JEREMY R. MANNING, PH.D.

LAB MANUAL

CONTEXTUAL DYNAMICS LAB, DARTMOUTH COLLEGE

PUBLISHED BY THE CONTEXTUAL DYNAMICS LAB, DARTMOUTH COLLEGE

http://caligari.dartmouth.edu/~jmanning

First printing, August 2015

Contents

Introduction

This lab manual is intended to serve two purposes. First, the manual provides a comprehensive overview of official lab policies, expectations, facilities, and personnel. Second, it provides a set of general tutorials and a list of relevant links, pointers, and/or references related to the techniques we employ in our research.

Who is this lab manual for? Every new lab member should read the latest version of this lab manual in detail and reference it later as needed. Periodically throughout the document, you will see margin notes with listed `TASK` items. Completing your read through entails both reading the contents of the manual and completing the relevant `TASK` items.

`TASK`: Upon reading through this lab manual for the first time, please make at least one edit. You could correct a typo, clarify something that's unclear, add a comment, etc. Focus your edits or additions on sections that are most relevant to the work you want to do. Importantly, be sure to push your edits to the manual's github repository so that everyone can benefit.

What should you do if you don't understand something? If you don't understand something you read in this manual, it is important that you *ask another lab member for help*. Every member of the lab brings their own unique knowledge base, training, life experiences, and perspectives. Respecting and celebrating those differences drives the science we do. If you're new to the lab or new to a particular technique, you might feel like a newbie today— but chances are good that if you stick around for a bit someone else will be seeking your expert opinion before you know it. In addition to learning, there's another good reason for asking for help: if you don't understand something you read in this manual, there's a reasonable chance that you've discovered a mistake!

`TASK`: If you don't understand something, ask another lab member for help!

Why is it worth my time to read through the manual? Aside from pursuing your own curiosity, a major reason that you've decided to join an academic research lab is probably because you want to gain training or career-advancing experiences. This manual summarizes the collective wisdom of past and present lab members in a way that we think will best allow you to achieve your objectives. *Learn from it*, *challenge it*, and *add to it*.

Official lab policies

Our lab's policies are intended to provide a framework for *maximizing efficiency*. Achieving our peak efficiency as a lab means we are being as scientifically productive as possible, in terms of knowledge discovery (learning new stuff) and disemination (papers, talks, conference presentations, publicly released datasets, software, etc.). It also means that our fellow lab members are achieving their training and career objectives. To achieve peak efficiency we need to succeed on two fronts:

- **Communication.** We want to foster an environment where everyone feels comfortable contributing to the collective dialogue. Our lab meets regularly to discuss logistical (e.g. temporal, financial, sociological) and technical issues. We also use a variety of software packages to synchronize and facilitate communication within our lab and between our lab and the broader scientific community.
- **Resource allocation.** Our lab resources (e.g. equipment, time, money, attention) are finite. We want to foster an environment where lab resources are used as efficiently as possible to achieve our collective goals.

Your job as a contributing lab member is to help us to achieve our collective peak efficiency (as a lab) while also maximizing your own training and career potential.

The lab hierarchy

Our lab is organized in a roughly hierarchical structure. The hierarchy is an organizational tool that helps to define lab policies and expectations. Importantly, the lab hierarchy does *not* serve an excuse for disrespecting or discounting the opinions of lab members at similar or different levels of the hierarchy. Each lab member's position in this hierarchy is determined by two factors: the lab member's job title and the amount of time they have worked in the lab. Moving "up" in the hierarchy generally entails working in the lab for some amount of time, gaining experience by working in other (academic or industrial) labs, and/or earning academic degrees. The lab hierarchy is intended to serve as a general framework for estimating what is expected of each lab member (e.g. in terms of research, supervising and mentoring, training roles, and other lab responsibilities). The hierarchy also serves as a general framework for determining lab member salaries and benefits. There are two branches of the lab hierarchy; although personnel on different branches may have overlapping responsibilities, the first branch is primarly concerned with directly carrying out lab research and the second branch is primariy concerned with supporting or managing the lab's research objectives. The research-focused levels of the lab hierarchy are defined as follows:

Research-focused levels of the lab hierarchy

R1-*x*: **Undergraduate research assistants.** This category includes undergraduate students (currently enrolled at Dartmouth College) who are pursing an active undergraduate research program in the lab. An active undergraduate research program may include for-credit projects (such as an independent study or an honors thesis project) or not-for-credit projects.

R2-*x*: **Postbaccalaureate research assistants.** This category includes lab members who have already earned an undergraduate degree (e.g. BA, BS) but who have not earned a graduate degree, and who are not currently enrolled in a degree-granting graduate program.

R3-*x*: **Postgraduate research assistants.** This category includes lab members who have already earned a non-doctorate graduate degree (e.g. MA, MS) but who are not currently enrolled in a degree-granting graduate program.

R4-*x*: **Graduate students.** This category includes lab memebers who are currently enrolled in a degree-granting graduate program (generally working towards a master's degree or doctorate).

R5-*x*: **Postdoctoral researchers.** This category includes lab members who have earned a doctorate degree and are not currently enrolled in a degree-granting program.

Note that the x's above should be replaced with the time elapsed since you joined the lab, in years. The supporting and manageareal roles in the lab are:

Support-focused levels of the lab hierarchy

S1-x: **Administrative support staff.** This category includes lab members whose primary roles, regardless of their academic degree, are to provide administrative assistance (e.g. assisting with grant or paper submissions, registration, scheduling, coordination) to facilitate scientific research in the lab.

S2-x: **Specialists.** This category includes lab members who, regardless of their academic degree, bring a specific special scientific skill to the lab (e.g. programmers, graphic artists). However, unlike research-focused positions, the primary role of specialist lab members is to provide research *expertise* rather than determine research *direction*.

S3-x: **Project managers.** This category includes lab members whose primary role is to provide managerial support to the lab by helping to direct and organize personnel and lab resources. Generally project managers will have earned a graduate degree.

In addition to the above components of the lab hierarchy, there's one more lab position that plays an important role:

J1-∞: **Lab director.** "*There can be only one...*" Becoming the lab director entails convincing a search committee at this or another department/university that you have what it takes to be a Supreme Ruler of Laboratory Science. Note: this position may or may not come with tenure and/or additional people to report to (e.g. senior colleagues, funding agencies, deans, provosts, presidents, etc.). This position is both research-focused and support-focused, hence its own designation.

Project hierarchies

Lab members at any level in the lab hierarchy may play different roles on different projects. The role you play on a given project determines (for that project) your research and administrative responsibilities, your supervisory responsibilities, your role in decision making or strategizing, and your authorship position in papers or conference presentations about the project. The project roles are:

The mapping between people and project roles is many-to-many: one person may play multiple project roles, and one project role may be shared by multiple people.

P1: **Project assistant.** This is a minor "non-authorship" role (generally project assitants will be listed in manuscript acknowledgements). This role is assumed by all project participants who do not satisfy the criteria for paper authorship, but who directly participant in the project's conceptual or scientific development. An example might be an undergraduate research assistant who helps to run participants but who does not contribute to any analyses or to the itellectual development of the project.

P2: **Junior co-author.** This role is generally assumed by junior lab members (e.g. research assistants, junior grad students). Junior co-authors assist with all aspects of carrying out the research (e.g. helping to write code, run participants, generate graphics, review communications, etc.). The primary difference from a senior co-author role is that junior co-authors provde less conceptual guidance than senior co-authors. Junior co-authors will generally hold "middle author" positions on communications related to the project.

P3: **Senior co-author.** This role is generally assumed by senior lab members (e.g. postdocs, senior grad students). Senior co-authors provide conceptual guidance, research assistance (though to a lesser extent than a project lead), experimental assistance (though to a lesser extant than a project lead), and writing assistance (e.g. providing comments on manuscript drafts, posters, and/or slides). Senior co-authors will generally hold "middle author" positions on communications related to the project.

P4: **Project lead.** This person is responsible for overseeing day-to-day operations for the project, and reports to the PI (or co-PI). This person's responsibilities include: writing and running experiments (or directly overseeing these processes), coding and running analyses (or directly overseeing these processes), writing the first complete draft of the manuscript(s), editing the manuscript(s), submitting the manuscript(s), designing conference posters, and putting together slides for talks (which may be presented by the project lead or lab director). The project lead is also responsible

Authorship on project communications requires meeting ALL of the following criteria:

- Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of the data
- Drafting the work or revising it critically for important intellectual content
- Final approval of the version to be published
- Agreement to be accountable for all apsects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

If a project collaborator does not meet all of the above criteria (but meets some of them), they may be listed in the "acknowledgements" section at the discresion of the lab director.

for scheduling project meetings and organizing all materials (code, data, etc.) related to the project. The project lead will generally be the first author on communications (manuscripts, abstracts, posters, talks) related to the project.

P5: **Principle investigator (PI).** This is the person listed as the PI (or co-PI) on the grant that's funding the project. (This role may be shared, e.g. in the case of a co-PI.) Generally the (co-)PI will also be the project lead and/or will be the lab director. The PI is responsible for overseeing the project's budget (in collaboration with the lab director) and ensuring that the project timeline is adhered to (in collaboration with the lab director). The PI should discuss "order of authorship" on project communications with the lab director and ensure that all project members are informed of their order in the author sequence at the start of the project. Prior to the project starting, the PI is also responsible for drafting and submitting the grant application (in collaboration with the lab director).

P6: **Lab director.** This is the most senior person on the project. Generally this will be the lab director of the computational memory lab (Jeremy Manning). For collaborative projects, the lab director role may fall to another faculty-level collaborator.

Starting a new project

Our lab uses a number of project management tools and policies to promote continuity across projects and lab members. When you start a new project as a project lead, here are the steps you should take:

JEREMY TO DO: create a "Getting started checklist" and add it to the lab manual.

1. Come up with a project name to uniquely identify your project (e.g. "EEG mind decoder"). Keep naming conventions consistent; the project will be referred to using this name from now on.

2. Create a RedBooth project and add all team members. See *Task management using Redbooth* for detailed instructions on how to organize the new Redbooth project.

TASK: Create a RedBooth account if you don't already have one. Make sure you add yourself to the lab's group.

3. Create a Bitbucket repository for your project. Give all team members write access to the repository; PIs and the lab director should have administrative access. See *Code and document management using Bitbucket* for detailed instructions on how to organize the Bitbucket repository. Add a link to the Redbooth project in the project's Bitbucket wiki page. Also add a link to the Bitbucket repository in Redbooth.

TASK: Create a Bitbucket account if you don't already have one.

4. Create a proposed budget spreadsheet (in Google Docs) for project equipment purchases and subject payments. Other project costs (travel expenses, publication fees, conference registration fees, textbooks, etc.) should be added to the spreadsheet as they become known. Send a link to the spreadsheet to Jeremy and cc the project PI (if not Jeremy).

All equipment purchases or other lab charges must be approved in writing by Jeremy Manning *prior to spending lab funds*. IMPORTANT NOTE: Budget spreasheets should not be attached to the Redbooth project. All budgets are to be kept confidential within the lab.

5. Create a Google Docs spreadsheet outlining all project personnel and their project roles, and share it with all team member (the PI may ask other project members to fill in personal information and contact details). This should include each project member's:

TASK: Create a Google account if you don't already have one (or if you'd like to create a new one for lab-only use). Make sure your account is linked with the lab's Google Apps account, which will give you access to extra storage space and some other additional functionality.

   - Full name
   - Lab hierarchy code (e.g. R4-0, J1, etc.)
   - Project hierarchy codes (e.g. P4 and P5)
   - Expected project role (keep it brief– e.g. "Project management; Code experiment; Run participants; Ensure consistent levels of caffenation maintained by all project members during lab business hours.")
   - Proposed authorship order (this will apply to any project communication– manuscripts, abstracts, talks, etc.)
   - Contact information (preferred email, preferred phone number, preferred mailing address, and primary office number or address if different from mailing address)

- Acknowledgement that the project member has joined the project, looked over (and corrected as necessary) their information, and accepts their project role. This column must be filled out individually by each team member (each team member should type their initials into the project field).

Add a link to the personnel spreadsheet in RedBooth.

6. Create a Google Calendar for project meetings and events.
7. Add a line to your lab snippet template for this project. (See *Lab Snippets*.)
8. Create a new Google Group for the project and invite all team members. Via Google Groups, send a polite but brief message to all project personnel welcoming them to the project. Include the following information:
   - A 1-2 sentence description of the project.
   - A link to a Doodle Poll proposing some times for a first team meeting.
   - A request that all team members join the project in Redbooth and Bitbucket. If any team members are not current lab members, also include a brief description of what Redbooth and Bitbucket are. (A project management tool and version control system, respectively.)
   - A iCal link to the project's Google calendar. Instructions for sharing calendars may be found here.
   - A note that you have outlined expected project roles and responsibilities in Redbooth, and that these roles and responsibilities will be discussed during the first project meeting. Ask the project members to look over what you've proposed and make note of any comments, questions, or concerns (either within Redbooth or elsewhere) prior to that first meeting.

Joining a project

If you are starting a new project (as the project lead), you automatically "join" the project. If you are a non-project lead team member, your agreement to join the project is officially signified when you add your initials to the project's Google Doc (sent out by the project lead) and agree to the project responsibilities outlined there. All project communications should be sent via the project's Google Groups mailing list.

Scheduling

Complex dynamic systems can be difficult to understand (e.g. describe, compute with). Fortunately for us, we do not need to start entirely from scratch with respect to attempting to organize some complex dynamic system we care about in our lab. For example, we can use tools like calendars and other software packages to organize and understand our own temporal dynamics. Our lab's scheduling policies are intended to facilitate lab member interactions between ourselves, our collaborators, and our experimental participants. There are three basic tools the lab uses to organize and schedule events:

- Google Calendar. We use the main lab calendar to keep track of lab-wide events including lab meetings, conferences, important talks. We use the DHMC events calendar to keep track of important events and meetings at the DHMC. We use the out-of-lab calendar to keep track of known absenses (e.g. illness, travel, holidays, etc.). We use the meetings calendar to keep track of scheduled meetings (regularly scheduled meetings with Jeremy or senior lab members, project meetings, etc.). When you add an event, it is important to include the following information as a comment (this does not apply to "out-of-lab" events):
  - Key contact names and contact information (email or phone)
  - Physical address (where the event will take place)
  - A brief description of the event and/or other relevant information
  - Attach any relevant documents via Google Docs
- Doodle. We use Doodle to converge on mutually good meeting times that fit (as well as possible) with everyone's busy schedules.
- Google Groups. We use Google Groups to send coordination-related emails to all relevant lab or project personnel.

Attendance policy

We abide by a "common sense" attendance policy that relies on an honor system. If you cannot attend a lab event or meeting, your privacy will be respected: you do not (generally speaking) need to provide a reason for your absense (although you are honor bound not to abuse this system!)– but you are expected to responsibly manage your schedule so that you get your work done nad minimize inconvenience to others to the extent possible. The one exception is that if you seem to be abusing this system (as determined by your

supervisor), you may be asked to provide additional information (in a way that does not invade your privacy– and if you are worried that this policy is overly intrusive, please bring your concerns to Jeremy). Here's the official lab attendance policy:

- All absenses should be entered into the out-of-lab calendar. This should be done prior to your absense if possible; the out-of-lab calendar is used to track vacation time, sick leave, etc. If you will be out of the lab unexpectedly, it is your responsibility to notify your immediate supervisor (cc'ing Jeremy) as well as anyone else your absense will affect (e.g. people you're scheduled to meet with, etc.). To enter an absense, simply create a new out-of-lab event with your first name followed by the word "out." (E.g. if Jeremy is out of the lab he would create an event called "Jeremy out".) Out-of-lab events can be all day events, multi-day events, or partial day events. You do not need to (and should not) label your event (e.g. sick time, vacation time, conference time, etc. will be indistinguishable on the out-of-lab calendar); this is done to protect the privacy of all lab members.

  - If you are feeling sick, *do not come into the office*. We can arrange virtual meetings (if you are feeling well enough) or re-schedule as needed. The health and safety of the lab is the top priority. Enter your expected "out of lab" duration into the out-of-lab calendar (update as you have more information so that we can correctly track your time).
  - If you must be out for an unexpected emergency, simply give as much notice as is possible. Enter your expected "out of lab" duration into the out-of-lab calendar (update as you have more information).
  - If you know that you will be out of the lab well in advance (e.g. classes, vacations, religious holidays, conferences, job interviews, doctor appointments, etc.) enter this into the out-of-lab calendar. This should be done at least 2 weeks in advance, and preferably as far in advance as possible. Enter this information into the out-of-lab calendar.

- You are expected to attend all lab meetings and other regularly scheduled meetings that are directly relevant to your work in the lab.

- If you are scheduled to present at a conference (i.e. you submit an abstract and the abstract is accepted as a talk or poster), you are expected to attend the conference to present your work.

- You are strongly encouraged to attend relevant PBS talks, DHMC meetings and talks, thesis defenses, and other relevant lab and/or Dartmouth-affiliated events. If you are overwhelmed with other work, have a conflicting meeting, are running an experimental participant, or are out of the lab for other reasons, you do not need to provide a reason for your absense (unless you've previously agreed to attend).

- You are expected to tend to your out-of-lab responsibilities (classes, family duties, etc.) as a top priority. If these conflict with your lab responsibilities please discuss with your supervisor and/or Jeremy as applicable.

Lab finances

As with most academic research labs, we (sadly!) must conduct our research within a limited research budget. The lab's financial policy is the following: we will do whatever is possible to ensure you have the equipment and resources you *need* to do your best work. If you can adequately justify an expense (typically done when proposing a project budget except when first starting out in the lab) and sufficient funds are available, then we will spend what it takes to get the job done. If you cannot justify an expense, or if the lab does not have sufficient funds, then we will likely need to get creative by figuring out how to get the job done anyway on a seemingly too-small budget. Usually we'll find ourselves somewhere in the middle of this continuum, which will help us to stretch our limited budget as far as possible while not making ourselves crazy or losing too much productivity in the process.

Startup money

Startup money is *unrestricted* money that may be used to purchase equipment, hire personnel, pay travel expenses, fund lab renovations, and grease the day-to-day wheels of the labs existance. Critically, startup money may be used for any project, and is therefore extremely valuable and special. (Grant money is generally designated for a specific project and may only be used for that one project.) Also, startup money never gets replenshed, which adds an extra dimension of caution to the mix.

As a new lab member, you will get your own little share of the lab's startup money. Your budget will generally consist of:

- An intitial pool of money to be used to buy a computer (laptop, desktop, or both) plus any minor computer-related accessories

Although you'll get some degree of flexibility with respect to how you choose to spend this money (with more senior lab members getting more flexibility), all purchase decisions must still be approved by Jeremy (just as Jeremy's purchases must in turn be approved by the administration, whose purchases must in turn be approved by the senior administration, and so on). Futher, all equipment you buy is the property of the lab. If you leave the lab, you are expected to return the lab's property!

you'll need (monitor, keyboard/mouse, etc.). You may also be allocated an existing computer from the available lab stock in leu of a dollar amount. Any computer equipment you need, repairs, or other computing costs you incur, will be expected to come from this pool.

- A yearly travel budget. Any lab-related travel you do will be expected to come from this pool.
- An equipment budget. Any experiment-specific equipment you buy will be expected to come from this pool.
- A "miscellaneous" budget. This is expected to cover things like textbooks, publication costs, poster printing, etc.

The precise amount of your mini startup fund will depend on:

- How long you expect to stay in the lab. For example, a short-term rotation or senior thesis student will generally be allocated less money than a longer term student, research assistant, or postdoctoral researcher.
- What research you expect to do. Some people need more powerful (and more expensive) equipment to get their work done, and may be allocated more money accordingly.
- How much you are expected to travel. If you're going to be going to lots of conferences, you'll need more money to get there!

Applying for research and training grants

Equipment policy

Computers

Other research equipment

Travel policy

Poster printing

Publication costs

Subject payments

Lab mailing list and contact information

Task management using Redbooth

Code and document management using Bitbucket

We use Bitbucket as a means of organizing, maintaining, and sharing

The lab's standard practice is to use the Git version control system. All projects *must* be managed using Git and hosted on Bitbucket unless there is a compelling (and documented!) reason to use another system.

our code and documents. Bitbucket provides a unified framework for documenting changes over time, managing and integrating code from multiple users, and submitting bug reports or feature requests. Atlassian's SourceTree client provides a convenient and easy-to-use desktop client for OS X and Windows systems. Each project should have *two* Bitbucket repositories. The first repository (<projectname>-main) is used to manage experiment and analysis code and related (non-data) files. The second repository (<projectname>-communications) is used to manage documents and images (papers, posters, slides, etc.) related to *communicating* the work to the broader scientific community. This two repository system is intended to prevent the main project repository (which will eventually be shared publically in most cases) from (a) growing too large and (b) containing information or files that would not normally be shared publically (e.g. in-progress drafts of manuscripts, raw image files for posters, editable figures, etc.). The *main* repository should be organized using the following directory structure:

- *code/main*: contains code for running experiments and analyses. When the paper is published, this folder (and/or its contents) will be made publically available. How this folder gets organized is up to the project lead.
- *code/main/contents.txt*: a list of
- *code/main/README.txt*: quick start instructions for using the code.
- *code/dev*: contains under-development and/or half-baked code. All project-related code should start life in this folder, and should be moved to code/main after it has been debugged and after its unit tests have been written.
- *code/debug*: contains unit tests for code in code/main. Unit tests should provide example scripts for running code/main code along with specific detailed descriptions of the expected behavior or output.
- *docs/admin*: contains organizational files related to the project, including:
  - **Project vision.** A high level description of the project along with a (rough) proposed timeline for the project's phases.
  - **Personnel list.** A description of all project members and their expected roles on the project. Authorship order must be specified in this document, and changes must be approved by the lab director.

- *docs/admin/forms*: official forms and approvals related to the project. Each experiment should have its own sub-folder containing:
  - IRB approval forms
  - Participant consent forms
  - Participant exit surveys (if applicable)
  - Participant instructions
  - Participant debriefing document
  - Ammendments to any forms (e.g. IRB approval extensions)
  - A document listing budget codes for grants that fund any part of the project

The *communications* repository should be organized using the following directory structure:

- *papers*: each paper should exist as a sub-folder of this directory. Each paper's sub-folder should contain the following:
  - *paper_name.tex*: main source file for document text
  - *boneyard.tex*: a source file containing pasted snippets of discarded text that might conceivably be useful at some later point (in this or other projects).
  - Other files needed to compile the main source file into a complete PDF.
  - *figs*: sub-folder containing complete PDF figures.
  - *figs/source*: sub-folder containing files relevant to constructing each manuscript figure (e.g. the images for each panel in a figure). Each figure should have its own sub-folder. For compound figures (e.g. a panel that has multiple sub-panels), each panel should have its own *source* directory that lives in its parent figure's source directory. Raw data should not be stored in these folders, but intermediate files or images that would be time consuming to regenerate (or that are useful to have in an easily accessed location) should be included. In addition, Adobe source files (e.g. .ai or .psd files) should be included in the source folders.
  - *replicate*: sub-folder containing links to the data and code relevant to the paper, along with **detailed** helpful instructions that would allow someone to download the project's *main* Bitbucket repository and data, and reproduce figures from each paper from scratch (assuming they had the appropriate hardware to run the analyses). The instructions should also list system requirements (as applicable) and software dependencies (along

with download links and installation instructions). This folder should also contain a "make_figs" script that, when run, should reproduce the basic versions of the paper's figures (e.g. before editing fonts and line styles or composing figure panels in Illustrator), assuming the *main* project repository has been downloaded to the specified location.

- *posters*: each poster should exist as a sub-folder of this directory. Each poster's sub-folder should contain:
  - The main .ai, .pdf, .pptx, or .tex poster file.
  - A copy of the associated conference abstract or paper.
  - A README.txt file containing bibliographic information for the poster.
- *slides*: sub-folder containing the .key, .pptx, or .pdf files for each presentation.
- *source*: sub-folder containing all source materials (figures, etc.) linked to in any poster or presentation. The source directory may contain additional sub-folders, but does not need to be separated by poster or presentation. This is because oftentimes the same source file(s) will be shared across multiple posters or presentations.

Data repository

Lab Dropbox account

Internal Review Board (IRB) approval process

List of active protocols

List of inactive protocols

Official lab techniques

Document formatting using LaTeX

Coding experiments using PsychToolbox

Data analysis using MATLAB and Python

Behavioral experiments

fMRI

Running fMRI participants

Data preprocessing

Multivariate Pattern Analysis

Topographic Factor Analysis

Scalp EEG and ECoG

Running EEG participants

Running hospital patients (ECoG)

Cluster computing