Forms of Positioning in Interdisciplinary Science Practice and their Epistemic Effects

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Abstract

We illustrate the usefulness of positioning theory for analyzing identity formations and their relation to problem solving and innovation in research science contexts. We analyze discursive strategies in terms of rights and duties enabling forms of sense-making in two biomedical engineering laboratories engaged in cutting-edge research in a major university setting. We organize selected examples into three categories to emphasize qualitatively different ways positioning can be seen to function in laboratory practice in an interdisciplinary context. Interview text examples coded as involving positioning display the highly integrated nature of social, cognitive, and affective aspects of the "speech acts" of researchers recorded as interview material.

This paper explores possibilities for using recent formulations of social positioning theory to analyze identity formations and their relation to problem solving and innovation in two interdisciplinary research science contexts. Our intent is to complement but expand upon efforts to apply positioning theory to science practice, of which the major directions are two: First, positioning has been invoked to account for rhetorical strategies in scientific writing and other forms of representation used in the formal justification of discovery practices. Notably, Latour (1987) addresses positioning tactics as forms of rhetoric for presenting research results - tactics including the use of numbers, pictures, graphs, other research, names, and other supportive devices, layered in such a ways as to minimize gaps in an argument, especially in relation to a scientific controversy. Latour calls positioning the process by which numbers are "arrayed and drilled" in a text for the purpose of convincing readers of the merits of an interpretation (1987, p. 50). Similary, van Langenhove & Harré (1999) analyze positioning strategies in relation to scientific writing and publication. Secondly, feminist critiques of science similarly engage the notion of subject positions to analyze power relations implicit in scientific discourse (Wilkinson & Kitzinger, 2003). However, we consider positioning theory to remain underutilized in relation to science, and believe it to hold great potential as an aid to interpreting the practices of scientific knowledge construction that precede and follow formal representational practices (e.g. writing, graphing), in ways that include but are not limited to gendered relations. We are especially interested in exploring the potential of positioning theory with respect to interpreting practices in interdisciplinary contexts.

Positioning Theory: Overview

Positioning is "the discursive process whereby people are located in conversations as observably and subjectively coherent participants in jointly produced storylines" (Davies and Harré, 1999, p. 37). Positioning analysis seeks to describe changes in relational configurations effected by various discursive strategies; that is, it concerns the social effects of speech. Positioning represents the action though which these effects are accomplished and a position can be understood as an effect. One identifies oneself and others through the positioning effects of speech. That positioning theory is likewise concerned with what has been traditionally labeled "cognitive" and "epistemic" is similarly emphasized in recent work: "Positioning theory is a contribution to the cognitive psychology of social action. It is concerned with revealing the explicit and implicit patterns of reasoning that are realized in the ways that people act toward others (Harré, Moghaddam, Cairnie, Rothbart, & Sabat, 2009, p. 5).

Precursors of positioning theory are as varied as psychoanalytic object relations theory (Fairbairn, 1954) and Vygotsky's theory of cognitive development (1978), with the sociological analysis of Erving Goffman (1981) the most important and direct line of influence. Even Adler's discussion of birth order and its effects on family dynamics and personality formation is an analysis of positioning within the family, although Adler's conception of position is more static than is the concept in more contemporary formulations of positioning (Adler, 1927/1992). With the exception of Adler, a point of cohesion between these varied approaches is an emphasis on forms of language (discourses) as the medium of identity production. Positioning theory relates most directly to the broad tradition of discursive psychology that has emerged as a "second

psychology" in the latter part of the twentieth century and beyond, dominated by concern

with and analysis of "actual episodes of social interaction as unfolding sequential

structures of meaning" (Harré and Moghaddam, 2003, p. 3). Positions are "patterns of

belief" or meaning structures as distributed among "members of a relatively coherent

speech community" (Harré & Moghaddam, 2003, p. 4). The focus of analysis is the set

of tacit though discernable rules (constraints), affordances, and negotiations

(transactions) that shape, confine, or enable human practices within the context analyzed.

Yet positions are always dynamically shifting and re-negotiated, both in their first order

(tacit) and second order (intentional or conscious) forms. Positioning, then, "can be seen

as a dynamic alternative to the static conception of role" (p.14).

Two features of positions clarify the nature of their social effects. First, positions

serve to establish the possibilities of action (i.e. analysis focuses on what actions are

"socially possible for any social actor at any moment in the flux of social life") (Harré

and Moghaddam, 2003, p. 4-5). A second, related point is that a position "can be looked

at as a loose set of *rights and duties* that limit the possibilities of action" (p. 5)… it "may

also include prohibitions or denials of access to some of the local repertoire of

meaningful acts" (p. 6). A point of emphasis in positioning theory is therefore the

"subtly varying presuppositions as to right of access to the local repertoire of acceptable

conduct" as well as "presuppositions as to the distribution of duties to perform the

necessary action" associated with various positions (Harré & Moghaddam, 2003, p. 4).

Hence different positions are understood to *make possible* different forms of practice and

require some forms of practice: positions serve to establish the possibilities for action,

broadly defined.

Positioning in Interdisciplinary Research Science Cultures

We provide evidence for the relevance of positioning theory to laboratory practice with interview data from our five year ethnographic investigation of two research laboratories in the interdisciplinary field of biomedical engineering. These laboratories are populated by "engineering scientists:" a breed of researcher who aims to make fundamental contributions to basic science as well as to create novel artifacts and technologies. The labs are cutting-edge research environments located at a Research I institution.

Lab A is a tissue engineering laboratory. During our study, the main members included a director, one laboratory manager, one postdoctoral researcher, seven PhD graduate students (three graduated while we were there, the other four, after we concluded formal collection), two MS graduate students, four long-term undergraduates (two semesters or more). Additional undergraduates and international graduate students and postdoctoral fellows visited for short periods. The laboratory director was a senior, highly renowned pioneer in the field of biomedical engineering. All of the researchers came from engineering backgrounds, mainly mechanical or chemical engineering and some were currently students in a biomedical engineering program. Some had spent time in industry prior to joining the lab. The tissue engineering laboratory, as an institution, had been in existence nearly twenty years when we entered.

Lab A's overarching research problems are to understand mechanical dimensions of cell biology, such as gene expression in endothelial cells, and to engineer living substitute blood vessels for implantation in the human cardiovascular system. The dual objectives of this lab explicate further the notion of an engineering scientist as having

both traditional engineering and scientific research goals. Examples of intermediate problems that contributed to the daily work during our investigation included: designing and building living tissue – "constructs" – that mimic properties of natural vessels; creating endothelial cells (highly immune-sensitive) from adult stem cells and progenitor cells; designing and building environments for mechanically conditioning constructs; and designing means for testing their mechanical strength.

Lab D is a neural engineering laboratory. During our study the main members included a director, one laboratory manager, one postdoctoral researcher, four PhD graduate students in residence (one left after two years, three graduated after we concluded formal collection), one PhD student at another institution who periodically visited and was available via video link, one MS student, six long-term undergraduates, and one volunteer, not pursing a degree (with a BS), who helped out with breeding mice. When we began our study, the laboratory director was a new tenure-track assistant professor, fresh from a seven-year postdoctoral fellowship in a biophysics laboratory that develops techniques and technologies for studying cultures of neurons. He already had achieved some recognition as a pioneer. His background was in chemistry and biochemistry, with his engineering experience largely self-taught, though highly sophisticated. The backgrounds of the researchers in Lab D were more diverse than Lab A and included mechanical engineering, electrical engineering, physics, life sciences, chemistry, microbiology, and some were currently students in a biomedical engineering program. As an institution, the neural engineering laboratory was in existence for a few months and still very much in the process of forming when we entered.

Lab D's overarching research problems are to understand the mechanisms through which organisms learn and, potentially, to use this knowledge to develop aids for neurological deficits and to improve human cognitive capacities. Examples of intermediate problems that contributed to the daily work included: developing ways to culture, stimulate, control, record, and image neuron arrays; designing and constructing feedback environments (robotic and simulated) in which the "dish" of cultured neurons could learn; and using electro-physiology and optical imaging to study "plasticity." Here, again, the researchers have dual scientific and engineering agendas.

Collectively, our research group conducted over 800 hours of in situ field observations and 148 unstructured interviews. We collected various other data, which we do not detail because our focus here is on the interview data. Broadly consistent with the aims of grounded theory, we have been approaching interpretive coding analytically and inductively (Glaser & Strauss, 1967, Strauss & Corbin, 1998) enabling core categories (and eventually "theory") to emerge from the data and remain grounded in it, while being guided by our initial research questions. A team of two doctoral level psychologists originally coded a subset of the interviews and presented emerging categories to a larger interdisciplinary ethnographic team for feedback. Codes were then refined through application to additional interview data. Through this process we noted several variations of what we found useful to categorize as positioning activity.

Our view of the research laboratory is that it constitutes a discursive (speech) community in its own right. Its rules and conventions of conduct, along with some of its terms and concepts are locally established through interaction particular to that community. Yet each laboratory community is embedded within wider discursive

communities, including the field of biomedical engineering of which it is a part, and the tradition that sustains the field itself and the discourse of innovation and science practice writ large. The idea of the laboratory as a discursive community is enhanced by considering its operations as a *story line*. As Harré and Moghaddam define it, a story line is a "working hypothesis about the principles or conventions that are being followed in the unfolding of the episode that is being studied. Such a story line might be 'David and Goliath' or 'Doctor and patient.' These titles sum up what is to be expected in the episode being studied and comprise the conventions under which to make sense of the events that have been recorded and to express them in a narrative…Each story line incorporates positions that relate the participants in a definite way "(Harré and Moghaddam, 2003, p. 9). The idea that laboratories are discursive communities with identifiable story lines relates more fundamentally to the idea of the laboratory as a constitutive social order (Garfinkel and Rawls, 2002).

The overarching story line of each laboratory - its ostensive purpose and research specialty along with the conventions that structure engineering science research more generally – is interwoven with a series of smaller story lines representing the particular projects and interactions of the researchers therein. To some extent these stories are 'written' by the conventions of academic rank and role: principle investigator, post-doc, undergraduate student. However, we have noted that the laboratories under our investigation are marked by an unusual distribution of expertise that cuts across roles. Because biomedical engineering is an interdisciplinary field there are distinct differences in the academic preparation and skill repertoire with which researchers begin as laboratory participants. Moreover, the "frontier" nature of research in each of the

laboratories we study results in an atmosphere in which all researchers occasionally feel that they are operating without a clear sense of direction. The interdisciplinary culture and the cutting edge, exploratory problem solving combine to set up an intricate set of story lines that continuously position participants in complex and shifting ways. Even though the objective of the educational program most of the researchers are participating in is to create individuals who are hybrid "bio-medical-engineers," we have noticed that researchers position themselves within this complexity in a variety of ways, with discursive strategies that anchor their work and identities more strongly in the normative frameworks of one of either engineering or biology and in science practice more generally. Statements made in interviews reveal these positions, the social and, as we shall argue, epistemic effects of which can be analyzed and compared. The interview itself is an additional storyline that interface with the story lines researchers are relating in the interview. Following Joseph Rouse (1996) we regard the interview as a conversation that is itself part of the process of science. Indeed, the necessity of painstakingly explaining ones work to interviewers from outside their field has been described by some of our participants as contributing to new ways of framing and making sense of what they are doing for themselves. The PIs of both labs noted that our interactions had made their researchers more reflective.

We will illustrate the usefulness of positioning theory by examining examples of discursive strategies enacted in the interviews. We analyze them in terms of rights and duties, cognitive and social, constraining and enabling forms of sense-making. We also explore relations between positioning and indications of emotional or affective experience. We organize selected examples into three categories to emphasize the

qualitatively different ways positioning can be seen to function in laboratory practice. We begin with examples in which researchers make explicit reference to professional or disciplinary affiliation, and we discuss their implications in terms of positioning theory by considering the rights and duties associated with the linguistic strategies in evidence. Secondly, we examine more subtle examples of positioning that relate closely to cognitive activities and knowledge construction, these having to do with ways in which ideas or methods are justified, extended, or modified in relation to the work of other researchers or scholars. Thirdly, we extend the analysis of positioning to the realm of researchers' relationships with the artifacts and objects central to their practice, in this case living cells. This broad division into three categories of positioning is intended to distinguish three forms, levels, or dimensions of identity formation in science practice. Interview text examples coded as involving positioning display the highly integrated nature of social, cognitive, and affective aspects of the researchers' discursive strategies recorded as interview material.

Although our emphasis is on illustrating the various ways in which researcher's accounts of their practices demonstrate positioning, we might note that we found positioning to be strongly represented in the interviews analyzed to date. To date we have coded 18 percent of transcripts and there are 57 instances of positioning codes. Also, there are 51 instances of identity, a code that overlaps conceptually with positioning but which was used in an earlier phase of analysis.

I. *Positioning in relation to professional and academic identity*

We first examine a class of passages that express explicit identification with a disciplinary tradition or with some configuration of disciplinary traditions. Generally

these entail alignments with either biology or engineering, but in some instances we see researchers aligning with the ways in which biology and engineering are combined in biomedical engineering or in bioengineering (these are distinguished).   That is, researchers in both laboratories position themselves during the interview as either engineers or biologists or as living blends of the specialties.   In the context of the interviews these positioning tactics serve to define a set of procedural and conceptual rights and duties in accordance with the disciplinary identification or the combination of identifications.

In an interdisciplinary culture, negotiations must be made as researchers enter the laboratory and find the place that best fits their own disciplinary background and skill set as they transition to an interdisciplinary researcher.   At a most basic level we would expect to find some division of labor in line with these differences in expertise.   As an example, here A11 characterizes the differences between biology and engineering as entailing a division in both focus and task in Lab A:

I. Now would you say this lab is primarily a biology driven lab? Where does biology fit in?

A11   *Fit in? It's in the sense that we are interested in pathways but just not chemical pathways...And it's definitely biologically oriented in the sense that we're doing a lot of cell work, a lot of animal work. But I would say it's ... I guess on my end it's not as biologically oriented. I guess you could say it's split because we have **some people that do mechanical testing of pumps** or just looking at micro C-T or figuring out better ways to use micro C-T. That's about half of our lab. The **other***

half does lots of cell culture. So I consider myself in the middle of these

two.

Of interest here is not only A11's perception of a labor division between those who "do

mechanical testing" and "figuring out better ways to use micro C-T" (engineers) and

those who spend time engaged in culturing cells (biologists), but A11's own

(unprompted) positioning of himself as "between" these.   That is, the interviewer's

question concerned the role of biology in the lab and A11's answer includes a statement

about identity: his own place in relation to the disciplinary partition he construes.

For other researchers distinctions between engineering and biology are expressed

less clearly in terms of focus (on mechanical tester or cells) or task (testing or culturing).

Rather, what seems to differentiate biology and engineering are differences in norms and

scientific *values*. These values implicate methods of problem solving and thus concern

specific procedures, but the researcher's emphasis is on the approach to science

characteristic of engineering or biology. By aligning with one side or another, these

differences become matters of identity.

For example, A10 characterizes engineering in terms of a high degree of

experimental control, in part through having well-defined variables:

I So is there a force in vivo that you're trying to simulate with this?

A10 *Right. So the blood vessel is a complex biaxial strain... **But, it's***

important as an engineer to really define your variables or your

***parameters**, or whatever …If I just stretched the cells…I would be able to*

say, you know, my cells did x, in my device, but you know, I don't want to

make it device dependent. You know, I want to say [to address/inform] the

strain pattern.

I So you think that your engineering background may be motivating

your…

A10 *Oh yeah!*

I … desire to control that?

A10   *Oh yeah! Oh yeah - a lot of people will just want to stretch them,*

and see what happens when they're stretched… a lot of people will extract

that kind of stuff, prematurely.

In this example, the higher degree of control that A10 associates with engineering also

enables more robust inferences and scientifically relevant generalizations, i.e. that relate

to the strain pattern of the blood vessel rather than the specific device used to test

(stretch) the cells.

In a later interview, A10 echoes the idea that engineers are concerned with high

levels of experimental control as the overarching goal of approximating a blood vessel's

environment:

I So why don't you briefly tell me what the flow loop is, and what it's

for, in your own words.

A10 *So we use the flow loop as um, a first order approximation of a*

blood vessel environment, is like, in that, um, as the blood flows over the

lumen, the endothelial cells experience a shear stress. **Well, um, as**

engineers, we try to emulate that environment. **But we also try to**

eliminate as many extraneous variables as possible, so we can focus on

the effect of one. Or perhaps two, such that our conclusions can be

drawn from change in only one variable.

A10 reiterates this emphasis on the engineer's superior control by way of contrast with "the biologist's perspective", and with ways of working that seem to be more popular with some general class of other "people" who would appear by association to be biologists (multiple interviewers):

I2 But it's interesting you kind of just talked about the, an optimal

situation, if you could reproduce..you know, or simulate a part of, a real

part of the body where it does have a pulsing, like, a heart, and you have

blood flow, that..

A10 ***People*** *do that*. [implication- just not us]

I2 They do?

A10 *Well, they just look at normal people. You know, they stick a couple*

catheters down there and see what's going on one side or the other, or

they'll do stuff where they'll take a big money clip, and they'll clamp it

over a rat aorta or something, which will cause a stenosis….You know, so

you can do stuff like that but um, the difficult thing is, you know, what is

doing that? The shear stress? Or what if putting the stenosis causes a

large growth factor of x amount?

I You just have more control with the flow loop.

A10 *Exactly.* ***It's well defined, you can change one thing and therefore***

whatever happens it's because of that one thing. *No matter what...*

Whereas like a biologist's perspective, would be, you know, let's see

*what's happening, but the problem is the conclusion…**a lot of times***

biologists will just try to draw conclusions.

I1 Like a causal model, or

A10 *Right*

I1   And that's problematic…

A10 ***Very** problematic*

I2   Why?

A10 *Because you **do not have a firm control over all your variables**.*

And you have so many variables, they all could be changing all at once,

there's no way to know, all you have is a snapshot here, a snapshot here,

…So, you know, it's so difficult to ascertain which is why we do this, you

*know, basic kind of research. This is a lot slower. And I think that's **why***

***people don't like it**.*

I   And so are the biologists content with the kind of systemic cause and

effect that they describe?

A10 *They **can get away with it in their circles**. Engineers, you know,*

don't really like that too much.

I1 So do the biologists make progress with that method?

A10 *Well, it's kind of like paleontology versus microbiology.*

Paleontology you see a bigger skull and a little skull and you say this

came from that. Microbiology [you say] these genes are totally different…

But a biologist would say this is this**. You know, the really, **engineering

mindset *would be let's look at genes, and let's see if can we actually draw*

this kind of relationship.

In these passages A10's efforts to align with engineering practices and "mindset' and to distance from those of biology position him as a more rigorous scientist; they establish epistemic rights and duties consistent with that position. Although he does not explicitly criticize biologists, he claims a more rigorous method and solid logical foundation for his own work by identifying with engineers and claiming that engineers are more systematic in drawing experimental conclusions on the basis of eliminative induction.

Conviction that engineering offers cognitive advantages is also expressed by A11, a PhD student. Of interest here is that the interviewer's question concerns *strengths*, and A11 answers in terms of disciplinary identification:

I So what are your strengths coming into the PhD program?

A11 *Well, I did a bioengineering… biomedical engineering background,*

so I had a engineering sort of discipline with a material science

background so I would say kind of the materials side of things.

Understanding more of the mathematics and things like that…

It is clear from the context that A11's implied contrast is biology:

I So what are your plans for the future?

A11 *I would like to work in some sort of medical device sort of uh*

project. So similar to what I did either on my internship or in a different

company and things like that. And working more in an engineering sort of

discipline.

I Rather than biology?

A11 Rather than biology.

I Why?

A11 *Uh* **probably some of it has to do with the fact that the engineering aspect was more successful than the biology** *was but I also think that the questions that you have* **in biology you really can't answer a lot of them very easily because no-one really knows what's going on.** *Whereas questions with engineering you may make very difficult equations and very difficult to solve but you can at least approximate them or reduce the problem down to something that's simpler and may not be appropriate for every aspect of what you are looking at but at least you can kind of address it on some level whereas* **biology is like a big black box**

In this passage A11 expresses his sense that the engineering side of biomedical engineering affords greater scientific efficacy than does biology. Engineering questions can be addressed more easily because of the methods employed in engineering, in this case involving engineered approximations of bodily environments.

The advantages ("rights") offered by biology emerge later in A11's account of biomedical engineering, even as he acknowledges a widespread view of engineering as a "hard" science and biology as a "soft" one:

A11 *For some reason a lot of engineering faculty think that engineering is a more… hard science as opposed to biology, which is still relatively soft. They're afraid that just by being called 'bioengineering' it's not really a true engineering. They're not doing like a true science work, which isn't*

really true. But I think because of that, not only the faculty but students

wanna make sure they don't lose touch with the engineering in their

projects. So I think most people come in, especially here they come in

from a more traditional engineering background, ME or ChemE, want to

make sure that they keep those in their projects. So they tend to start out

*trying to do a true engineering project. **Then they realize that with tissue***

engineering they can't really like answer all the questions, or all the

important questions with just engineering so then they end up switching

over to biology sorts of approaches and end up doing more biology near

the end.

The idea here that engineering is something with which students and faculty do

not want to "lose touch" underscores its position as a more rigorous approach to scientific

problem solving, with "hard" here likely referring to the superior control and quantitative

manipulation of the features of biological phenomena afforded by engineering expressed

more directly by A10. However, A11 also suggests in this passage that at some point the

affordances of engineering run out. Therefore control must be exchanged for the broader

set of questions and methods that biology can afford.

This view of biology as offering a more open-ended, theoretical approach to

problem solving is similarly expressed by A14, who expresses the most explicit

identification with biology of anyone in Lab A:

I From what X has gathered you are kind of the only biologist in the lab

A14 *Essentially, yeah.*

I We had kind of developed a kind of description of biologists and engineers from things that people have said. [we developed this from things that had been said in the lab]. And I was curious about your response to this..

A14 *Now when you say do not, do not invent [pause] I think there's innovation in biology so I wouldn't discount that. It's totally that the work goes on in a vacuum. **You see the thing about biology is that biology is really a part of life** and even though engineers may not realize it, due to training and such, biology is the thing that... I mean you ... **I want to say it's almost innate.***

Here A14 seems to be portraying biology as natural, accessible realm, drawing what is perhaps an implicit contrast with the artificial constraints of engineering that enable tighter control. For A14, biology and engineering represent contrasting approaches to inquiry. He characterizes these as two *perspectives*, providing an example of how the difference bears out in relation to a specific example, wherein an engineering student is experiencing a series of frustrations in his efforts to culture cells:

A14 *I can think of one specific example … the perfect example of engineering and biology. I was working in a mechanical engineering laboratory and a student was trying to grow some cells.. The cells after a couple of days would shrivel up and start to die... I used the same media used the same temperature, put them in the same incubator. They* [the student] *looked at both incubators – the temperature was the same. From an engineering mind they looked at, you know, measuring things.*

Everything was the same, so I said "well, let's look a little bit outside of

the box" … I asked the question what about the micro environment of the

chamber …. His device was something that he created and built based on

the mechanical properties. But …he did not take into account that maybe

some of the materials used to build his device were toxic. …So once again

*it is something of trying to **look at the whole picture instead of being***

***focused on one thing** - getting the cells to grow and stick. And so once*

*again **two different perspectives.***

Although the ostensible point of A14's storyline is a description of biology and

engineering as offering alternative perspectives on science, there is a clear positioning of

biology as an ultimate authority through a more holistic and systemic focus.   The

authority thus conferred on biology in turn positions A14, the sole biologist, as an

arbitrator of natural wisdom, as underscored by A14's suggestion that engineers come to

him for council:

"What **happens in some instances is they end up coming back to me**

and saying, well, I need a little bit more advice"

By contrast, however, a researcher in Lab D positions biology as concerned with

identifying causal mechanisms, but as unequipped to provide a theoretical account of

their workings. This contrast is drawn as D7 tells the interviewer the story of how he

joined Lab D:

D7 *I started searching for people who are doing neuroscience work like*

mine, so then I can apply my physics there, and model it from a physics

point of view.

I Tell me more about what it means to model what people are doing here from a physics point of view.

D7 *What biologists do, they take some data and analyze that and say, "OK, this means that." But, **how** it is, like, hmmm. For example, ok, this is some spike pattern going on. **And since every time it moves the spike pattern is coming up, so this means that this is causing this or this or this,** or this is a result of this behavior. **That's what biologists do. Now I will ask why, how it is happening. That is physics.***

These examples help to illustrate the difficulty of characterizing the precise nature of disciplinary divisions within the culture of the laboratories as these are expressed in the identifications assumed by researchers. Disciplinary configurations are made even more intricate by what the complex ways in which dual identifications are enacted by some researchers through discursive positioning. The complexities of identity as a general category underscore a need to consider both the relatively stable developmental trajectory of identity and the fact that social conventions and current interactions provide the conditions through which this identity can be claimed as one's own. We see the relevance of both of these considerations in the disciplinary identifications of biomedical engineers in our two research laboratories. Researchers are responding to the traditional ways "engineer" and "biologist" have been identified and they are struggling to understand what it means to be a hybrid "biological engineer", a category with a less venerable and established history than those of engineering and biology. At the same time, researchers bring their own interpretations to their ways of positioning biology and engineering and biomedical engineering.

D6, for example, after noting that his background is in biochemistry, says that he is *using* neurobiology and is *interested* in cognitive science and neural modeling. He then positions his interests to constitute a kind of divided subject:

> *"My background is, uh, in chemistry actually, but, I'm, I uh, I'm using*
>
> *neurobiology and interested in all sort s of cognitive science issues and*
>
> *neural modeling, that sort of thing.* **The biologist in me** *is interested in*
>
> *learning and memory, and how it is that we learn and what changes in our*
>
> *brain when we learn something. And* **the engineer in me** *is interested in*
>
> *taking some of those ideas and applying them to computing, figuring out*
>
> *completely new ways of computing that currently aren't being used in any*
>
> *of our human made artifacts right now."*

Note that in positioning himself as dually motivated by biology and engineering, D6 opens two quite divergent sets of rights that work together to equip him for the work of Lab D. Identification as a biologist drives his questions; identity as an engineer enables the computing applications that result in the innovations he can claim.

A similarly mixed identity is expressed by D4, but with a less sanguine assessment of its benefits:

> D4 *So I come from a total electronics, engineering background core: no*
>
> *biology. And then I did a masters electrical engineering. Then I took*
>
> *courses in the biomed department, somehow managed to get an*
>
> *interdisciplinary masters degree in EE and biomedical, but, if people ask*
>
> *me in biomedical, like … "So, What's your Masters?" I say, "Biomedical*
>
> *Engineering." And people ask me in engineering, I say "EE."* **So… I**

*can be both ways. My certificate actually says interdisciplinary. ..**BME***

***requires both** because of the engineering background - engineering skills*

*as well as biology. **It's not one little thing**. You're not really an engineer,*

because the engineers don't like you any more, they think you're

traitors"…Yeah! They're like, "You're not engineers, you're not electrical

engineers." Because I am not doing core electrical engineering, ok. The

biologists don't think that I am a real biologist because I know kind of

biology, …So, when we're neither engineers nor biologists. We're just

BMEs. (Laughs). We're nowhere. We're somewhere, but right now we

don't know anything. We don't know the biology, we don't know the

engineering. So, we're somewhere in the middle.

Despite its humor, this account expresses inherent drawbacks associated with her own

identifications as an interdisciplinary researcher and problems this creates for knowledge

construction in Lab D and in biomedical engineering more generally. The claim that

BME *requires* both engineering skills and an understanding of biology can be analyzed

from the point of view of positioning theory as a statement about the *duties* of positioning

the field and oneself as interdisciplinary. There are cognitive requirements and these

have emotional corollaries that are not always easily managed: they include insecurity

about the knowledge foundations supporting new problem-solving. Nevertheless, D4

also expresses recognition that the very confusion invited by mixed identity also serves to

open inquiry:

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D4 *I think it's the way the fields are going. It's kind of nice to get a blend of both… I think it broadens your outlook on things. Generally I think it's interesting.*

The opening of inquiry is a *right* afforded by the positioning of oneself as negotiating two disciplinary identifications.

A similar sentiment in relation to the interdisciplinary nature of bioengineering is expressed by A26, who holds a PhD in bioengineering.

I   So do you, do you consider yourself more biology or more engineering? Or kind of right down the middle?

A26   *So well, I came here to get more biology.* [What] *I would change if I had the option, knowing where I would be now, which is I would do a more classical engineering undergrad degree. ..Bioengineering undergraduate degree, especially when I did it, which was very early on, there were very few bioengineering undergraduate programs—is too interdisciplinary. And so you don't learn strong fundamentals in any one engineering. So, how do I view myself? I view myself as someone with an engineering bias, but a **weak engineer** if I compare myself to a chem E [chemical engineering], or mech e [mechanical engineering] at this school. But not a biology student. So I'm kind of …*

I Mm hmm

A26 **Which is a little disconcerting, but a little empowering**.

The characterization of an interdisciplinary program as both disconcerting and empowering illustrates that mixed or complex disciplinary identifications affect emotional as well as cognitive functioning.

To summarize briefly, in this section we have considered a range of positioning strategies researchers display through speech acts, specifically as these relate to explicit disciplinary alignments associated with specific cognitive practices. In accordance with positioning theory, we have examined rights or duties effected by the strategies. We have identified cognitive and/or epistemic rights and duties associated with various disciplinary positions. In turn, emotional and motivational dimensions of experience appear closely tied to the identity commitments and approaches to scientific problem solving these commitments implicate.

II. *Positioning as Warrant and Justification*

We now turn to a class of discursive moves we classify as more subtle cases of positioning. By 'subtle' we mean that they do not make explicit reference to disciplinary identifications; rather, they demonstrate alignment of methods or ideas with those of other persons, laboratories, or traditions, or distancing away from others' methods or ideas. These are expressions (speech acts) that function to anchor the researcher's own problem solving or provide warrant for a developing idea. We originally assigned a label of "latching" to capture researcher's attempts to justify epistemic actions by means of alignment with existing knowledge or traditions. In the case of an alignment, something is conveyed as stable, reliable, or trustworthy, and it functions as something with which one seeks to associate a project, method, or line of thinking. Our observation that a parallel *distancing* maneuver, in which one moves away from standard, established, or usual practices serves similar functions led us toward the higher level category of "positioning," and to turn to positioning theory as a way to inform what we observed so frequently in the interviews. The frequency is not surprising. On one hand, it might be

said that all of science involves positioning, inasmuch as problems and methods are always situated in relation to others, and justification for conclusions so obtained. However, positioning theory offers the analytic strategy of considering the (epistemic) rights and duties of these alignments and distancing maneuvers.

We begin with a rather typical example of the way in which a decision to pursue a particular line of research is made though a combination of desire and interest ("what I wanted to do") and by positioning what other researchers are doing. In this case A4 refers to other researchers in Lab A:

I : So, what are the major research questions you are struggling with right now? …Tell me how you settled on this project?

A4 *Um, it pretty much was a process of elimination and **this was what I wanted to do**. I didn't really want to work with endothelial cells; I didn't want to work with the flow loop. I wanted to stay more with the chemical aspect and basically the whole mimicking and biomechanical influence on constructs to behave in the right manner. And so one thing A13 was talking about was the certain influence of mechanical stimuli on biological marker so, I said ok, I had done a little bioengineering so let's look at biology* [aligning]. *Well, after I read, I realized it was a lot more biology. And it's very interesting but I think it's gonna be a lot more difficult than I expected because of my learning curve which is so steep* [distancing]. *And **I see where I'm an asset here** in the lab 'cause next week A10 wants to do western analysis* [aligning]. *So A41's gonna go to the X24 lab and he doesn't really do that anymore but I've done it* [replacing A41]... **I was**

telling them about degradation and what you need to store, because I'm kinda going more along the biological route [distancing]. And then I took this biochem class and **they think I know something** although I know nothing. **But I think that'll be my influence as my knowledge grows**.

In addition to illustrating aligning and distancing moves, A4's description in this passage calls to mind George Herbert Mead's concept of the "Generalized Other," a concept Mead uses to express that formation of identity or 'self-concept' is conditional upon awareness of the configuration of roles and expectations in the groups (social systems) of which one is a part. Mead uses the analogy of a baseball game for the notion that one needs to have a sense of what others are doing, what functions they are serving in order to have a sense of where one belongs within the configuration, what one's own position can be (Mead, 1934). A4 expresses his struggle to be of value in the lab not merely because of his unique experiences but how these experiences fit into the web of knowledge and expertise already in place within Lab A.

In the language of positioning theory, A4's series of aligning and distancing maneuvers through which he positions himself as one who can have an influence in Lab A confers on him the right to view himself as a competent and valuable member of the laboratory community - "an asset" in his words. But there are also requirements (duties) included with the position, as he expresses in his commitment to acquiring the knowledge needed to have continued influence in the lab. However, that the "rights" associated with positioning are not merely cognitive but also emotional is evident in A4's account, as it is in a similar sentiment expressed by A17, an undergraduate working in Lab A:

I What would you like to get out of this experience?

A17 *I want to be able to do something that… I want to be able to finish my project and have it make sense to me and feel like I actually did something which will help me write my paper and make sense and, um, for me to feel like I played a small part. What am I trying to say? That my experience played a small part in this lab and in going up and getting better.*

A similar expression of determining one's course of work through an initial set of aligning and distancing maneuvers is expressed by A51. Note here that the interview question is phrased in terms of what A51 was trying to *understand*, and that A51 answers this question by reference to the *interest of the PI*.

I So you said this was in the first year—I'd kind of talked with PI about the—where you're going to go with your research, so tell me where your—what your research was at that point and what you were trying to look at, and **what you were trying to understand**.

A51 *Ok, well when I first came in kind of the, the project was very broadly defined. **He** was interested in looking at different types of fibrocartilage which are found in various portions of the body, in the menisci in your knee, that's the biggest one, you also have a little disc in your jaw joint, it's a little piece of tissue, you have a piece in your wrist, actually, or intervertebral discs have portions of them that are very similar in structure. And so **he was kind of interested in**, you know, looking at how can engineer these fibrocartilage tissues, much like how other people in the lab are working with an articular cartilage. Um, so*

*originally **we were focused** on this little disc in your jaw joint, mainly*

*cause it's smaller-… So that's kind of how **I started**.*

The change of pronouns in this passage from "he" to "we" to "I" illustrates the intricate play of identity in even the choice of a research problem and understanding of that problem, things traditionally identified as cognitive practices. That there is always an historical dimension to positioning within the laboratory context, that positioning includes understanding not only of what others are doing but what they *have* attempted or accomplished in previous problem solving efforts is point expressed in our group's previous characterization of the labs as evolving distributed cognitive systems, and is central to the analysis undertaken by Kurz-Milke, Nersessian, and Newstetter in their paper "*What has history to do with cognition*" (2005).

Positioning through aligning and distancing takes place not only within the social group of the laboratory but in relation to the wider field within which ones work is situated. This form of positioning relates closely to the norms of good practice upheld by the wider community of scientists. These norms inform both the questions it is legitimate to ask in a given scientific context as well as the methods and techniques one is empowered (has the *right*) to use in addressing them. In this passage, A5 demonstrates a broader form of positioning (i.e. outside the immediate context of Lab A) in defending the appropriateness and usefulness of an experimental technique:

I Have you ever tried to write a program that would allow you to measure

something new from a machine? Or you use existing software and

machines?

A5 *When it comes to analysis...I have not designed my own instrument…*

[laughs..] that is sort of the cardinal rule of PhDs – don't do that...

I   Don't?

A5 *Because if it doesn't work you have nothing... ... **But it is also nice if you can use an existing technique so you can compare it to what other people are doing… So that is sort of an advantage…people are more accepting if it is a gold standard technique… It's kind of a balance… you have to find something that is appropriate for your question, but you know it has got to be useful as well.* **(2005-02-17-A-A5)**

Similarly, D4 justifies her model and procedure against a generalized background of "what people do usually" and the problems therein:

What people do usually *is take this couple of neurons and um, stimulate or probe them to see what the activity is then put in some kind of stimulus or inducing stimulus, whatever the inducing stimulus is and probe again to see what's happening... did it produce a change did it or not**? I think that's a very static model of studying the brain** 'cause the brain doesn't really work that way... So, **my way of doing it**, I'm going to have something that is, this series is going to be like a background stimulation. **My model** is basically the brain has, is getting inputs all the time. **My protocol** works with getting rid of bursts. So, I'm gonna have that as a continuous background stimulation which always goes on through out the experiment and then on it, **I'll do whatever stimulation experiments I want.***

Distinguishing her model and procedure through distancing what is usual or typical can be seen here to equip D4 with the *right* of agency, as expressed in the assertion that she will do whatever stimulation experiments she wants to do. In another interview, D4 distances her understanding of "burst" from the common practice in the literature of using the term to refer to the activity of a single neuron in explaining the origin of her lab's use of "barrage" to refer to the activity of the dish. Her pronoun use "we" and "they" suggests identity with the practices of her lab in opposition to those of the literature on bursting; this distancing affords new opportunities for the development of technical vocabulary and subsequent theorizing that need not conform with the understanding of burst phenomena in the literature at large. These are rights afforded by the shift in position she effects with the distancing strategy.

This broader positioning – i.e. positioning not only in relation to the laboratory configuration but to the efforts, successes and standards of the wider field - also includes an historical dimension, connecting present thinking and procedure to previously sanctioned ideas and methods. In lab D, a researcher distances his procedure from that of "most people" and aligns his own systemic focus with that of Karl Lashley:

> D1 *The difference between doing this and the type of two electrode preparation that most people do, is (that) there's a lot of data that will tell you that whatever the memory mechanism is that is out there, you're not going to find it between two neurons. It's actually a distributed process – and you know that, you see studies where they have lesions, and you have*

things like recovery of function. And Karl Lashley spent ten years trying

to, in the 50's or 60's – I think it was the 50's- where he would go through

and teach a rat to traverse a runway, and he would find what part of the

brain was coding this particular radial arm or runway. And he sectioned

it up into smaller and smaller pieces isolating different parts and the rat

kept performing the task, and eventually he concluded that there was no

memory. He was joking. Right, but what his conclusion was, was that

*whatever this code is, it's distributed over a large area, and **you need to***

***be able to study the functioning across that large area**.*

The reference to Karl Lashley serves to legitimize the way of thinking and

proceeding by aligning current efforts with an historical effort widely regarded as

transformative in its field. This positioning offers a 'right' to carry on in the

intended direction because there is a well-respected historical precedent. By

distancing from "most people," A23 succeeds in positioning himself as superior in

his approach to the problem. On one level this activity is no different than the

standard practice of framing one's current research question in the context of

previous work, as might be found in introduction to many research papers. But

what is interesting here is that the context is not a formal paper but, rather, a

casual interview with an ethnographer. There is no prescribed format for

justifying ones procedures to an interviewer from another academic discipline, no

clear indication that the interviewer will understand the significance of alignment

with Lashley. It is tempting to read this as a transposition of an expectation from

the normative framework that exists for positioning formal research productions

(papers, presentations) in relation to historical precedents.

Finally, we encountered a few instances in which positioning related not only to

the laboratory environment or to the field of practice, but to the wider organizational

system within which biomedical engineering research is situated. In this example from

A10, the "rights" associated with product development (engineered tissue) are altered by

positioning research laboratories in relation to a federal agency (the Food and Drug

Administration):

> A10 *It's a little more difficult to prove, you know, (that) x came from y.*
>
> *But then again, if you do things our way, it's very unlikely that we'll*
>
> *develop a product very quickly. The product you do develop will be very*
>
> *likely to work better, and you know, um, right now **regulations, like***
>
> ***federal regulations are such so that it's up to the government to***
>
> ***determine um, effectiveness of your product**. **But now, like since last***
>
> ***march FDA is really trying to put it on to the employer to determine that**.*
>
> *Instead of using mean values, like actual whole statistical groupings,*
>
> *because obviously you got this mean value that says "yes." Well, what's*
>
> *the distribution? You could have this huge window of "no" that but then*
>
> ***they get all produced and put into people** and you know, like, that's*
>
> *getting better and better, because, you know, people are becoming more*
>
> *conscious of these kinds of things.*

A10's remarks implicate his identity as a research scientist or perhaps identity as a

biomedical engineering researcher more generally rather than as a member of Lab A or as

a participant in the field of tissue engineering. He first positions the federal government as the arbitrator of standards of an engineered product's effectiveness, then alters the government's position in such a way as empowers the individual laboratory. This shift opens a set of rights previously denied, namely the right to determine the effectiveness of one's products. It simultaneously requires a new set of duties. A10's regard for the potential consequences of poor research design, a failure to consider mean scores and ignore the pattern of distribution, is expressed in his acknowledgement that they get "produced and put into people." This seemingly casual statement reflects awareness of the ethical dimension of his research efforts, awareness of a larger normative framework embedding his particular problem solving.

In this section we have examined the significance of our observation that researchers at varying levels of expertise engage in two forms of positioning as basic sense-making strategies: alignment with or distancing from existing practices in the laboratory, other laboratories, biomedical engineering, and science practice at large. This form of positioning is closest to what Latour (1987) discusses as a matter of three choices forced upon scientists and engineers by the technical texts they read: "giving up (the most likely outcome), going along, or working again through what the author did" (p. 63). Our analysis suggests that researchers make these same choices not only in relation to technical texts but in relation to their own understanding of other practices within different levels of organization: the laboratory, the domain of research practice, biomedical engineering, Science. They appear to use a 'map' of practices to configure their own stance and strategies. Moreover, these positioning strategies impact not only epistemic rights but also emotional and motivational dimensions of practice.

III.   Positioning in relation to laboratory objects and artifacts

We here extend the analysis of positioning in the laboratory to include person to object or person to artifact relations, focusing on relations with cells. In our framework, the constituent members of each biomedical engineering community include not merely the researchers and other laboratory staff, but the objects and artifacts of biomedical engineering practice. At a minimum the community includes living cells, which are cornerstones of the engineering practices under our observation.

Inasmuch as "positioning" is a social psychological construct, our analysis effectively constitutes inclusion of cells in the social realm. That is, we are considering cells to be part of the social realm of the researcher. We highlight two principal ways cells may be considered participants in the community of researchers that is the biomedical engineering laboratory.

Attributions of agency and experience

 In both labs we observed a pattern of anthropomorphizing to be widespread, and that is especially directed toward cells, although it also is directed to the physical devices they design and construct for the purposes of manipulating or interacting with cells. By anthropomorphizing we mean, of course, the act of ascribing human qualities and abilities to nonhuman things. Although traditionally regarded as a "sloppy" linguistic practice given the (assumed) erroneous nature of the attribution, anthropomorphism is increasingly recognized as a cross-cultural and functionally important human practice, one designed to establish order through endowing the world with social meaning (Heberlein & Adolphs, 2004; Horowitz & Bekoff, 2007). In the laboratories,

anthropomorphizing takes many forms, ranging from calling cells "guys," as in this example from A7,

> *you can see on this guy more of the activity is localized to this guy and may be spread out when you go later on. So I am basically saying that a burst is something that goes through out this guy.*

To referring to cells "sitting down" and "feeling effects:"

> A10   *So **the cell sits down like this**… Like if the cell is just kind of hovering over this thing, stretching this membrane is not going to do anything. So you want to be able to look at it, and see it—the cell- like **feeling the effects of something.***

to rather explicit depictions of cell agency:

> *But I feel that **if the neurons can actually themselves control how they get stimulated, then that stimulation has meaning in a sense**.*

Similarly, D4 positions the network of cells as an agent, one responsible for her occasional bewilderment and loss of direction:

> I So what do you think the causes of all your struggles are?

> D4   ***Uh, the network has a mind of its own!***

The significance and function of these anthropomorphizing expressions varies with the context in which they are used, but attributions of agency are most interesting and perhaps the most theoretically important. For example, D4's attribution positions the network of cells as having cognitive but also seemingly emotional impact on her work. The cognitive "rights" opened to D4 by positioning the network as having its own mind are best understood by visiting

our concept of "cognitive partnering," which we used to code expressions of cooperative engagement in problem solving. Although we first used the cognitive partnering code for expressions of person to person interaction – mentor to apprentice or peer to peer – we began to notice in the transcripts many expressions of cooperative interaction with cells or networks of cells. Cognitive partnering codes thus overlap with and are closely associated with anthropomorphizing expressions especially when the attributions concern the agency of the cell or network. Cognitive partnering can also be considered a form of positioning, in as much as it entails a researcher positioning the cell or network as a cooperator toward some epistemic end. We have previously focused principally on what cognitive partnering affords, what kinds of cognitive practices it enables (Nersessian, 2006; Osbeck & Nersessian, 2005). Interesting in the example from D4, however, is the quite emphatic expression of costs associated with partnership. As in any partnership, there are disappointments to manage and compromises to be made; goals are impeded as well as advanced.

Because the cells in Lab D are neurons, it is not a great stretch for researchers to speak in terms of mind and even agency, however philosophically problematic. However, Lab A transcripts reveal similar expressions of relationships with cells. Across labs, two forms of this expression of relationship with cells are particularly interesting; they bear an important relation to one another and to the concept of cognitive partnering:

Perspective taking

The first form involves appeals to the point of view of a cell or artery:

I. How about the—how about the size of the chamber. Is that—is that part of the, ah, is that an approximation, or...

A10: *Well, um, no in the sense that it doesn't really approximate. Like, most arteries we look at are going to be smaller than that surface. But* **from a cell's perspective, the cell sees basically a flat surface**. *You know, the curvature, is maybe one over a centimeter, where as the cell is like a micrometer. You know, like 10 micrometers in diameter. It's like ten thousandth the size.* **So to the cell - it has no idea that there's actually a curve to it** . . .**The cell, when it looks around, just sees a flat surface**. Just like we think the earth is flat. (2002-7-09-A-A10).

Perspective taking is a form of positioning in that it entails a shift of location to another point of view. What is the significance of the practice? Importantly, George Herbert Mead considered perspective taking to be a distinguishing mark of sociality and to establish the limits of community:

The limitation of social organization is found in the inability of individuals to place themselves in the perspectives of others, to take their points of view. ... In the field of any social science **the objective data are those experiences of the individuals in which they take the attitude of the community, i.e. in which they enter into the perspectives of the other members of the community** (1932, p. 175).

Perspective taking thus becomes a more fundamental condition of cognitive partnering than are attributions of agency. Agency is attributed to other natural objects (e.g. storms), but objects do not enter into the participatory community of

an actor until the actor has at least the *ability* to assume their perspective. Note here that it is the actor who by perspective taking defines the status of the object as community participant (cognitive partner). However, this does not imply that the social world is entirely of the actor's making or that the process is an arbitrary construction. As noted, Mead regards personal identity as contingent upon the ability to assume the perspective of others. If there is no community without the actor, there is equally no actor without a community. But also, it is not the case that any object is equally likely to receive attributions of agency or experience. Pets are more frequently the target of anthropomorphisms than are rocks. Their perspective is more easily taken and that important functions are served by taking the perspective of pets is easier to imagine. The owner is more likely to be diligent in feeding an animal and tending to its toiletry needs if she is able to take the perspective of the uncomfortable pet. Likewise in the laboratories cells receive more attentive care when their perspective can be assumed by the researcher to whose work they are essential.

Identity as caretaker

Therefore, it is especially interesting that among the first set of interview passages we labeled as having something to do with identity were passages we coded as "identity as caretaker of cells" before thinking in the broader terms of positioning theory. This passage from an "exit interview" with postdoctoral researcher A8 is the most striking:

I2 You often refer to your cells as "my cells." You seem like …you like them!

A8 *They're my children!*

I2 Do you ever think of them that way?

A8 *When I was, first being trained, uh, the woman who trained me,* **called 'em children**, *I think that's a very good analogy because* **you have to feed 'em, you have to keep 'em alive, you have to take care of them, you know, and they, they eat, and they get hungry**, *and...it's a good, pretty good analogy, ...***I do call them mine, because…I think of them that way**.

I2 It hard to think of a, a …new piece of rubber like that…or something like that, Right?

A8 *well then you think of it as property, but not as much as* **something you're taking care of. …**

In this passage A8 positions herself as the caretaker of the cells, which establishes her *right* to "call them mine" and *duties* which include feeding them and keeping them alive. Because the cells she cares for are central to her success as a tissue engineer, the rights invoked through this positioning are epistemic (affording problem solving), social (enabling success in her chosen profession) and presumably emotional.

Indeed, their status as living things, or rather, the fact that they are living things on whose lives the biomedical engineers *depend* for successful problem solving is the second important reason we consider cells participants in the laboratory community. A cat wandering into the laboratory or the microscopic organisms that inhabit laboratory nooks and crannies are not participants in the community in the sense we are trying to describe. For the cells, of central importance is the dynamic tension or *resistance* effected by their status as living objects *and* the fact that they are central to the work of each laboratory. They do not always behave as researchers expect or want them to do,

and they can die. Thus we can draw a comparison between this "resistance" and the concept of constraints by which a 'rule' is understood in positioning theory. Researchers are positioned by the actions of cells, establishing rights and duties in accordance with the position.

We noted earlier an association between identification as an engineer and an emphasis on the benefits of experimental control. Here a graduate student acknowledges the loss of control and possible negative implications for her progress introduced in partnering with living objects:

A7 *I think the next point for me is my proposal.* **I don't think I want to hinge all of my work on animals because that's so uncontrollable.**

I Tell me by what you mean by uncontrollable.

A7 *I mean when we are in the lab we can control the media we put in, we can control their environment completely...But when we move into an animal model its more physiologic, the challenge then is that it's a much more complex system. So I would like to integrate some in vitro work here in the lab with um the in vivo work so that way you are not, if one thing doesn't really work* **you are not stuck** *when you are considering finishing your thesis.*

More strongly, D2 blames his inability to complete experiments directly on the cells:

That's been another problem why I haven't been able to do any experiments lately, cause the old neurons have been dying

On the other hand, the living status of cells is precisely the reason A8 finds her work as an engineer engaging and enjoyable:

I Have you changed at all on, on the how you see the relation of biology

and engineering and what you're doing or…

A8 *No, I don't think I've changed. I think I still see myself as an engineer*

using biological tools.

I Do you enjoy working with biological stuff more?

A8 *Oh yes… Well, **I like to work with things that are living, which is why***

I love the cell culture… I just think its really enjoyable working with

things that are living, where you interact with them and they interact

back with you.

I So that would be different than some other forms of engineering?

A8   *Well, like, you build a device, I mean you can leave 'em for a month*

*and come back and its going to be exactly the same. I don't know, **its not,***

its not quite as live, as lively. (2003-06-19-A-A8)

In both laboratories, despite the best efforts of researchers to culture and nurture

living cells, cells "act" in unpredicted ways, the most radical and challenging of which is

to die. Cell death, the very possibility of cell death creates a dynamic, even 'dialectical'

tension between researcher and cells. The actions of cells determine the range of actions

possible for the researcher. Cells and researchers thus position one another with their

actions, with analyzable social, emotional, and epistemic effects.

We further illustrate the application of positioning concepts to researcher-cell

relationships with a more detailed example from Lab D. This interview with an

undergraduate researcher took place shortly before he was to graduate with a degree in

biomedical engineering. Prior to this interview he had given more enthusiastic accounts

of his experience with laboratory research. Early in the interview he declares his recent interest in going to medical school after graduation, a goal he had never previously identified to the interviewer. Although medical school is only one possibility he is considering, he is definitely ruling out graduate school in biomedical engineering or a related research field. In the interview he ties his change of career plan to his experience with cell death:

> D32 *Well…after working in the D lab I was like 'I really don't want to do this.' I don't want to have to do research that fails all the time and…have to write papers and…It didn't seem that fun.*

> I: Well, the last time I talked to you it was really fun. When did it stop being fun?

> D32 *I was actually going to do an experiment where we were measuring the effective simulation range of a single electrode on an MEA, like that whole semester. I mean, I talked to you and then after that that's when D4 had all the cell death so I couldn't do anything and so I just did grunt work.*

Later in the interview he provides more detail about the events surrounding the cell death. It is clear that the cells have died despite best efforts:

> D32…*they were using the same protocol but with mice…they'd been doing the same thing over and over again and one day they just kept having cells die. So they'd plate cells again and after two weeks they'd die and they'd just keep on doing this and they were like 'What's going on?" So then they started like in the middle of the fall last year. I mean,*

they found there was a little problem with their system. They fixed all the

problems and they were still having cell death.

The wide-scale cell death has shifted D32's position in relation to his work in the

laboratory. Rights are lost- he views himself as unable to do *anything*. New duties are

assumed—he now does *grunt work*. The impact of this change in rights and duties is

weighty. Rights D32 previously assumed to be unproblematically his own, such as the

right to do his experiment, the right to be a full-fledged participant in the intellectual life

of the laboratory, are suddenly and seemingly permanently denied. His previous right

was to propose work that would give him status in the lab. He had a right and duty to

generate data for the whole lab that would advance their understanding of cell interaction

over time. His plan was to make a contribution by advancing understanding of how cells

in cultures interact. The cell death, however, signals a kind of resistance or 'stance'. The

cells have deprived him of his contribution, have shut down his work and even altered his

career plans. They have, in effect, transformed him into a 'grunt worker.' This is not to

claim that the cells have agentive *intent*, only that they behave in ways that are not

determined by the researcher and that constrain and limit his learning and problem

solving with their 'actions.'

The cell death also appears to be associated with new disciplinary alignments.

That is, changes in *identity* through the experience of cell death are evidenced in the new

appeal of health care and the assumption of a stance of wanting to help others:

> *D32 I never really considered that 'cause its really health care but they*
>
> *can tie that to the sensory like they can really make prosthetics that are*
>
> *tied to the nerves and that would be really awesome for me… I want to*

improve people with problems and that would be the perfect way to do it, I

think...I want to have that patient interaction, I think.

This would appear to have a positive spin if it did not stand out against a feeling of being

ineffectual and *incomplete*:

Interviewer: You put in a lot of time in that lab.

D32: Yeah, but I feel like I haven't accomplished anything. I feel like I

just did the bare minimum. I don't feel like I did the best I could do for

D4's lab, so I feel like I kind of owe it to him to do something big, or...

Interviewer: It sounds like it was the cell death that... like you were all

lined up to do something, right?

D32: Yeah, that's why I feel incomplete, I guess. It's not really my fault.

Also interesting is the suggestion of the network of laboratory relationships connected in

various ways to the cell death and its effects. D32 identifies the cell death as an event for

someone else: "*that's when <u>D4</u> had the cell death*", yet D32 is affected. Thus D4's

position in relation to the cells impacts the position of D32 in relation to his own problem

solving and learning. Moreover, emotional effects of the cell death are described here as

broad in scale across the laboratory. D32 affirms that all the graduate students were

angry ("super pissed off") and that the experience was *demoralizing* for them.

Of course, the fate of other objects, artifacts, and devices might similarly hamper

or enhance work in the laboratory. Equipment failure might be just as effective in ruining

D32's experiment and prodding him away from a research career. However, as noted,

anthropomorphisms in the interviews more commonly apply to cells and we see

researchers sometimes assume the cell's perspective for cognitive purposes. These

actions confer sociality and social meaning onto the cells. In turn, cells 'speak' through actions resulting from what is done to them, and in speaking elicit a response.

Conclusion

In this paper we have considered possibilities for using positioning theory as a framework for organizing a set of codes emerging from our analysis that implicate identity and identifications in various ways. Our claims in relation to this task are modest. As Harré and Langenhove caution, positioning theory "should not be regarded as a 'general theory' that calls for a deterministic application to several specific subject matters. It is not like gravitational theory. Rather, it is to be treated as a starting point for reflecting upon the many different aspects of social life" (1999, p. 9-10). Our analysis is admittedly one-sided and departs from conventional procedure in that we have not examined how interviewers are positioned by the speech acts of researchers. Instead we have focused on ways in which researchers position themselves in relation to other researchers and within wider disciplinary and institutional frameworks. We thus use positioning analysis to address personal and professional identifications. However, we have also considered more subtle ways in which positioning through alignment and distancing in relation to others serves important cognitive and epistemic functions. Finally, because positioning theory is generally used in analyzing conversations, we have moved even farther afield in extending our analysis to researcher 'interactions' with cells, and in proposing a view of cell *death*, even the potential for death, as analogous to a speech act in its potential to shape and constrain human action. The illustrative value of this material points to the potential for extending the social psychology of science to include laboratory objects and artifacts in their intricate relations to scientists. We thus abide by the spirit if not the

letter of the law in applying positioning theory, given that "discursive practices" signify

"all the ways in which people actively produce social and epistemic realities" (Davies

and Harré, 1999, p. 34).

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