

Making SABRE Enhanced Low-Field NMR Experiments Accessible to Modern
Research Labs

The Academic and Social Consequences of Multidisciplinary Laboratory Structure in the
Context of Dr. Warren Warren's Laboratory at Duke University

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On my honor as a student, I have neither given nor received
unauthorized aid on this assignment as defined by the Honor
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Introduction

Most labs are structured in a way that encourages a variety of research that can be categorized under the same field of science. However, Dr. Warren Warren's lab at Duke University somewhat breaks this typical structure by consisting of two groups performing research into different phenomena. One subgroup of the lab does research into laser spectroscopy, and the other subgroup does research into NMR spectroscopy. In this investigation, the dynamics between the mostly autonomous groups and the motivation of their formation will be explored.

Research into the origin and development of the structure may yield insight into the merits it provides, and investigation into the intended effects will be performed to explore the motivations behind it. The general structure may not be rare on its own, but the official and unofficial activities associated with it reveal a philosophy of interdisciplinary collaboration and development of scientific communication skills. This investigation will also focus on uncovering the routines and social consequences that these practices have on the lab members and their communications with the outside world.

The subject of the prospectus and the technical topic for the Dept. of Biomedical Engineering are not related. The technical topic that will be covered is a project to create an easily accessible low-field hyperpolarization device for the purposes of NMR related experimentation. This project is designed to expedite the research into producing viable low-field MRI devices that may be vastly more affordable than current MRIs. In the technical portion of this prospectus, the technical details, social implications, philosophy, and potential ethical effects of the project will be explored in full. The philosophy associated with the project is one of accessibility in an academic and economic sense, which has the potential to cause interesting sociotechnical consequences.

Technical Topic

The goal with the technical project is to create a low barrier to entry low-field hyperpolarization device for magnetic resonance experimentation. The primary goals of the project are to design a 3D-printable coil set for magnetic field application, create a computational framework for *in silico* optimization efforts, and establish protocols for effective utilization of the previous two tools. The completion of these goals will ideally allow for expedited development of low-field MRI devices and clinically compatible pulse sequences.

Magnetic Resonance Imaging (MRI) is an important and rapidly developing clinical imaging technique. The imaging technique is fundamentally limited by the low signal intensities produced at most magnetic fields, requiring very large magnetic fields to produce clear images. The reduction of the operating magnetic field would lower the production cost of MRI technology significantly, as the large magnets used can require a huge initial energy investment and come with the expense of maintaining a superconducting magnet. The inherent size of MRI machines also limits their portability significantly, making point-of-care imaging impossible. The development of portable MRI machines and advances in post-acquisition processing would have large implications for the future of medicine (Cooley et al., 2015; Zhu et al. 2018).

Because MRI is typically done at large magnetic fields, most biologically relevant molecules have not had their magnetic properties characterized in low-field regimes. With low-field magnetic properties largely unexplored, and MRI technology heading into this regime, it is crucial to provide a framework for the investigation of these properties. This is the goal of this proposal. Ideally it would facilitate the study of magnetic parameters commonly used in MRI to ease the transition from high-field techniques to low-field techniques.

STS Prospectus

In this investigation, the dynamics, motivations, and philosophies of the two mostly autonomous groups within Dr. Warren Warren's lab at Duke University will be explored. By having the structure in the lab be separated at such a high level, the groups can act mostly separate from each other, with a few key exceptions. As the two groups share a lab space, there are mild social ties between individuals from each group. There is also an effort by the primary investigator and lab leader, Dr. Warren, to facilitate a diffusion of knowledge between the groups and diversify each group's perspective on their research and their connection to the outside world. The research that I propose here will provide insight into the timeline of the lab structure, the academic and social implications of the structure, and the philosophies underlying the entire arrangement.

There are several questions I would like to address with the proposed investigation. Does a split lab result in more positive outcomes for collaboration and critical thinking as anticipated, or does it result in augmenting social and academic confusion? How strong is the desire for members between the groups to participate in collaborative projects? What degree of collaboration inside the groups is there compared to collaboration between the groups, and has that ratio remained constant since the beginning? How much do individuals on both sides of the lab feel that they have benefited from critique originating from the opposite side? How strongly do lab members feel that they are all from one cohesive unit versus distinct groups? Finally, I want to investigate how the split structure of the lab came to be and establish a timeline of key events leading to its formation. I anticipate that the structure of the lab does result in positive experiences in an academic sense, and I believe that the social behavior between the groups will show a shallow division rather than a sharp one. However, it seems likely that collaboration between the groups

will not be strong, and the benefit of this separation mostly comes from intergroup feedback and transfer of knowledge.

In the Warren lab, there is a large focus on the interdisciplinary aspect of research education. Direct research collaboration between the groups may be lacking, but there is an organized structure of in-group meetings and full-group meetings with the intention of addressing both specific in-group needs and exposing all group members to research outside of their academic focus. These research presentation meetings are most likely to broaden people's horizons and make them better prepared to talk about their highly specialized research topics with individuals in other fields, but that is just the surface level analysis. They may also provide benefit to the social and academic wellbeing of Warren lab researchers in many other ways.

Though interdisciplinary research environments can be fraught with difficulty, the potential benefits that it can provide to developing research skills are worth the effort (Klassen, 2018). Practical issues pertaining to topic specific knowledge and philosophical issues pertaining to different practices between disciplines can hinder this type of work (Campbell, 2005; Gunawardena et al., 2010). The structure of the Warren lab likely minimized situations where this sort of conflict would arise, and instead focuses on the development of researchers to better themselves. This may present itself as the development of young undergraduate and graduate students, or the possible increase in research performance (Feldman et al., 2013; Pelz, 1956). The interplay between social strain and interdisciplinary benefit is certainly a topic I will be focusing heavily on during my research into this lab.

Another phenomenon I will be investigating is the focus on development of scientific communication skills. The lab takes advantage of its two-discipline structure to provide a testing ground of sorts. This testing ground is for scientific speaking practice, which takes place in whole-

lab meetings each Friday. During these meetings, an individual researcher will present on a topic of interest, whether that be their own research or someone else's. The point is not the topic, but the presentation itself. The large audience involved, and the frequency of these meetings is the perfect practice for reducing public speaking anxiety and increasing scientific presentation proficiency. Due to the large population of non-native English speakers in the Warren lab, this is an especially useful practice (Docan-Morgan, Schmidt, 2012). The intention of developing these skills also serves to improve the whole lab's ability to connect with the public in a way that is not focused on in many academic environments (Brownell et al., 2013). Due to this focus on the development of scientific communication, and the lab's primary focuses not necessarily being the most popular with the public, I plan to investigate the impact these "opposing" effects have had on lab communication in the past.

Given the unusual structure of the lab, the leadership plays an especially important role. Dr. Warren Warren is the primary investigator and head of the lab in a traditional sense, but one side of the lab has a separate figurehead, Dr. Martin Fischer, who runs the optical spectroscopy experiments with a large degree of autonomy. The consequence of this is that the lab operates somewhat like two separate entities. I intend to investigate the origin of this leadership structure and the questions it may arouse. In particular, I am interested in the timeline of how this lab structure came to be. With this information I want to make some conclusions on what practices were intentionally developed and what practices arose out of circumstance. The lab may be useful as a case study to investigate how practices like those in the Warren lab develop and impact the students who occupy those learning environments.

The lab may also prove to be very useful as a case study of how groups focused on different scientific endeavors may develop into their own unofficial academic and social institutions

(Griffith, Mullins, 1972). Since the research focus of each group has sufficient differences to be classified as separate topics with separate background knowledge, each group may have developed characteristics unique to their work. Research into this in an environment with only mild divisions can provide information into the extent of this effect. Conducting this research and using Social Identity Theory to analyze variables such as group permeability and legitimacy will help to determine the efficacy of the split-lab structure as an academic tool (Tziner et al., 2012). By comparing the group characteristics of the whole lab versus the subgroups, conclusions on the cohesiveness of the entire lab as an academic institution can be drawn.

To successfully quantify these effects, I intend to use Actor-Network Theory (ANT) and the Social Construction of Technology (SCOT) framework as tools. The somewhat autonomous nature that the sides of the lab display, along with the common resources, leaders, and locations, indicates that attempting to identify actors and the structure of the network will be very useful as an organizational tool. The SCOT framework as an investigative tool may prove useful due to the small number of social groups with well defined interests and limited resources. Due to the scale of the Warren lab and its interactions with the public, these networks may be relatively easy to define well, further increasing their potential usefulness in this situation. The Social Identity Theory mentioned above will likely also play a central role in this investigation, as the prominent effects I am exploring are mostly social. This framework can be used to describe groups and the different variables defining them and it will be crucial to effectively communicate the findings of this study.

Data collection will consist primarily of interviews and participant observation. Due to the nature of the questions, insight into individual experiences will likely yield the most useful knowledge. I will also study any potential past full group collaborations in my attempt to define a

timeline for the separation of the two sides of the lab. Additionally, quantitative data on the work hours spent by members of the laboratory leadership on activities relating to each of the independent lab subgroups will be collected. This should provide some insight into the oversight and different leadership styles for each side. Because I will be collecting qualitative data from a number of sources, it will be important for me to deal with biases as effectively as possible. To avoid what I anticipate being the largest source of bias, demand characteristics, I will structure interviews and surveys so that they do not have an obvious expectation. This will primarily be done by increasing question variety and lowering question specificity. My connection to the lab through my work there will also help me keep interviews casual due to the interviewee's familiarity with me.

The current research plan consists of several stages of interviews and observation. I plan on doing an initial round of interviews with key members of the lab to ask questions regarding the big ideas of this project (interdisciplinary work, scientific communication, timeline etc.). This would occur at the beginning of the research process. Next there would be an observation period, where I attend meetings and keep track of important interactions. During this observation period, I will gather information on past inter group collaborative projects and attempt to establish a timeline. The last portion of research would consist of several rounds of interviews to ask more specific questions based on findings from the observation period. After this I would have collected most of the information needed and may schedule some later meetings if it seems necessary at that time.

With this research project, I hope to understand the dynamics, motivations, and philosophies of the Warren lab at Duke University. I intend to conduct interviews and establish a timeline to understand the origin, development, and key events that led to the unique social and

academic structure of the split lab. Investigation into the interdisciplinary nature of the lab to determine how such a structure operates as a sociotechnical environment is also a primary goal. Philosophies on scientific communication also make themselves apparent in this lab, and another goal is to identify the differences this makes in the lab's public perception. I anticipate discovering the positive effects such a unique academic environment can have on the social and intellectual quality of a researcher and using these lessons to identify useful practices.

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