reproduces the boundaries between observer and observed/authentic and inauthentic phenomena that underlies most empirical claims. Garfinkel's "breaching experiments" (Garfinkel 1967), however, instead of cultivating empirical distance, encouraged intervention as a mode of revealing social worlds. Garfinkel's breaching experiments were exercises developed for his students that encouraged them disrupt or "breach" ordinary social situations to illuminate unwritten rules and implicit structural features, or "background expectancies" (Garfinkel 1967, 36) of those situations. Garfinkel's commitment to understanding local, context-embedded meanings and practices is exemplified in his remarks on the "awesome indexicality of everyday life" (11). The notion that breach, breakdown, or disruption of ordinary activity can reveal its implicit and indexical structure both precedes and pervades Garfinkel's work (see Goffman 1956, 1963)[58], but what distinguishes his breaching experiments is that they turn this principle into a method

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[58] A predecessor and contemporary of Garfinkel's who was concerned with the empirical function of breakdown for revealing the structure of social life was Erving Goffman. In particular, Goffman's early studies of mental institutions and other stigmatized groups provided examples of interactional breakdown and stigma around which he built his dramaturgical theory of the self, which seeks to maintain "face" and avoid breakdown along with its damaging social repercussions.

for making these implicit indexical features accessible to study. Examples of Garfinkel's breaching experiment "assignments" included having students haggle with grocery store clerks, repeatedly ask for clarification during smalltalk, and behave as a lodger in their own homes.

Performance Studies makes something akin to a "breach" the rule rather than the exception, not only in its foregrounding of performative practices and embodied knowledges, but in its simultaneous challenge to institutional categories of what counts as scholarship or as scholarly method. I want to highlight compatibilities between Garfinkel's breaching experiments and avant-garde performance traditions that adopt strategies of disruption in order to reveal and critique aesthetic, political and social norms by way of the formal conventions, routines, relations, and roles through which they are articulated. What these approaches share is a reflexive methodology of working with/on/against the norms and routines of a given institution, genre, or situation in such a way that reveals, challenges or critiques aspects of that situation. While it is possible to recognize reflexive strategies in many art movements (and individual works) on the basis that a movement or a piece reworks or challenges the style, technique, or strategies of its predecessors, I want to highlight examples that employ a strategy of disrupting or rearranging interactional and/or institutional norms.

Yoko Ono's "Cut Piece" (1965) and Marina Abramovic's "Imponderabilia" (1977/2010), for instance, breach social norms of personal space, trust and intimacy by inviting (or impeling) audience members into novel intimate encounters, like being asked and entrusted with to cutting the clothing the performer is wearing (Ono 1965), or having to brush up against a performer's naked body in order to fit through a gallery's entrance (Abramovic 1977). Adrian Piper's work, especially her "Catalysis" series (1972-73), not only enacts similar disruptions, but stages them in public and claims them as an empirical strategy. Piper's work breached bodily and behavioral norms, this time in spaces like city buses, trains, parks and department stores. Piper entered these public spaces, and encountered their inhabitants, in various states of abjection: her interventions included browsing through a bookstore after brining herself in a mixture vinegar, eggs, and cod liver oil, and riding the bus with a red towel stuffed her mouth (Lippard and Piper 1972). Piper's work stages direct encounters with viewers that call attention to the here-and-now of the cultural resources activated in that situation, particularly resources used to enact and maintain categories of race and gender (Piper, 1989). Piper describes her approach as a staging of unmediated encounters in the here-and-how - enrolling viewers into a critical moment that she, like Garfinkel, identifies in terms of its "indexicality": "the indexical present" (Piper 1990). Julia Steinmetz (2009), writes of Pipers's work,"[t]he indexical present instantiated by her work seemed to act as a catalyst for social mindfulness, awareness of the here-and-now of interpersonal relations." (web). Interestingly, Piper did not describe these encounters primarily in terms of their effects on the people around her, saying she had not been "cataloging the kinds of reactions I have gotten" (Lippard and Piper 1972, 77). She describes instead a turn inwards, becoming attuned, through these encounters, to "the boundaries of [her] own personality" (ibid). In Piper's indexical present, encounters are not reduced to responses to be cataloged, but are opportunities for phenomenological research on the limits of the socially constituted self. In addition to highlighting how all three of these artists stage social research, I want to flag Piper's comments on her method because they show that there is more than one way of enacting the empirical function of performances. This will become relevant later, when I give two accounts of EXPF: one which functions more as a "catalog" of actions and reactions, and one which is more of a phenomenological reflection on what we encountered in inhabiting our performance.

My intention in these brief descriptions is not to give an exhaustive account of these performances, or to suggest authoritative interpretations, but to highlight the structural aspects of these performances that resonate with "breaching" as a methodology. In drawing out these resonances I aim to amplify the empirical functions of performance and the theatrical properties of research. I locate EXPF, then, as part of two empirical traditions: an ethnomethodological framework and a performance repertoire. Our move to experimentally engage with and manipulate the situated materials and practices of research is an example of what Yelena Gluzman (2017) calls "Research as Theater" (RaT). For Gluzman, RaT is a way of taking performativity seriously by engaging with the theatrical properties of research: "theatre performance is central to the performativity of scholarship, allowing scholars to engage not only with the *fact* of performativity, but rather with the concrete, situated *processes by which scholarship is materialized*." (2). The RaT perspective, with which I identify EXPF, opens STS methodologically to intervening by re-staging the social and material mechanisms of scientific practice.

With EXPF, Tyler and I re-staged features of experimental practice by inverting the experiment's typical agential structure. Bracketing any proper cognitive hypothesis, we instead made subjects' experiences and expectations, (ordinarily ignored, redirected, or managed), into an independent variable, which would act upon the experiment's design, the dependent variable. Our performance was iterative, transforming in response to each subject in a sequence, allowing the transformations in the activity to transmit and amplify the experiences of the subjects who inhabited it.

EXPF's Iterative Design

In a typical cognition experiment, like those I describe earlier in this dissertation, all subjects run in the same experiment, with subjects distributed across two or more experimental conditions, data is aggregated, and if all goes well, researchers get a statistically significant result that allows them to make a claim about cognition (See Fig. 4.2) . In this model, *repetition* is what affords its statistical power to locate and stabilize cognitive processes inside of people. In contrast, for EXPF we turned instead to *iteration* to register features of experimental activity that undergird its capacity for repetition.

In order to do this, we found inspiration in an alternative experimental paradigm in research on iterated learning. Iterated learning is a theory of cultural transmission and a proposed mechanism for cultural evolution. According to one of its key practitioners, Simon Kirby, iterated learning "describes the process whereby an individual learns their behaviour by exposure to another individual's behaviour, who themselves learnt it in the same way" (Kirby 2014, 108). In studies using mathematical modeling and laboratory experiments, an iterated learning paradigm resembles the "telephone game" in which a message transforms as it is whispered around a circle. In an iterated learning experiment, subjects in a "vertical transmission chain" generate the data from which subsequent subjects learn (109). The way the learned behavior (a drawing, gesture, language, song) transforms as it moves through the chain can help answer questions about how structure emerges in linguistic and cultural evolution, or about how constraints (such as learner's biases) shape transmission (ibid).

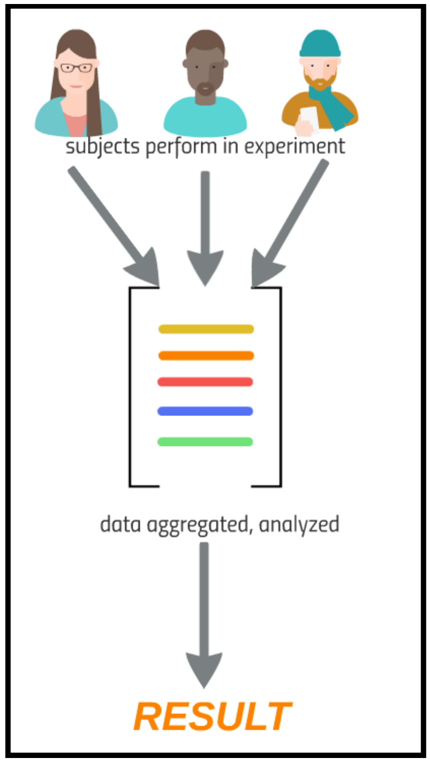

Figure 4.2. Typical Experimental Design

For EXPF, Tyler and I adapted the structure of the "transmission chain" from iterated learning. Instead of transmitting a learned behavior, though, subjects in our experiment encountered and revised the experimental design. Each subject (with the exception of the first in a chain) would experience an experiment that had been revised by the impressions of subject who had come before. In this design, the experimental activity itself was rendered responsive to subjects' reported interpretations and suggested revisions. The transformations to the experiment were our primary source of data, not about a cognitive process happening inside a person, but about performative entanglement within the experimental system (See Fig 4.3).

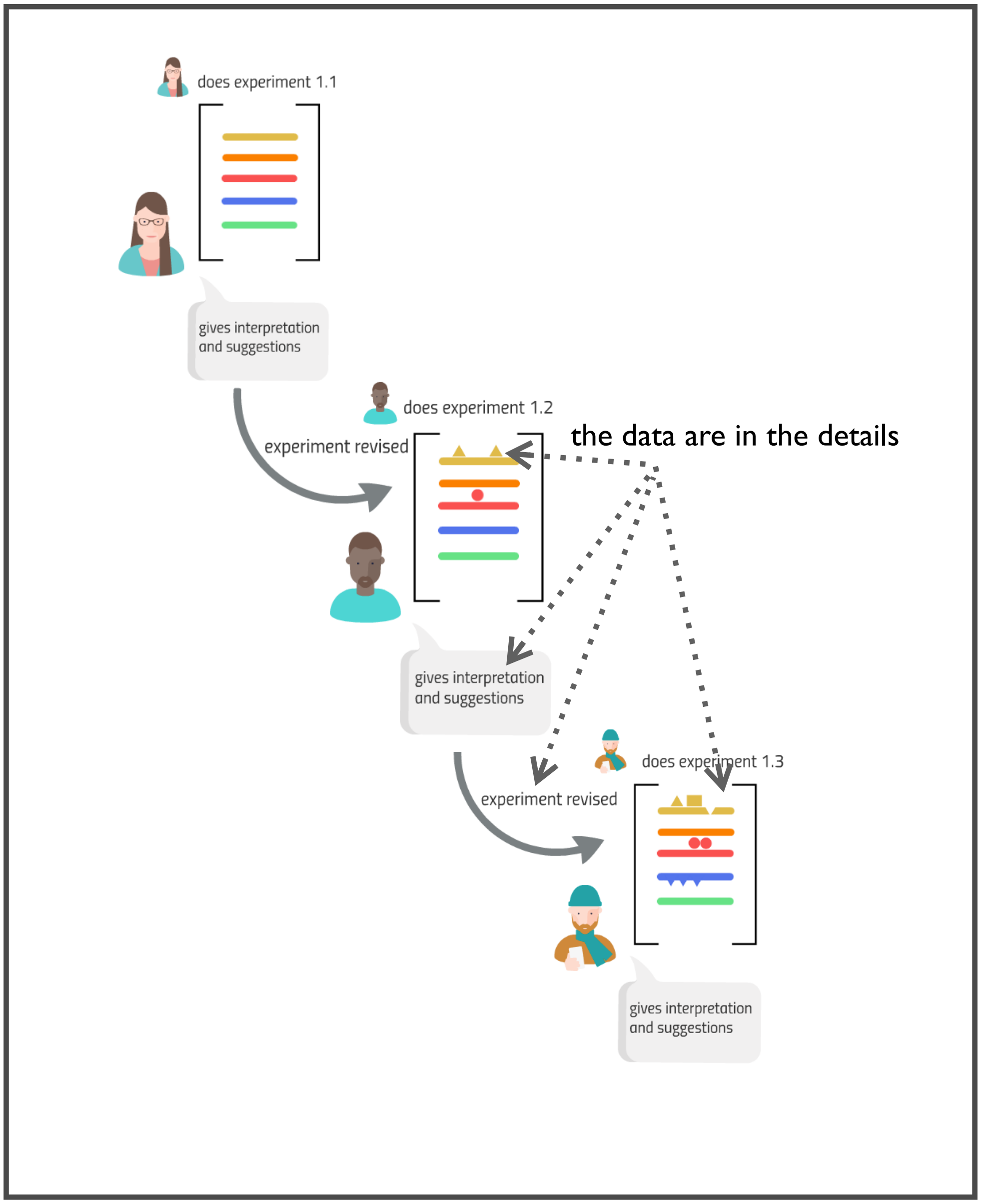

Figure 4.3 EXPF experimental design, Klein & Marghetis 2015

EXPF Score

In a conventional methods section, readers would encounter an idealized description of the experimental procedure that the researchers implemented in their study which necessarily omits a great deal of specific methodological activity. EXPF destabilizes this structure to register precisely those ephemeral features of the experiment that ordinarily go unregistered, but upon which a generalized, repeatable experimental performance rests. A description of EXPF's procedures, then, reproduces this tension while exceeding the limits of a conventional methods section. In describing EXPF procedures in terms of our performance score, I aim to capture how we implemented its iterative structure. In this account of our score, I move between generalized descriptions of the parts of our procedure we aimed to keep stable, specific examples of aspects of the experiment, such as the stimuli, task, instructions, etc, that were available for revision, and explanations of choices we made. Italics indicate a "channel" of the experimental design that was available for revision.

Participants: We recruited participants using Sona, the university's experiment volunteer management system, which allows students to participate for credit or compensation. For this study, we chose to only allot credit hours, which limited our subject pool to students who were taking lower division courses in psychology or cognitive science. Participants were not necessarily majors in these programs. In this experiment, we recruited a total of 12 subjects over 2 chains. 6 subjects participated in the first chain, the experiment was "re-set" to its "original" or base settings, and then 6 more subjects participated in a second chain. For an ordinary cognition experiment, one relying on averaged electrophysiological data or response times, this would not a sufficiently large sample. However, for the purpose of enabling iterative transformation, 6 subjects per chain was sufficient.

In the following section, *italics* indicate a component of the experimental experience that was made available for revision. When participants arrived at the lab, they completed a consent form[59]. We then brought them into the testing room, where they first filled out a short *demographic questionnaire*. Our "base" setting for the questionnaire was modeled after a convention for cognitive psychology experiments, in which it is often standard to collect information about languages spoken (first/second, etc) and about handedness[60]. In addition to these questions, our original questionnaire included a question about in what courses in psychology or cognitive science participants were presently enrolled (though subsequent iterations added and removed items to the questionnaire).

Next, we had participants complete what appeared to be a standard computer-based cognitive psychology experiment which *instructed* them to respond to a set of *stimulus images*[61] by pressing keys and typing words. In the original setting of the

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[59] The consent form was a static part of EXPF, because the procedures of EXPF fit within the description of a computer-based cognition experiment in the "blanket" consent form that Tyler's lab used to cover a number of experiments implemented by its members.

[60] That this is common information to gather as a part of cognition research is a product of cognitive psychology's long history of research on brain lateralization and handedness, along with the very widespread use of two-handed keyboard responses.

[61] We began each chain with the same starting set of image stimuli. However this changed, when in one chain, songs were incorporated into the stimuli.

experimental task, we followed the convention of having two “blocks” with a break in between, and in the second block had subjects inverse which keys signified like/dislike. We used ePrime, a software program for running experiments in cognitive psychology, to run the computerized *experimental task*, which included on-screen *instructions*.

We wanted the “base” stimuli to have the potential to evoke different interpretations, but not to overdetermine these interpretations by having them share obvious conceptual or physical characteristics or be otherwise categorized in terms of a single recognizable cognitive construct. Our solution to this problem was to create a script for ourselves on how to use google image search to select images: In a move that served dual purposes of obscuring any single cognitive hypothesis in being cheekily self-referential, we selected 6 search terms from the psychology department’s web page listing faculty research interests. These search terms were “addiction”, “control”, “child development”, “language”, “learning”, “number”, and “perception”. Upon entering each of these into google image search, we chose the first distinct 6 images for each term (no duplicates or near duplicates), that had no written text, and were not graphic or predictably disturbing (the “starting set” of image stimuli is displayed in figure 4.4). This script also provided a bit of score to follow later on when revising the stimuli in response to feedback, only extracting search terms from subjects’ language.

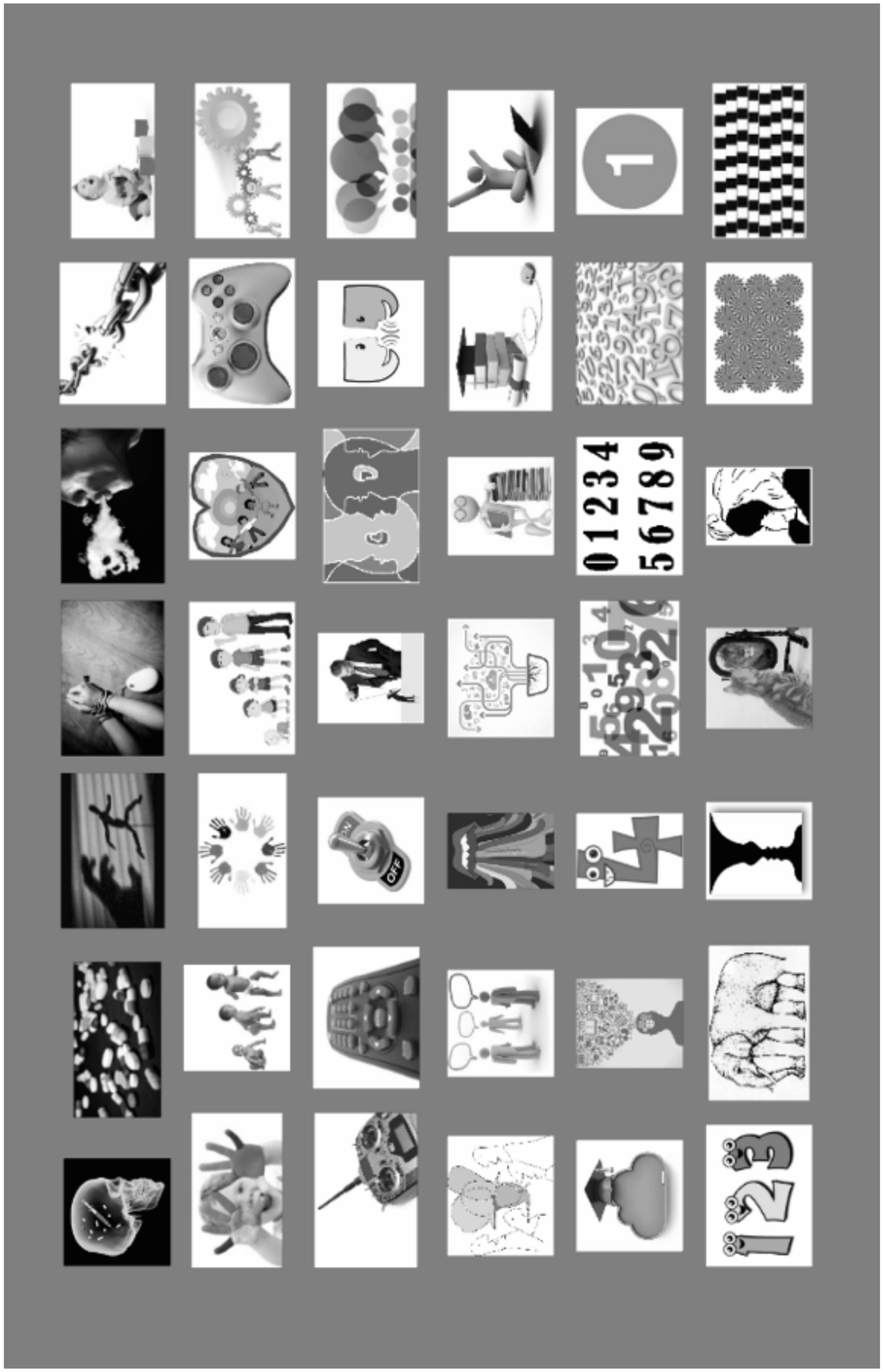

Figure 4.4 Original “Starting” Stimuli Set (X.0 in chains)

Once this experiment-like experience ended, we had a debriefing/feedback session, where we asked a subject for their thoughts on the experiment's purpose and design. Debriefing after participation in psychological studies is an important convention (often required by/written into ethics protocols) which typically involves the researchers asking the participant what they thought the experiment was testing before revealing its purpose and clarifying any questions they had (Kimmel 2004, 61-62). This procedure, in addition to clarifying the experiment's purpose for ethical and educational purposes, can also provide valuable information to the researchers about participants' interpretation and experience of the experiment. This is often done to confirm that participants were not able to guess the experiment's true purpose: since participants are known to reshape their behavior to conform to their interpretation of the experiment - part of the expectancy effect phenomenon called "demand characteristics" - hiding the experiment's true purpose can be considered methodologically critical. In fact, data from participants who guessed the experiment's true purpose may even be removed from any analyses. Debriefing in typical cognitive psychology experiments, then, can have an ethical function for participants as well as an epistemic function for researchers in sorting good from potentially compromised data.

In EXPF, our lengthy debrief interview resisted the distinction between authentic and inauthentic data, instead aiming to channel the "distorting" power of the subject's impressions back into the experimental design, gathering impressions and suggestions that would become the revisions that Tyler and I would implement before the next subject arrived. In other words, debrief feedback would typically be used to 1. ensure that a subject had not been harmed by the experiment or, 2. determine whether to include or exclude a subject's data. Instead, in EXPF, debrief feedback became a crucial part of our data, which encompassed the unfolding, iterative experimental activity as an agentially re-configured whole.

In our debrief/feedback interview, we expanded the interview beyond eliciting their interpretation of the experiment's purpose by asking subjects, *given* that interpretation, how they thought they performed, and for general and more specific suggestions for improving several different design areas of the experiment. Tyler or I would go through our script for the debrief[62], while typing the participant's answers into a google form. After a subject completed our "debrief 1", we did a "genuine" debrief, revealing that we were interested in the expectations and experiences of experiment and explaining their place in the iterative structure. Ironically, because we followed the convention of keeping our true purpose hidden until the end, subjects were not aware of their structural power until they no longer had it.

At this point, after a subject had completed the experiment and been debriefed, Tyler and I had to respond to and resolve their feedback before the next subject arrived, whose impressions revised the experiment for the next subject, and so on, creating an iterated chain of performance and revision.

Registering Transformation - Where/what was our "data"?

The argument implicit in EXPF's design is that the experiment - in the activity itself - becomes an instrument to capture the invisible experiential and interactive traffic

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[62] The full debrief script can be found in Appendix 4A.

that on the one hand makes experiments possible - unspoken agreements, roles, complicities, compliances - and on the other hand, might also threaten them (mis-interpretations, resistances, anxieties, errors). If EXPF's insight into experimental performativity is to be found in the transformations the experiment underwent, how to locate and account for those transformations?

What data did we collect, and how to understand it? In order to keep track of revisions, we maintained a digital folder for each iteration in the chain, containing sub-folders of materials for each revisable channel of the experiment (questionnaire, instructions, task, stimuli, space/layout, experimenters). Between participants, before beginning the process of revising the materials, we would duplicate the preceding participant's suite of folders. In each iteration's folder, we included a document outlining the specific changes that would be reflected in the next iteration (so that we would not have to search for the changes in order to find them). Even while having its structure and content transformed, the ePrime program which ran the 'experiment' portion of EXPF actually logged reaction times and the words that subjects entered in response to stimuli, so these more conventional forms of data exist as well, though their conventional usefulness was limited by the morphing task parameters[63]. We also videotaped debrief

[63] Because the task parameters and instructions changed, analyzing these reaction times or responses in a standard manner through aggregating is made difficult by the lack of controlled variables.

sessions and revision sessions[64]. Finally, we have our memories and experiences of carrying out our score, anchored by notes and aforementioned video. This unruly data set smooshes together material traces and memories, cross-contaminates disciplinary incommensurables, and renders quantifiables impotent while instrumentalizing subjectivity. If our data was made up of these materials for and traces of our experimental activity as a shambling whole, how to cut through all this stuff, to account for what happened?

In the following analysis, I offer two attempts at reading our undisciplined data set, acknowledging that any account is partial and that each arrangement makes different interpretations possible. The first presents and considers a holistic attempt at visualizing how the experiment transformed based on iterative revisions to the experimental materials. The second works from ethnographic description and video documentation of our process to describe how the changes were implemented by us, and in the process, how EXPF staged novel encounters with subjects, with one another, and with a dynamic experimental apparatus.

[64]We had planned to videotape each debrief and each revision session (though our camera arrangement and taping protocol was subject to revision). In many instances, we videotaped the debrief with the subject and some or all of the revision process. Exceptions included when a subject did not consent be videotaped, when the placement and use of the camera was revised by a subject, and when the battery ran out of power.

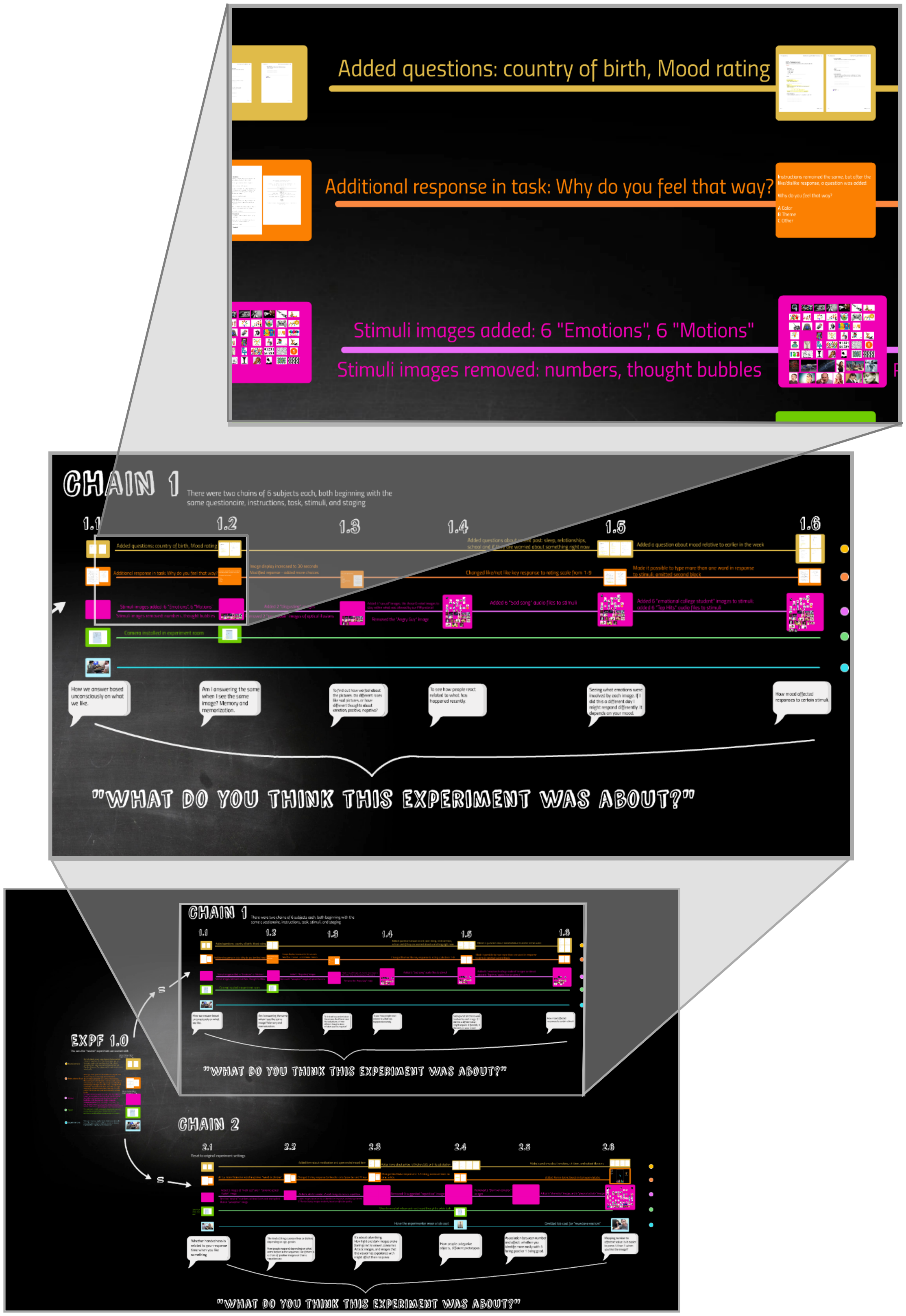

Figure 4.5 Visualization of EXPF, with magnified details

What happened? [I] Visualizing the shape of EXPF

One of the ways we sought to capture and understand the what happened in EXPF was by making a visualization that reflected the iterative design and showed the changing shape of the experimental design. I did this by collecting the logged changes to each channel of each chain using online prezi software, organizing them into an interactive timeline that displayed the changes made in each iteration. This visualization is pictured in figure 4.5[65]. It illustrates the transformation to the experimental materials across each horizontal "channel", embedding zoomable versions of the revised materials (questionnaire, stimuli, etc), for each (vertically grouped) iteration in the chain. In between each set of materials runs text descriptions of the revisions made between each iteration, and a distilled version of each participant's reported interpretation of the experiment appears in a speech bubble below the corresponding iteration.

This visualization represents how the experiment changed as subjects experienced and revised it. The visualization can ground some broad observations about how experimental performativity operated in EXPF, as well as make visible particular shifts from which to speculate about what kinds of changes lead to what kinds of interpretations and so on.

The first thing to note is that the two chains were quite different despite beginning with the same settings. The first chain "became about" emotion and mood halfway through, winding its way through imagined research questions (and corresponding feedback and revision) about unconscious preferences, memory, race and response to

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[65] An interactive, zoomable version of this visualization is available at this link: https://prezi.com/l1gg0gmectou

images, and the effect of participants' recent life events on their affective response to images. The second chain started with a interpretation that the experiment was testing the relationship between handedness and speed of response, circled around marketing and prototypes, and ended up with two back-to-back interpretations about the mapping of affective value onto number ratings.

In Chain 1, revisions were made to three channels: the questionnaire, the stimuli, and the experimental task. The questionnaire in chain 1 grew from 2 to 4 pages, incorporating items about country of birth and various questions about mood, including a mood rating, then questions about recent problems with sleep, relationships and school. The task had some parameters changed, for instance adding a third response to the task: following the like/dislike and typing a word in response to an image, came the oddly reflexive question "why do you feel that way?". This question had its reflexiveness quashed (or rather, scientized) by the multiple choice selection that accompanied it : "a) color, b) theme. c) other". Another change to the task was replacing the like/dislike response with a 1-9 rating. The stimulus set ballooned up, incorporating more items than were deleted, including adding images of "motions", "emotions", "disgusting" and "sexual" images, and even adding music into the stimuli, first "sad songs", then, presumably in response to the "sad songs" google found for us being too unpopular, a selection of happier "top hits". In order to describe the way the visualization represents the performance, I've given an overview of the revisions here, rather than listing every single change. Because figure 4.5 does not permit legible detail of the whole performance, I've included a set of tables with a more exhaustive list of the revisions to both chains in Appendix 4B.

Our visualization registers transformation by foregrounding the marks made on the materials proscribed by our revision "channels". What kinds of insights can be drawn from organizing and accounting for the performance in this way? By illustrating, through material traces, how our design unfolded iteratively, one effect of this visualization is to objectify experimental performativity. Based on the observation of two distinct chains, we could ask what would it look like if we carried out 10 or 100 chains? How many different interpretations of the original settings would that generate? Based on the observation that repetition of the interpretation emerged near the 3rd or 4th iteration in each chain, we could speculate about whether the emergence of interpretive coherence had a predictable shape, and if so, what would happen if the chains continued for 12, 24, 50 iterations? Based on observations of particular sequences of revision and interpretation, we could ask whether certain changes were more suggestive than others, even suggestive of a given interpretation, or whether a more powerful factor shaping interpretation came from the psychology or cognitive science courses the participant happened to be taking. These questions were primarily speculative and channelled the richness captured in the performance and organized by the visualization as a jumping off point to imagine how we might generalize beyond what our initial data could support.

Holding something one way makes certain features and interpretations more accessible, and holding it another way makes others available. A few moments crop up in otherwise unmodified channels in the visualization that suggest another way of understanding what happened: Participant 2.3 revised the experimenters so that Tyler and

I had to wear a lab coat[66], and Participant 2.4 changed the location of the camera to face the participant and change the priority for what was recorded. These changes serve as a reminder of other responsivities within EXPF which were largely obscured in the visualization, namely the activity of the experimenters in making EXPF work, and the capacity of the camera to record whatever happened in front of it.

What Happened? [II] Becoming instruments

In contrast to the visualization's simplification of the relationship between the participants' experience and the transformations to the experimental design, these transformations were never a direct imprint of participants' impressions and expectancies. To transform the experiment was work: Tyler and I were responsible for carrying out EXPF, including eliciting feedback, deciding how to respond, and implementing the revisions, usually within the hour or so between participants. This work was located in interactions: between the experimenters and subjects, between one another, between ourselves and the material and performative infrastructure of the experiment we were working on. Many of these interactions were recorded on video, others are recalled with the help of the visualization, or from field notes. The following account reports and reflects on the work of becoming responsive, using fieldnotes and a moment transcribed from the video as anchor points for what happened.

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[66] Counter to the image of the white-coat-wearing scientist reflected in the participant's suggestion, we did not have a lab coat on hand, and had to track it down in the limited time between participants. After making frenzied texts and requests via social media, Tyler found a colleague who had one. This mad dash is not registered in the visualization.

Deciding how to implement the subject's interpretations and suggestions was itself an act of interpretation and negotiation. Sometimes this was because the suggestions they made were ambiguous, and sometimes it was because they were impossible (time constraints, constraints of the program architecture, constraints of the IRB agreement under which we operated, and so on). Becoming responsive forced us to continually and improvisationally negotiate material and temporal constraints in the experimental design under revision. It also forced us to continually confront the boundaries of our own score, by balancing between what was logistically possible, what was true to participants' feedback, and what was going to allow our performance continue to "work".

Procedural inertia and making ripples

Over the course of EXPF, some subjects suggested revisions that required compromise to implement given our time and technical constraints, and our commitment to responding. In negotiating how to respond, we encountered how and where the experimental design was malleable, and how where it was more inflexible. For instance, subject 1.4 (Chain 1, 4th participant) suggested that we incorporate sad music videos into the stimuli set, but the e-run software could not play video files. In order respond to their suggestion within the constraints of what we could accomplish with the program in around 45 minutes, we compromised and use audio clips of "sad songs" rather than multimedia videos. At times, the workarounds we compromised on would introduce unsuggested changes, like when subject 2.5 suggested we add a “Tetris[67] break” between blocks of the experimental task. When we discovered the computer on which we were running the experiment couldn’t download new software, we decided to install the game on the computer in the adjacent testing room, which introduced a room change and additional experimenter-participant interactions that had not been part of the feedback. The work of becoming responsive to subjects’ experience revealed emergent hard and soft components of the experimental design: Sometimes, this process revealed a kind of stiffness or procedural inertia, while other times the process revealed unanticipated porousness between parts of the design, inviting unplanned ripples into the performance. While encounters with the affordances and constraints of infrastructures of experimental design are already part of the everyday work of devising and running experiments, EXPF reconfigured the conditions under which we had those encounters. The iterative aspect of EXPF meant that we encountered the design again and again in rapid succession, and the agential inversion of EXPF opened the horizon of possible changes beyond one constrained by the scientists’ viewpoint.

In addition to putting us into an unpredictable creative interaction with the material infrastructure of the experiment, EXPF also necessitated revising our own understanding of our score. In the following fieldnote excerpt, some of these contact points emerge. It begins by invoking our expectations and desires for EXPF in characterizing what “went well” about the first day of data collection, which included

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[67] A popular, classic block stacking computer game

running two subjects, and goes on to discuss a conundrum that emerged regarding limits on our role as performers and experimenters.

> Things that went well - the first sub was very willing to talk and give her interpretations. We made changes as best we could. The second subject was less talkative but still made suggestions and changes - a procedure for how to debrief amongst ourselves and make the revisions before the next person is becoming clear.
>
> Interesting:
>
> The interpretations of the subs are not necessarily coherent, nor are the changes that they suggest. For instance, the first subject suggested that we add a multiple choice question into the task, to ask why the person liked or disliked the image; but did not explicitly suggest that we change the instructions (probably because the instructions prompt came before the task prompt). Not sure if we should go back and prompt her to standardize this. The 2nd sub's experiment was missing an instruction about this - I tried to smooth it over, but T says not to editorialize and just to let it be confusing if that's what it is. He says "it's their responsibility". At the same time, we are the ones mediating how to implement the changes.
>
> (Klein, EXPF Fieldnotes 05/06/2015)

Amid early uncertainty about how EXPF would work, a key concern was whether the participants would give us enough feedback to make iterative transformation possible. Their willingness to talk was key for our aim - having collected that talk, we were then able to try out how we would respond that feedback in deciding what revisions to implement. It seemed, after the first day, that our debrief interview was working to elicit enough feedback, that is, enough feedback that we had changes to implement. The "procedure" that was becoming clear was that we would discuss how the subject debrief had gone, come to a consensus on what changes to make, summarize them in a word document, and then divide up the work of making the revisions.

EXPF "coherence" and actors' categories

In the second part of the fieldnote, Sarah goes on to describe a decision we faced about what to do if revisions introduce incoherence. The "coherence" she is concerned with is in the excerpt is not that she doesn't understand their interpretations, but that following the participants' suggestions as given could mean the revisions could introduce incoherence for subsequent participants. Our debrief procedure, despite its exhaustive questions, couldn't ensure that the participant's interpretation would be reflected evenly in their suggested revisions, or that their revisions would never contradict one another. In this note, Sarah is concerned about the incoherence that would occur for the following participant if we followed their suggestion to changes the responses available to the images as suggested, without making an accompanying revision to the instructions. We faced a dilemma when introducing the next participant to a revised component of the experiment - if it is too confusing they might not know how to proceed. The fieldnote reports that she attempted to smooth the explanation over when explaining the instructions to the next participant, but that when she mentioned this to Tyler, he responded that we should try "not to editorialize", that it was "their responsibility". Tyler invokes our role with respect to our score, to temper what was likely Sarah's impulse to manage/control the experience of the participants. Tyler asserts that the responsibility of maintaining the coherence of the experiment belongs to the participants, both as suggesters of revisions and as recipients of (potentially disjointed) iterated experimental materials. Allowing the participants to be "responsible" for the experiment's design, as Tyler suggested above, meant we should leave any emergent procedural contradictions to fester - if the experiment becomes incoherent as a result, so be it. This dilemma exemplified the tensions we faced in performing and thus encountering our own score. What was more important, adhering strictly to the score we had imagined for ourselves (by not filling in gaps in participants' feedback, not making any change that wasn't explicitly suggested), or responding in such a way that would enable EXPF to go on?

It turned out that neither making subjects "responsible", nor the complement of that goal, rendering the experiment responsive, were as straightforward as we had imagined for ourselves. Ultimately, the iterations to the experiment didn't render it so incoherent that it stalled or stopped, but neither were we able to maintain the detached role that Tyler suggests in the excerpt. In rendering the participants the agents responsible for the experiment's design, we also had to face their categories for experiencing the experiment, which did not neatly line up with ours.

In the process of implementing revisions, we found that the infrastructure of the software did not abide by the same distinctions between "task" and "instruction" channels that we had devised for ourselves and presented to participants. We had divided the "task" and "instructions" into two separate channels/folders, with two distinct corresponding questions in our debrief interview. We had imagined that revisions to the "instructions" channel would be about how the experimental task was explained, primarily through on-screen instructions, and also verbally by experimenters. Revisions to the task, on the other hand, would change the character and sequence of instruments that the E-Run program executed. However, in responding to suggestions, we encountered mundane interdependencies in the infrastructure of E-Run that muddied this distinction for participants.

E-run administered the on-screen instructions, the stimuli, and the instruments for capturing different kinds of responses, and the interdependence or independence of these different components was not transparent to the participants. For example, in order to revise a like/dislike key-press response into 1-5 rating scale, the new response keys would automatically be displayed in the on-screen instructions. For other parts of the experiment, the on-screen instructions were the only visible marker of that task for the participant. For example, when participant 2.1 suggested we revise the task to make it possible to type more than one word in the text box, the only way to communicate that revision to the next participant was to change the on-screen instructions regarding how many words they could type ("a word" became "word or phrase"). The part of the program that defined how many words or characters could be typed into a field was invisible to participants. It was not until we were faced with the concrete task of making specific revisions that we encountered the gap between how we had conceptualized the experiment's channels, the way they were integrated by the software program, and by extension, and how they were distinguished (or not) for participants. We had conceived of our role as one of mediation between the iterated materials of the experiment and the elicited feedback of participants, but becoming responsive put us into unexpected positions and encounters. In this example, the software infrastructure emerged as a mediating instrument between our idealized performance score and the emergent, local categories of the participants in their given iteration.

"Making the call"

These examples of becoming responsive in EXPF focused on relations between components internal to the experimental activity - between between a participant's interpretation and the constraints of the materials we were working with, or between our conceptualization of the "channels" of the experiment, and the categories that emerged for participants. In addition to those encounters, some suggestions and contingencies also forced us to contend with ethical and institutional boundaries of our experiment-performance. In the following fieldnote, I describe a decision to ignore a part of a participant's suggestion because of the risk of introducing certain "dangerous" images into our stimuli.

> The 2nd sub didn't like the optical illusion images, and since she thought we were investigating something to do with memory, she told us to remove them. She suggested we replace them with images of disgusting bugs - we actually decided not to use bug images but instead the images that came up in google when we search "disgusting" that don't include bugs, in case people have phobias of bugs. Making the call of what is ok/ isn't ok is an interesting limit.
>
> (Klein, EXPF Fieldnotes 05/06/2015)

We decided against using images of "disgusting bugs" because we did not want to introduce potentially upsetting or traumatizing images into the stimulus set. We had made a similar decision in the first chain when a subject suggested we add "more sexual images" - our compromise was to omit any graphic sexual images from our image search, and select only G-rated images. Images of "disgusting bugs" or "sexual images" risked falling outside the bounds of what our ethics approval allowed. These decisions differed from the compromises described in the previous section, because the constraint was not technical or originating from our vision of how our score would work. These suggestions, which were technically simple to implement, forced us to bump up institutionally imposed ethical constraints about what should and shouldn't happen in a cognition experiment, or more accurately, what can happen in a cognition experiment without submitting a new application to our institution's IRB. What materialized in response to these suggestions was our own cautious and conservative interpretation of our institution's definition of potential harm, or "making the call of what is ok/isn't ok." In other words, our performance's transformation was also shaped by institutional limits, insofar as our decisions reproduced them. EXPF could not, in fact, become just anything. The sudden appearance of the institution's vision of experiment in our response to any slight suggestion of "riskiness" illuminates the broader institutional context in which research regularly operates, with its own set and scale of norms and rules. As anyone who has had to revise their research protocol knows, procedural inertia functions from the institutional scale too, making particular research configurations and interventions more and less possible.

At the same time as we were carrying out a performance aiming to open experiment to iterative transformation, we wound up enforcing our institution's vision of what constituted a low-risk experiment. Our ability to suddenly switch gears from responsive implementers to institutional enforcers is somehow poignant, revealing how rooted our own responses were in the broader system we were working to breach. Response-ability is itself an ethical framework for doing science, though not one based on universal rules for preventing harm to both the individual and to the institution. Response-ability instead is premised on becoming-together, and the flexibility and sensitivity that entails. In the cases where responding faithfully to a subject's suggestion would have put the experiment outside the bounds of what we felt was ethically-institutionally “ok”, we were suspended between a local response-ability on the one hand, and an institutional responsibility on the other.

Reflection

EXPF breached the performative structure of experiment by rearranging its agential configuration, in order to register and amplify its invisible constitutive traffic, or as Piper and Garfinkel might have termed it, its indexicality. Our intervention was not episodic, like Garfinkel’s breaching and Piper’s Catalysis, but iterative. This allowed us to create iterative chains of “heres-and-nows” that were mutually and sequentially implicated. In this chapter, I have tried to account for what happened in these iterative in two different ways, two modes of accounting for the performance. Each account provides a way to slice through the textured, dimensional indexicality that EXPF made available. Looking at it as a kind of material-semiotic sculpture, as our visualization attempts to convey, presents a clean, ideal version of EXPF as we imagined it: a catalog of iterated impressions and transformations to the performative structure of the experiment, leaving its marks on the shape of the activity and its accompanying material remains. What the visualization masks, however, is the complex work of becoming responsive, which was the locus of our direct engagement with relations and infrastructures that enable and constrain experimental performances. In the role of responsive implementers, we occupied a new relationship to the experimental apparatus, one that mediated between subjects and researchers. This forced us to repeatedly and improvisationally wrestle with the experiment’s material, conceptual, and institutional constraints as well as our own expectations as researchers working in different ways with experiment. In staging EXPF as an encounter between responsive experiment and response-able subject, we became instruments of response. Each decision, each struggle, and each compromise, was a different "here-and-now" of experimental performativity, rendering sensible unexpected affordances, obstacles, and interdependencies in what might otherwise be opaque and unquestioned procedure.

As an experiment in becoming responsive to research subjects, EXPF was also an experiment in enacting responsive relationships between ethnographers and the scientists we study. Collaborating with a cognitive scientist meant entwining divergent motivations, concerns, and particular disciplinary subjects, and objects. Experiment, as a structured activity that is already built to be taken apart and reassembled, lent itself well as a medium, object, and frame for our collaboration.

Ultimately I am not suggesting that performance-collaboration should displace classical experimental or ethnographic methods. Rather, that by adding it to our toolbox, this kind of approach has the potential to shape and sharpen the other methods we would be using alongside it. Collaborative performance-making can help cultivate radical reflexivity in research practice. This approach can help move beyond the paralysis that often accompanies reflexivity when it's treated as a purely cognitive norm or textual strategy. In taking performativity seriously by making performances together, we can develop research designs that take account and advantage of the ways that we are already acting together.

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Conclusion

Implications, Limitations, and Iterations

I have argued throughout this dissertation that cognition experiments are enfolded performances of intersubjective agency between subjects, researchers, and technologies. By looking closely at different facets of experimental practice, I've been able to describe how folding operates in the making of the central research object, the Event-related-potential. I've shown how a temporal brain signature holds together brain and world, event and processing of the event, to enact a space for inferences about mind. I've described disciplinary practices and embodied performances needed to produce cognitive objects, where body and mind are sites for and and obstacles of one another. I've described how scientists relate to one another's experimental designs through a social practice of reading, enacting experiments as architectures for inhabiting and manipulating. And finally, I've intervened in the performative structure of experiment itself, breaching its ordinary agential configuration to reveal its tacit and embedded indexical infrastructures. The empirical arc of the work has been to move in a fine-grained way from the smaller scale of performance (neural activity), through the scale of the data-productive body, to the larger scale of performing experimental design (though admittedly my scale has not exceeded laboratory walls). The methodological arc has been to move from upholding a premise of empirical distance, to including myself within a system of practice, to actively intervening in the system.

This work has implications for material-semiotic STS, as a case study supporting the local specification of generalized theories of performative entanglement. It complicates accounts of scientific psychology and the "neuro"- as opposed to, or evacuated of subjectivity, showing instead that complex layered maneuvering inside of research practices are more productive than reductive. And it supplements some canonical STS accounts of inscription by showing how the literary technology of the journal article can operate not only representationally and at a distance, but also in proximate, situated, and praxiological encounters. Finally, this dissertation explores novel methodological configurations for being together with scientists.

One limitation of this research is that it is very specific to a time and place and type of scientific practice. While other configurations and materializations of cognition may be locally relevant for other sites of cognitive neuroscientific research, embedded in different methods, technologies, or paradigms. For example, Some EEG experts are developing software and hardware that makes more naturalistic movement possible during experiments, with the assumption that that will enable previously/presently inaccessible research questions and more ecologically valid findings. While I obviously endorse the project of locally specifying how scientific entanglement operates in different research practices, I expect that certain features of the performances of cognition I described here to be widespread. For instance, even though there are many challenges I describe which are specific to the organization of the EEG and ERP apparatus, other forms of brain imaging do seem to have analogous problems with body artifacts and movement, even though their material setups differ (Alac 2011, 69).

My past experience with cognitive psychology experiments leads me to conclude that a the empirical approach to objectifying/materializing cognition that I've described here is widespread, but that not all forms of cognitive neuroscientific data are as semiotically complex as the Event-Related Potential. Reaction time and accuracy, key behavioral measures for systems like perception, memory and attention, do not seem to require as much flexible interpretive work as the work of reading/writing with brains, or even of forms of neuroimaging that are more reliant on spatialization of functional maps.

One topic that I have not been able to explore in this dissertation are the views that other cognitive neuroscientists and cognitive psychologists hold of ERP research, which in my unsystematic assessment falls somewhere between skeptical and lukewarm. The general impression I have gotten from talking with cognitive neuroscientists and psychologists who work primarily in areas other than ERP research is that ERPs are not seen as the most robust scientific objects. Even though many ERP components are very easily reproducible, the fact that there are still multiple theoretical models that can compete to explain a given component means that they are seen as epistemically unstable. Ironically, this is has probably helped to make ERPs an interesting object for my analysis - the work of stabilizing ERPs is ongoing, requires narrative context, and is thus very available to observation.

Another potential problem/limitation could be that some of the communicative and interactional patterns I have described here, such as anthropomorphic or identificatory folding, or creating conceptual space through gesture, are simply features of communication and not specific to research practices on cognition. It may be the case that identification with or "lived-into" objects, processes, or experimental designs is just a specific instance of an ordinary communication strategy for humans in general. Still, what remains particularly striking about these accounts is their uncanny resemblance to the subjective experiences that are simultaneous with "cognition" but which are insufficiently objective to be claimed as as target material or as method. The account of folded cognitive objects I elaborate here could be deepened or complicated by joining conversations with researchers examining how cognition is enacted when interactions between researchers and research subjects operate through different communicative pathways than those shared by researchers with able-bodied, healthy, english-speaking adult undergraduates. Cognition research on babies, birds, and people who communicate in non-normative ways would have to arrange different resources to make inferences about cognition possible.

There are several threads in this dissertation that do not take center stage, but which I am elaborating separately. I am in the process of developing future a project about cognitive science's local material-semiotics, and an ethnographic-collaborative study of reproducibility. The first emerged from my literature review on ERPs, where I encountered studies that used non-meaningful or "pseudo-objects" as experimental controls for studying the brain's response to meaningful stimuli. These would be made up words, distorted objects, fictitious orthographies , and entities with face-like shapes. These stimuli which are designed to be recognizable as part of a category but are "empty" of meaning by design. These objects seem to embed a lay-semiotics within the scientific study of the brain's responses to meaning. I am developing a project to learn about the processes by which "pseudo-meaningful" stimuli are designed.

I have also developed a research proposal for a collaborative ethnography of reproducibility problems. As I briefly touched on in the dissertation, responses to the replication crisis have mainly focused on accountability infrastructures and open science. While members of the research community do admit more local or situated explanations for failures to replicate, such as the context-dependence of psychological phenomena, and conceptual gaps between theory effects sought, these situated explanations have not been studied in any systematic way. This project builds on the methodological interventions in this dissertation by proposing to deploy ethnographic methods and collaborative performance making with cognitive scientists, working with them to study and intervene in their own research practices. By extending the work of ethnographic data collection and analysis to the scientists, I envision that we would work from collaborative analysis of research practice to identify possible opportunities for performative intervention (problems, sources of noise, conceptual contradictions, etc.).Then, ethnographer and scientists would design experimental structures that probe, deepen, or attempt to resolve these issues. This project would entwine reflexively generated empirical observation, like the practical contradictions around real and imagined phenomena described in Chapter 3 with the methodological orientation developed in Chapter 4 (collaborative performance design). Despite completing my fieldwork around 2 years before writing this conclusion, the practices of the BLL have continued to inspire me to get experimental.

Appendices

Appendix to Chapter 2

Key of Transcription Symbols Used

Unless indicated, these transcription conventions used in this chapter are from "Glossary of Transcript Symbols", Gail Jefferson (2004)

*Any of my additions are indicated by a **

Symbol	Indicates
[	Left square bracket indicates onset of utterance overlap
]	Right square bracket indicates end of utterance overlap
= =	equals sign indicates no gap; a pair of equal signs at the end of a line and the beginning of a line indicates no gap/break between the lines ** I use red equal signs to indicate no gap between two speakers when there other utterances that appear temporally and spatially in between the two lines with no gap. For instance, the following is a transcript of a conversation between A, B, and C about something suprising they just saw A: Did you [see] that?= B: [whoa ha ha] C: =Oh my gosh
(0.2)	Numbers in parentheses indicates time elapsed in tenths of seconds
(•)	dot in parentheses indicates a very brief gap between utterances (±0.1 s)
How about it	Underscoring indicates stress. Short underscore is lighter stress than longer underscore
:::	Colons indicate the lengthening of the sound immediately prior

Symbol	Indicates
_:	Combination of underscore and colons indicate intonation contour. The underscore “punches up” the letter or sound it underscores. _: indicates up to down contour: Hi: : indicates sound at point of colon is “punched up” :_ indicates down to up contour: Wh:at
↑ ↓	Arrows indicate especially high or low pitch
.,?	Punctuation marks indicate the ‘usual’ intonation
WORD	Upper case indicates especially loud in relation to surrounding talk
°word° °°word°°	degree symbols bracketing a sound indicate especially quiet in relation to surrounding talk. ** Double degree signs indicate super quiet.
-	dash indicates a cut-off utterance.
> < < >	indicates pace: right/left carats bracketing an utterance indicate it is speeded up relative to surrounding talk. left/right carats bracketing an utterance indicate is slower than surrounding talk.
•hhh	dot prefixed row of ‘h’s indicates a breath. With no dot, indicates an outbreath.
wor*hh*d	Italicized ‘h’s in a word indicates breathiness
wor*hh*d	Italicized ‘h’s in a word indicates breathiness
( )	Empty parentheses indicate transcriber was unable to get what was said.
((description))	double parentheses contains transcriber’s descriptions.

Appendix to Chapter 3

Unless indicated, the transcription conventions used in this chapter are from "Glossary of Transcript Symbols", Gail Jefferson (2004) and Hindmarsh and Heath (2000)

*Any of my additions/adaptations are indicated by a **

Symbol	Indicates
[	Left square bracket indicates onset of utterance overlap
]	Right square bracket indicates end of utterance overlap
=	equals sign indicates no gap; a pair of equal signs at the end of a line and the beginning of the next line indicates no gap/break between the lines
(0.2)	Numbers in parentheses indicates pause, approximate time elapsed in tenths of seconds
(•)	dot in parentheses indicates a very brief gap between utterances ($\underline{+}$0.1 s)
How about it	Underscoring indicates stress. Short underscore is lighter stress than longer underscore
. , ? !	Punctuation marks indicate the 'usual' intonation
SOUND	** Capitalized words **in this transcript** indicate a non-verbal sound (ie, percussives - BAM, TAP)
°word° °°word°°	degree symbols bracketing a sound indicate especially quiet in relation to surrounding talk. ** Double degree signs indicate super quiet. ** I also apply degree sounds to mark relatively quieter sounds, eg,°TAP°, and unusually small gestures, eg, °°*nod*°°.
-	dash indicates a cut-off utterance.

Symbol	Indicates
> < < >	indicates pace: right/left carats bracketing an utterance indicate it is speeded up relative to surrounding talk. left/right carats bracketing an utterance indicate is slower than surrounding talk.
((description))	double parentheses contains transcriber's descriptions.
description	** Italics indicate description of gestures
P ________down_____	Line underscore indicates timing of gaze direction, letters or words indicate object of gaze. In this example, the person starts out looking at "P" and then shifts their gaze down (Hindmarsh and Heath 2000)

Appendices to Chapter 4

Appendix 4A

EXPF Chain 1 Transformations

Chain 1 Questionnaire	Revision
1.1-1.2	Added items asking about place of birth and a mood rating
1.2-1.3	
1.3-1.4	
1.4-1.5	Added questions about recent life including recent mood, relationships, and school issues, and whether they were worried about something right now
1.5-1.6	Added a question about mood now relative to earlier in the week

Chain 1 Stimuli	Revision
1.1-1.2	added 6 images of “motions” and 6 images “emotions” images with numbers and thought bubbles removed.
1.2-1.3	2 “disgusting” images were added, 2 optical illusion images were removed.
1.3-1.4	6 “sexual” images were added while an image of a man yelling angrily was removed.
1.4-1.5	6 “sad song” music files were added.
1.5-1.6	6 “emotional college student” images and 6 recent “top hit song” music files were added.

Chain 1 Task	Revision
1.1-1.2	+ additional response in task, “Why do you feel that way” with multiple choices: a) color, b) theme, c) other
1.2-1.3	increasing time the image stimulus is displayed, adding into multiple choice response: a) color, b) theme, c) shape, d) personal memory, e) other
1.3-1.4	

Chain 1 Task	Revision
1.4-1.5	Changed binary like/dislike response to 1-9 rating scale
1.5-1.6	Shortened experiment by omitting second block, allowing typed responses to be longer than one word

Chain 1 space	Revision
1.1-1.2	Installed camera in experiment room [this was not a result of feedback but because our video consent form was not available until participant 1.2

Chain 1 Experimenters	No Revisions

EXPF Chain 1 Interpretations

Chain 1 Iterations	Interpretation: "What do you think the experiment was about?"
1.1 (original set)	How we answer based unconsciously on what we like.
1.2	Am I answering the same when I see the same image? Memory and memorization.
1.3	To find out how people feel about different pictures. Do different races like sad pictures, or have different thoughts about emotion, positive or negative?
1.4	To see how people reacted to what has happened recently
1.5	Seeing what emotions were involved by each image. If I did this a different day I might respond differently. It depends on your mood.
1.6	How mood affected responses to certain stimuli.

EXPF Chain 2 Transformations

Chain 2 Questionnaire	Revision
2.1-2.2	
2.2-2.3	Added items about medication and open-ended mood question
2.3-2.4	Added items about political affiliation, socioeconomic status, and life satisfaction
2.4-2.5	
2.5-2.6	Added questions about smoking, children, and optical illusions [these were stimuli]

Chain 2 Stimuli	Revision
2.1-2.2	Added 3 “math test” images and 1 “dynamic optical illusion” image. Removed “number” images without faces and one optical illusion image
2.2-2.3	Added a “twin” similar but not identical image for each existing image to reduce repetition. Programmed E-Run to display images randomly by affect instead of by image; coded for affect using S2.2 like/dislike responses.
2.3-2.4	Removed 9 suggested “repetitive images”
2.4-2.5	Removed 3 “blurry or complex” images
2.5-2.6	Added 6 “chemistry” images and 6 “physical activity” images.

Chain 2 Task	Revision
2.1-2.2	Allow more than one word typed response: "word or phrase”
2.2-2.3	Changed key response for like/dislike from “P” and “Q” keys to Space bar and “V” key
2.3-2.4	Changed like/dislike response to 1-5 rating, increased decision time to 50s
2.4-2.5	

Chain 2 Task	Revision
2.5-2.6	Added 5 min tetris break between blocks

Chain 2 Experimenters	Revision
2.3-2.4	Experimenter wears a lab coat.
2.4-2.5	
2.5-2.6	Omitted lab coat for more "mundane realism"

Chain 2 Space	Revision
2.4-2.5	Moved camera to behind the computer monitor and recorded the whole task.

EXPF Chain 2 Interpretations

Chain 2 Iterations	Interpretation: "What do you think the experiment was about?"
2.1 (original set)	Whether handedness is related to your response time when you like something.
2.2	The kind of thing a person likes or dislikes based on age, gender/How people respond depending on what came before in a sequence, like if there's a chain of positive images then a negative one
2.3	It's about advertising. How light and dark images invoke feelings in the viewer, consumer. Artistic images, and images that the viewer has experience with might affect their response
2.4	How people categorize different objects, different prototypes
2.5	Association between number and affect; whether you identify more easily with 5 being good or 1 being good.
2.6	Mapping number to affective value: Is it easier to press 5 than 1 when you like the image?

Appendix 4B

EXPF Debrief 1 - Thank you for Participating in our Pilot Experiment

1. What do you think was the purpose of this experiment? In other words, what question was it asking?
2. Do you think your behavior helped answer this question (Y/N)
3. How do you think you behaved, relative to the question you think the experiment was designed to answer?

General Feedback

4. Let's assume that the experiment is, in fact, designed to answer the question you suggested. We would like your advice on how we can improve our experiment, in order to increase our chance of success. Do you have any general advice on how we could do that? You can talk about any aspect of the experiment

Specific Feedback

5. *Demographic Questionnaire.* Assuming that the experiment was in fact designed to investigate the question you suggested, how could we improve the demographic questionnaire? Are there any questions we should add? Are there questions we should remove? Are there questions we should change?
6. *Instructions.* Assuming that the experiment was in fact designed to investigate the question you suggested, how could we improve the experimental task? What are some things we could improve? Should we change, omit, or add anything to the experimental task? You can talk about any part of the task.
7. *Stimuli.* Assuming that the experiment was in fact designed to investigate the question you suggested, how could we improve the stimuli? Are there certain images we should remove? Can you think of images that we should include?
8. *Layout.* Assuming that the experiment was in fact designed to investigate the question you suggested, how could we improve the layout of the space?
9. *Experimenters.* Assuming that the experiment was in fact designed to investigate the question you suggested, how could the experimenters be improved? Are there any things that they should change about their behavior, appearance, or affect? You can address any feature of the experimenters.

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